OUTPUT

Media	Speed	No. of Multiplexed Channels
Flexowriter	10 chars/sec	
Teletype via Buffer	10 char/sec	7
Charactron via display console	15,000-20,000 ch/s	30
Flight strip via display console	15,000-20,000 ch/s	30
Flight strip punch and printer	10 char/sec	12
Data Link	30 char/sec	7
Analog-Digital conv to radar trackers	30 char/sec	2
Inter Computer via buffer	200,000 char/sec	1

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

(For a minimum system)

Type	Quantity
Tubes	0
Diodes	
About 5 types	1,500
Transistors	23,000

2N393
2N599
2N416
2N498
2N404
2N595
and a few others

CHECKING FEATURES

Checking features include parity on all registers, and all information exchanges between units. A dual adder is used in the arithmetic unit. Complete checking is performed.

Maddocks Photo for Librascope Division, GP, Inc.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	3 Kw
Power, air conditioner	2 Kw
Volume, computer	140 cu ft
Area, computer	23 sq ft
Floor loading	20 lbs/sq ft

Air conditioner is internal

Weight, computer	3,000 lbs

Air conditioner is included in above

PRODUCTION RECORD

Number produced to date	2
Number in current operation	1
Number in current production	2
Time required for delivery	12 months

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Construction techniques utilized to insure reliability includes "NOR" circuitry, RTL logic, 100% incoming inspection, rigid testing, "worse, worse" case type of design, extensive field reports on failures plus immediate corrective action, and the use of double rank registers.

ADDITIONAL FEATURES AND REMARKS

System is particularly suited to systems requiring random retrieval from large unsorted files and systems with large numbers of input-output devices.

Maddocks Photo for Librascope Division, GP, Inc.

FUTURE PLANS

It is planned to change to a 6 microsecond memory cycle time and increase the pulse rate, which will reduce the operation times by a factor of 4. Also, index registers will be added and the drum capacity will be increased.

INSTALLATIONS

Librascope Division of General Precision, Inc.
808 Western Avenue
Glendale 1, California

LIBRASCOPE ASN 24

Librascope ASN 24 Airborne Digital Computer

MANUFACTURER

Librascope Division
General Precision, Incorporated

Photo by Librascope Division, GP, Inc.

APPLICATIONS

The ASN-24 Computer is a highly versatile general-purpose electronic digital computer which by virtue of its non-fixed internally-stored program, is easily adaptable to many commercial, scientific and military uses. In addition, its small size and weight and low power requirements make it particularly well suited for application in compact systems.

While the ASN-24 Computer can be utilized for extensive on-line general purpose computing applications, it has been designed primarily to satisfy the complex environmental and operational performance requirements of airborne/spaceborne systems real-time applications. The computations may be made from doppler derived ground speed, manually fed fixes, true heading, celestial position determination, and radio aids. Automatic inputs of the following form may be accepted. (When utilized with appropriate complementing input-output equipment):

Compass heading
Astro compass heading
True air speed
Doppler ground speed and drift angle
Inertial velocity
Radio aids
TACAN range and bearing
Automatic sextant (Celestial altitude and azimuth)
Altitude above terrain or above sea level
An internal standard for both sideral and solar time
Star tracker
New equipment as it is developed

Information may also be fed into the computer manually. Manually stored information may be latitude, longitude, range, bearing, wind force or angle, or any direct fix data not available from the aircraft's instrument.

Basic data necessary for navigation may be set manually into the computer before take-off, or in the air.

The ASN-24 will perform the following basic computations as well as solve other desired navigational problems:

Ground position in latitude and longitude with computing errors not to exceed 0.01% of distance traveled.

Ground track

Polar navigation

Great circle course and distance to alternate destinations

Magnetic variation and true heading

Wind direction and velocity (and has provision for wind memory)

Celestial fixes

Position from radar or radio aids (and will check these fixes for credibility)

Range and bearing to a moving target

Range and bearing to a collision point with a moving target

Time to destination

Altitude and azimuth of a celestial body

Image motion compensation and timing for aerial photography

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	25
Binary digits/instruction	25
Instructions/word	1
Instructions decoded	not applicable
Arithmetic system	Fixed point
Instruction type	Two-address (One-plus-one)

The "one-plus-one" addresses are of the operand and the next instruction.

Number range -1 to $+1 - 2^{-24}$

Instruction word format

$P_{24}P_{23}P_{22}P_{21}P_{20}$	$P_{19}P_{18}P_{17}P_{16}P_{15}$	$P_{14}P_{13}P_{12}P_{11}P_{10}P_{9}$	$P_{8}P_{7}P_{6}P_{5}P_{4}P_{3}$	$P_{2}P_{1}P_{0}$
T_α	T_β	S_β	S_α	0

T_α (P_{24} - P_{20}) represents the track address of the next instruction

T_β (P_{19} - P_{15}) represents the track address of the operand (except for transfer and store orders)

S_β (P_{14} - P_{9}) represents the sector address of the operand (except for transfer and store orders)

S_α (P_{8} - P_{3}) represents the sector address of the next instruction

0 (P_{2} - P_{0}) represents the order to be performed

Transfer Orders: (T_β, S_β) represents the track and sector addresses of the next instruction if the contents of the accumulator is positive

Store Orders: (T_β, S_β) defines the location into which the contents of the accumulator is stored, or defines the modified store order to be performed

Automatic built-in subroutines include Add, Subtract, Multiply, Divide, Extract, Clear and Add, Conditional Transfer on Sign of Accumulator, Store, and Modified Store (Multiple).

Registers include 4 recirculating registers. These are the Instruction, Accumulator, Multiplier, and Multiplicand.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	625	156
Mult	4219	3907
Div	4375	4063

Construction (Arithmetic unit only)

Transistors	382
Diodes	3553
Capacitors	347
Transformers	87
Resistors	1894
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec
Magnetic Drum	2,560	64,000	10,000 Max 156 Min

INPUT

Media	Speed
Incremental Pulse Train	0-6000 pps
Shaft Position to Binary Coded Discs	Sample: 100/sec Slew Rate: 800 bits/sec Speed can be made higher

Input/output equipment must be designed for each particular application; however, the particular design and wide applicability of the ASN-24 Computer insures minimum required design effort for input/output equipment.

OUTPUT

Media	Speed
Discretes (voltage pulses)	Max 100 pps

Signals of various time lengths and amplitudes are possible. Signals used to excite other equipment, close relays, etc.

Encoder Disc	Sample: 100 or 200/sec Slew Rate: 800 bits/sec

Can be coupled to synchro, potentiometer, or other similar type shaft mechanism.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	3,553
Transistors	382

Only silicon diodes and transistors are used for high temperature operation capability. These units have high back resistance and low leakage characteristics at high temperatures. The higher collector voltage ratings of silicon transistors permit larger logic swings, these reducing the susceptibility of the computer to noise.

The resistors are 1/4 watt, carbon composition type, have low dielectric loss, DC resistivity, and high thermal shock resistance.

Most of the capacitors are a solid tantalum type which have high dielectric strength and

have no derating of voltage over a large temperature range. The very small capacitors are the subminiature ceramic type.

CHECKING FEATURES

Routines programmed to check all instructions or order codes and the contents of the memory. Discrete signals, suitable for driving indicators, generated to indicate successful completion of check routines. The support equipment includes a Fill-Test Unit, which will fill and check memory contents in conjunction with a tape reader and control the computer program with one-step or loop operation. It also provides test route and synchronization signals for oscilloscope presentation of computer information and Card Checker will check operation of individual circuit and logic cards.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.132 Kw	0.189 KVA	0.7 pf
Does not include I/O			
Volume, computer	0.55 cu ft		
Area, computer	1.42 sq ft		
Weight, computer	37 lbs		

System requires a suitable surface, table, etc., that is fairly steady, can support 31 lbs. etc. System requires only electrical power outlets, 28v DC and 3 phase, 400 cycle AC.

PRODUCTION RECORD

Number produced to date	4
Number in current operation	3
Number in current production	12
Number on order	16

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Supervisors	4
Analysts	1
Programmers	3
Clerks	4
Engineers	20
Technicians	7
Draftsmen	13

ADDITIONAL FEATURES AND REMARKS

Outstanding features include extremely wide variety of applications, operation under sea-level to space environments, light weight, low power drain, in actual operation in field, programmable high speed (200 times (sec). Integration of inputs and/or extrapolation of outputs independent of main authentic section, and data read-out for telemeters.

Basic computer unit designed and in field operation, input-output can be designed to meet a multitude of applications with minimum cost and time expenditures. Tie-in with pulse integrating accelerometers.

Magnetic Memory Drum

Capacity and Tracks:

41 tracks (1600 bits/track) of non-volatile main memory, arranged as follows: 38 tracks with 1 read head each; 2 tracks with 1 read and 1 write head each; 1 track with 1 read head and a 200 bit recirculating register.

1 1600 bit clock track

2 25 bit recirculating registers (2 registers on each of 2 tracks)

1 25 bit recirculating register with 4 additional heads on the same track

1 track with head spacings for either 200 bit or 800 bit recirculation.

Speed:

6,000 rpm

Clock Frequency:

160 kc

Motor:

Location: Contained within drum

Power: 35 watts from 3 phase, 400 cycle, 208 volt Line-Line (60 watts starting power)

Runout:

0.0001 T.I.R.

Drum Assembly Dimensions (including shroud, a head mounting surface surrounding the drum proper; cover; and heads):

6 1/2 inch diameter x 5 11/16 inches long

Drum Assembly Weight (including shroud, cover and heads):

11 1/2 lbs

Drum Surface:

The entire drum surface is milled, similar to the clock track on many other drums (i.e. slotted), with the slots parallel to the axis of rotation. There are 1600 slots around the drum periphery. After milling, the slots are filled with 3M iron oxide.

Heads:

Separate read and write heads are used with this drum. Minimum readback from read head is 0.4 volts peak to peak. The write head requires a 300 ma peak current of 2 microseconds duration through a half-winding. Storage tracks with only read heads requires special techniques.

Environmental Specifications

Ambient Temperature Range:
-55° C to $+100^{\circ}$ C

Humidity:
Entire assembly can be hermetically sealed

Altitude:
Sea-level to space

Shock:
20g for 11 milliseconds

Vibration:
6g from 15 cps to 2000 cps

Constant Acceleration:
10g radially, 3g axially

FUTURE PLANS

Many possible new applications being investigated and radiation testing of circuitry is being planned.

LIBRASCOPE CP 209

Librascope Model CP 209

MANUFACTURER

Librascope Division
General Precision, Inc.

APPLICATIONS

System is used for airborne navigation and bombing ballistics, including loft, and real-time, high speed tracking problems.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	14
Binary digits/instruction	6
Instructions/word	Variable-One, Two or Three
Instructions decoded	30
Arithmetic system	Fixed point
Incremental or Digital	Differential Analyzer
Instruction type	System can process 8 operands, storing them in 3 parallel positions.
Number range	$\pm (2^{27} - 1)$

Automatic built-in subroutines include integration and sine-cosine.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	59	59
Mult	59	59
Div	177	177 (by sub routine)

Construction (Arithmetic unit only)	
Vacuum-Tubes	304
Transistors	100
Condenser-Diodes	4,500
A-D inputs	12
D-A outputs	14
Arithmetic mode	Parallel Arithmetic Units operating Serially
Timing	Synchronous
Operation	Sequential

STORAGE

Medium	No. of Words
Magnetic Drum	85 Computational Blocks with 4 Integrand Lines

INPUT

Media	
Paper Tape	Used to fill Memory
Analog Digital Converters	200 divisions/sec
Manual Inputs	

OUTPUT

Medium	Speed
Digital-Analog Converters	200 increments/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	
6021	33
6111	197
5784-WA	36
5639	36
Diodes	
406621	
Transistors	
2N338	
2N657	

CHECKING FEATURES

Checking features include a diagnostic routine programmed for maintenance.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	1.76 Kw
Volume, computer	3.0 cu ft
Area, computer	1.77 sq ft
Floor loading	133 lbs concen max
Weight, computer	133 lbs

PRODUCTION RECORD

Number produced to date	48
Number in current operation	21
Number in current production	6
Number on order	5
Anticipated production rates	5/month
Time required for delivery	10 months

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Operators	1
Technicians	1

Training made available by manufacturer to users includes a factory training course for maintenance men.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Fleet service records indicate that failure-free operation time averages 90%.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include a stored program, retraceable sine-cosine operation, K-Line scaling for flexibility and exact multiplication.

Photo by Librascope Division, General Precision, Inc.

LIBRASCOPE MK 38

Librascope Attack Console Mk 38 (U. S. Navy)

MANUFACTURER

Librascope Division
General Precision, Inc.

Photo by Librascope Division

APPLICATIONS

The system consists of a serial, incremental, computer consisting of two identical sections working from a common control and input-output section. It is used for real-time fire control problems.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits/word	18
Number of binary digits/instruction	5
Number of instructions per word	18
Number of instructions decoded	70
Arithmetic system	Fixed point
Instruction type	One-address operation orders
	Two-address increment orders
	Four-address distribution orders

Operation orders consist of integration, remainder, digital servo, transfer, and sine-cosine generation.

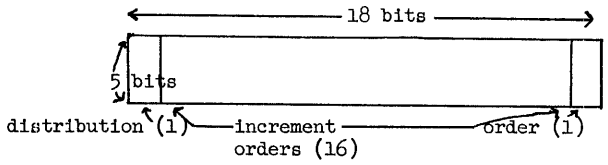
Distribution orders take the increment outputs of the operation orders and store them in temporary registers.

Increment orders communicate the increment outputs

between the operation orders and make decisions on incremental transfers.

Number range $\pm 2^{15}$

Instruction word format



ARITHMETIC UNIT

Operation	Time Microseconds
Integration	72
Remainder	72
Servo	72
Transfer	72
Sine-Cosine	144
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec
Magnetic Drum	6,874	122,112	4/bit

INPUT

Media	Speed
Analog-digital convérters 32 max, 18 used	Each sampled every 10 millisec.
Switches 16 used	Each sampled every 10 millisec.
Paper Tape	20 char/sec

Tape reader is used for initial fill only.

OUTPUT

Media	Speed
Servo output 32 max, 15 used	Repositioned every 10 millisec.
Relay Lighter 16 used	Repositioned every 10 millisec.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	None
Diodes	
1N621	11,087
1N663	4,275
1N914	128
10Z10.7A	4
1Z12	72
SV128	1
1Z4.7	4
1N647	40
SU122	40
Transistors	
2N697	1,686
2N699	29
2N1252	144
2N1253	704
S4048	

CHECKING FEATURES

Built in Test Program.
Marginal Check Power Supplies.
Card Tester.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer

Volts	cps		Kw	KVA	PF
115	400	3	2.74	3.92	0.70
115	400	1	1.109	2.64	0.42
115	60	1	0.032	0.115	0.28
28	60	1	0.29	0.29	1.00
28	DC		0.294	0.294	1.00

Volume, computer	26.67 cu ft
Area, computer	4.67 sq ft
Room size, computer	8 x 9 ft
Power, air conditioner	Forced air
Weight, computer	3,000 lbs, Total (Includes Analog Section)

Refer to OP 2687 for installation requirements.

PRODUCTION RECORD

Number produced to date	14
Number in current operation	3
Number in current production	6
Number on order	54
Anticipated production rates	3 per month

Above data is as of 29 June 60

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Supervisors	1
Operators	2
Technicians	1

Training made available by manufacturer to users includes a 6 month course for Navy personnel at Key West for operation and maintenance of entire system.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System features and construction techniques utilized by manufacturer to insure required reliability include built in test programs, giving both identical sections the same program for comparison testing, a card tester with fixed pattern for testing all circuit cards, silicon components used for greater heat stability, and pluggable etched circuits cards for quick replacement.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include the option to reprogram the fixed program gives the computer the facility of handling a weapons system compatible with the number and range of analog-digital converters.

FUTURE PLANS

Plans include continued adaptation of computing equipment to any rocket thrown torpedo or similar missile requirement. Incorporation of electric set and wire-guide torpedoes as well as other short range weapons.

LIBRASCOPE MK 130

Librascope Digital Computer Mk 130 Mod 0 (U.S. Navy)

MANUFACTURER

Librascope Division
General Precision, Inc.

APPLICATIONS

Computer performs target motion analysis, target prediction, and data smoothing for Fire Control System Mk 113.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits/word	18 bits plus sign
Number of digits per instruction	5 bits for address orders 7 bits for non-address orders
Arithmetic system	Fixed point

Floating point is programmed as a subroutine of two consecutive words; 8 bits are used for the exponent and 30 bits are used for sign and numeric value.

Instruction type	One address
Number range	0 to $(2^{19} - 1)$

Photo by Librascope Division

Instruction word format

Addressable order

1	5	1	12
Sign	Order	B	Address

Non-address order

1	13	5
Sign	Non-Address Order	I/O Device Designation or Number of places for shifts

Automatic built-in subroutines

The trapping of control is dependent on the overflow of the delay line (relative clock). When trapped, computer obeys the instruction in location $(0002)_{10}$ of memory.

Registers and B-boxes

One B Modification register, usually known as

index register.

Approximately 3,650 instructions are decoded for a fire control program.

There is also an indirect addressing feature available. A bit in the sign position is utilized for this purpose. This differs in that instead of referring to an address 0001 the desired address is found in location 0001. This process may be carried further.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec.	Exclud. Stor. Access Microsec.
Add	40	16
Mult	40-424	16-400
Div	40-460	16-436

Construction (Arithmetic unit only)	Transistors
Arithmetic mode	Parallel
Timing	Synchronous
Operational	Sequential

The machine has a microprogram unit which controls its function. The microprogram unit is synchronous, the arithmetic unit is asynchronous.

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec.
Magnetic Core Memory	4,096	Sign digit + 18 digits	20

No magnetic tape is associated with the Mk 130 Mod 0.

INPUT

Media	Speed
Switch Bank on test panel	Instantaneous

Information is read directly into the accumulator.

Analog Modules (Digital Data from Shaft encoders)	157 times per second

Information is converted from analog voltages to binary via I/O Buffer, is read into the K Register. From the K Register, the program gets the information into the Accumulator.

Flexowriter or Ferranti tape reader	Photo reader original rate 530 chars/sec

The speed is dependent on the amount of tape on the reel.

Switches in Mk 50, Mk 51, and Mk 75 of FCS Mk 113 and all Mods, and Sensor operator's Mark Signals	128 micro sec pulses

Some of these signals are stretched to more than 2.25 seconds.

OUTPUT

Media	Speed
Analog Modules (Digital data from shaft encoder)	157 times/sec

Program transfers information from Accumulator to K Register, then via I/O Buffer to analog components.

Light Banks on test panel	Instantaneous

The accumulator and the counter register are displayed.

Lights on Mk 51 of FCS Mk 113 all mods	Instantaneous

For quality of sol'n lights, relative course light, constraint lights, etc.

To relays in Mk 50, 51 and 75 of FCS Mk 113 all mods	Instantaneous

To signal that range, course, speed, and bearing for a particular channel has been calculated and are available as analog information.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	None
Diodes	
1N251	97
1N270	76
1N429	38
1N537	11
1N645	97
1N659	11,762
1N663	2,412
1N749	22

Does not include diodes in which less than 10 per type are used.

Transistors	
2N335	20
2N388	1,317
2N501	3,232
2N597	68
2N599	2,361
2N665	17

Does not include transistors in which less than 10 per type are used.

Magnetic Cores	82,000

Used in computer memory and switching.

The Mk 130 Mod 0 uses "resistor coupled transistor logic" (RCTL) or "nor" logic throughout.

CHECKING FEATURES

Fixed checking features include a card test panel, capable of checking all circuit boards, a computer test panel, providing manual communication with all portions of computer, and a margin check panel, wherein switch settings determine voltage variation for marginal checking.

Optional checking features include a test console, which can duplicate computer test panel and in addition can furnish input/output facilities of flexowriter, high speed punch, switch inputs, camp outputs, digital shaft encoders, and output servo modules. It is used for factory checkout only.

Existing computer circuitry can be utilized to activate portable flexowriter or high speed punch without use of test console if desired. Portable input/output devices not available at this time but can be developed with minimum design effort.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

	Power Kw	KVA	Factor	Remarks
Power, computer	2.85	3.15	0.9	400 cps, 3Ø, 115V
	1.97	1.54	0.8	60 cps, 1Ø, 115V
	.21	.21	1.0	26V, DC

Volume, computer	27.4 cu ft
Area, computer	6.7 sq ft
Floor loading, computer	244 lbs/sq ft
	244 lbs concentrated max.
Weight, computer	Approx. 1,647 lbs

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1
Number in current production	1
Number on order	8
Anticipated production rates	1 per month
Time required for delivery	6-8 months

PERSONNEL REQUIREMENTS

Training made available by manufacturer to users includes a factory maintenance course on the Mk 130 digital computer, which comprises 3 to 4 weeks of instruction. The Mk 130 digital computer is an unmaned piece of equipment in its tactical application. Maintenance will be performed by user personnel (U.S. Navy) aided by Librascope Field Service.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

All circuitry is completely transistorized and mounted in readily accessible modules. Test points have been provided on all circuit modules and chassis assemblies for ease of maintenance. A circuit module tester capable of testing all circuit modules is provided as part of the digital computer. All subassemblies are accessible from the front of the computer. Diagnostic routines are available to the user. Circuitry is conservatively designed and will operate over an ambient temperature range of $0^{o}F$ to $110^{o}F$. During prototype evaluation only two failures have occurred in over 1000 hours of operation.

ADDITIONAL FEATURES AND REMARKS

Unique system advantages include a micro-program unit which can be modified to create new or variations of existing commands to tailor computer operation to suit individual situations without major redesign.

Photo by Librascope Division, General Precision, Inc.

Photos by Librascope Division, General Precision, Inc.

LIBRATROL 500

Libratrol 500 Computing System

MANUFACTURER

Librascope Division
General Precision Equipment Corporation

APPLICATIONS

Manufacturer

General purpose computing where computing equipment must communicate directly with equipment external to the computer, via digital inputs or via voltage inputs.

General purpose computing where computing equipment must send control signals to equipment external to the computer.

Examples of applications are quality control for both continuous and batch production processes-real time, process control for both continuous and batch processes, and equipment test stand instrumentation (data acquisition, logging and calculation).

Frankford Arsenal

This computer is being incorporated into a breadboard of an automatic checkout system, the purpose of which is to automatically and rapidly test and evaluate the performance of combat vehicles. The above tasks include fault isolation of malfunctioning components or parts, the preparation of logictics data in the English language, and record keeping of items which pass through the test station. The first item to be so tested will be of the engine and transmission system of the M48A1 combat tank.

Photo by Public Service Company of Colorado

Public Service Co. of Colorado

Located on West 3rd Avenue and Lipan Street, Denver, Colorado, the system is used on-line for calculation of hourly gas loads delivered into company systems by suppliers. Input by telemeter from remote stations through digital converter to computer. It is also used off-line for calculation and printing of orifice meter deliveries to gas customers, input by paper tape, and miscellaneous engineering problems, as they arise.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	30 bits plus sign
Binary digits/instruction	4
Instructions per word	1

Integrated System

Instructions decoded	16
Arithmetic system	Fixed point

Floating point is programmable.

Instruction type — One address

0	1 12	13 16	17 18	19 24	25 30	31	Sp
Sign		Instruc-tion		Track	Sector		Spacer

A complete set of compiler and utility programs are available.

Registers include counter register, accumulator, and instruction register.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	7,750 (Mean access)	250
	23,000 (Mean access)	15,000
	23,000 (Mean access)	15,000

Construction (Arithmetic unit only)

Vacuum tubes	175
Diodes	1,750
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Photo by Frankford Arsenal

Though operation is listed as being sequential, the input system of the LIBRATROL 500, since it is independent of the computing portion of the machine, is capable of inputting information while calculation is proceeding concurrently.

STORAGE

Manufacturer

Media	No. of Words	No. of Digits
Magnetic Drum (Main)	4,096	126,976
Magnetic Drum (Buffer)	64	1,984

Access time is variable between 500 and 15,000 microseconds.

Magnetic tape will be developed.

Frankford Arsenal

Medium	No. of Words	No. of Digits	Access Microsec
Magnetic Drum	4,096	31 binary	9,000 (avg)

Public Service

Magnetic Drum	4,096	32 binary

INPUT

Manufacturer Media	Speed
Analog	60 samples/sec
Digital	60 char/sec
Paper Tape	10 or 60 char/sec
Typewriter	10 char/sec

Above items are standard.

Frankford Arsenal	
Paper Tape	approx 5 char/sec

Mechanical tape reader.
Flexowriter used and input also available through Flexowriter keyboard.

Public Service	
Electric Typewriter	570 char/min
Analog-Digital Converter	75 words/sec

Data can be supplied by punched paper tape.

OUTPUT

Manufacturer Medium	Speed
Paper Tape	10 char/sec
Frankford Arsenal	
Flexowriter	approx 8 char/sec
Public Service	
Electric Typewriter	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Manufacturer Type	Quantity
Tubes	
6AN8 5915 5965 2D21 5687 5963 6197 3RP1A	Total 175 approx

Photo by Librascope Division, General Precision

Diodes	
1N617	1,450 approx

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer	
Power, computer	2.5 Kw
Volume, computer	49 cu ft
Area, computer	13.7 sq ft
Room size	24 sq ft
Floor loading	78 lbs/sq ft
Weight, computer	1,000 lbs (nominal)

A separate 115 volt, 20 ampere circuit is recommended.

Frankford Arsenal	
Power, computer	2.3 KVA
Volume, computer	30 cu ft
Area, computer	10 sq ft
Room size	20 ft x 60 ft
Weight, computer	1,000 lbs
Public Service	
Power, computer	2 Kw
Power, air condi (2 required)	7.25 Kw each
Volume, computer	47.4 cu ft
Volume, air conditioner	89.4 cu ft each
Area, computer	13.22 sq ft
Area, air conditioner	29.8 sq ft each
Floor loading	110 lbs/sq ft
Capacity, air conditioner	7.5 Tons, each
Weight, computer	1,450 lbs

Reinforced floor (wood).

PRODUCTION RECORD

Manufacturer

Number produced to date	Over 400
Number in current operation	380
Number in current production	15
Number on order	15
Time required for delivery	3 months

COST, PRICE AND RENTAL RATES

Manufacturer

	Cost
1 Libratrol 500 Computer with 120 input channels and analog to digital converter	$84,500
Frankford Arsenal	
Basic System	
Computer and Flexowriter	89,000
Additional Equipment	
Commutator extender	5,000
Digital inputs & high speed input mode	20,000
300 magnetic latching mercury wetted relays	20,000
Spare parts	5,000
D/A converters (5)	1,000
Total	$51,000
Public Service	
Basic System	
Computer, Digitizer, 1-Flexowriter	90,000
Additional Equipment	
1-Flexowriter	4,000

PERSONNEL REQUIREMENTS

Manufacturer

	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Supervisors	1	1	1
Programmers	1	1	1
Operators	1	2	3
Engineers	1	1	1

Thirty days of instruction time is included in the sale price for programming and maintenance training of customer personnel.

Frankford Arsenal

	One 8-Hour Shift	
	Used	Recommended
Programmers	1.5	1.5

Method of training is informal.

Public Service

The department, which is the principal user of this computer has 16 employees. The two engineers in the department, program and maintain the computer. Two girls prepare tapes and, to a large extent, operate the computer, and file tapes and work sheets. While it is planned to train additional department personnel to work with the computer, there is no need for increasing the number of employees doing any one computer job.

Methods of training includes on-the-job training.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Manufacturer

The combination of conservatively rated, carefully engineered components, with simplicity of design, conspires to allow the computing elements to function with only 113 vacuum tubes. Reliability should normally exceed 99% up-time over a 6 month period.

Public Service

Good time	166 Hours/Week (Average)
Attempted to run time	168 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.988

Above figures based on period 1 May 60 to present
Time is available for rent to qualified outside organizations.

The reliability figures refer only to basic computer operation. We have had difficulty with input of data through the analog-digital system which has been combined with the computer. Reliability figures on the total system would be greatly lower. Because of the input problem the system has not as yet been accepted.

ADDITIONAL FEATURES AND REMARKS

Public Service

An outstanding feature is that the system permits computer-controlled input of telemetered values. It has two Flexowriters (off-line and on-line) which are controlled by the program.

The fact that the system permits working off-line programs and a continuing on-line program is a unique advantage.

FUTURE PLANS

Frankford Arsenal

It should be noted that the Libratrol 500 Computer has been assimilated into the Automatic Checkout equipment. It is now merely a component of the system, and is no longer identifiable as a Libratrol 500 Computer. The questionnaire answers, however, are with respect to the computer portion of the checkout system only, i. e., only the computer memory is discussed although additional memory capability is inherent in the checkout system.

Public Service

Possible replacement in 5 or 6 years is planned.

INSTALLATIONS

U. S. Army Ordnance Arsenal, Frankford
Bridge and Tacony Streets
Philadelphia 37, Pennsylvania

Public Service Company of Colorado
900 15th Street
Denver, Colorado

LIBRATROL 1000

Libratrol Computing System Model 1000

MANUFACTURER

Librascope Division
General Precision Equipment Corporation

Photo by Librascope Division, General Precision, Inc.

APPLICATIONS

System is intended for general purpose computing, where computing equipment must communicate directly with equipment external to the computer via digital or voltage (analog) inputs and where computing equipment must develop control signals to equipment external to the computer. Examples of applications are quality control for both contonuous and batch production processes-real time, process control for both continuous and batch processes, and equipment test stand instrumentation - data acquisition, logging, and calculations.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	32
Binary digits/instruction	5
Instructions per word	1
Instructions decoded	32
Arithmetic system	Fixed point
Floating point is programmable.	
Instruction type	Two address

Instruction word format

	Operand Address		Next Inst Address		
S1 4	5 11	12 17	18 24	25 30	31
Command	Track	Sector	Track	Sector	Address Modify Flag

A complete set of compiler and utility programs are available.

Additive index register and double length accumulator.

Lower accumulator can be made to operate on eight words at a time.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	1,000	250
Mult	17,000	16,250
Div	17,000	16,250
Arithmetic mode	Serial	
Timing	Synchronous	
Operation	Sequential	

Though operation is listed as being sequential, the input system of the L-1000, since it is independent of the computing portion of the machine, is capable of receiving information while calculation is proceeding concurrently.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Magnetic Drum (Main)	8,000	256,000	250
Magnetic Drum (Buffer)	64	2,016	250
Magnetic Tape			
No. of units that can be connected		64 Units	

Magnetic tape is a future development.

INPUT

Media	Speed
Analog	60 samples/sec (2,000 samples/sec optional)
Digital	60 char/sec (Standard)
Paper Tape	10/60 char/sec (Standard)
Typewriter	10 char/sec (Standard)

OUTPUT

Media	Speed
Paper Tape	60 char/sec (Optional)
Typewriter	10 char/sec (Standard)
Control (analog or digital)	120 char/sec (Standard)
Line Printer	300 char/sec (Optional)

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity	
Tubes		
CRT	1	(digital display for monitoring)
Diodes		
1N617	2,400	
Transistors	650	(basic system)
2N1301		
2N393		
2N404		
2N357		
2N597		
2N1130		

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	2 Kw
Volume, computer	48 cu ft
Area, computer	12 sq ft
Room size	24 sq ft
Capacity, air conditioner	1 Ton
Weight, computer	1,000-1,200 lbs

Air conditioner is included and self-contained

PERSONNEL REQUIREMENTS

One operator required for each shift.

Training made available by the manufacturer to the user includes programming and maintenance.

FUTURE PLANS

Magnetic tape input and a core buffer unit are planned.

INSTALLATIONS

Librascope Division
General Precision Equipment Corporation
808 Western Avenue
Glendale, California

LINCOLN CG 24

Lincoln CG 24

MANUFACTURER

Massachusetts Institute of Technology
Lincoln Laboratory

APPLICATIONS

CG 24 is a general purpose computer attached to a long-range radar both for receiving detected echoes and for directing the antenna. It is operated in real time primarily for the collection and processing of radar tracking data. Storage of such data is made directly into high-speed memory under program control. The research was supported jointly by the Department of the Army, the Department of the Navy, and the Department of the Air Force under Air Force Contract No. AF 19(122)-458.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits/word	24 plus sign
Number of binary digits/instruction	24
Number of instructions/word	1
Total number of instructions decoded	46
Arithmetic system	Fixed point

Photo by Massachusetts Institute of Technology

Instruction type (Floating point sub-routines)
One address

Number range
$-1 \leq n \leq 1 - 2^{-24}$

Instruction word format

Bit	0-3	4-9	10-24
	Index	Instruction	Address

Registers and B-boxes include 5 sets of registers of 8 bits each and a real time clock register.

Negative numbers are treated in two's complement form.

Arithmetic algorithms handle either positive or negative numbers.

CG-24 CHARACTERISTICS

GENERAL

CONSTRUCTION: SOLID STATE

APPLICATION ····· GENERAL-PURPOSE PLUS REAL-TIME CONTROL

TIMING ····· SYNCHRONOUS, 330 Kcps.

OPERATION ····· SEQUENTIAL, SUBJECT TO SELF-MODIFICATION

NUMERICAL SYSTEM

INTERNAL NUMBER SYSTEM ···· 27-BIT BINARY WORDS, INCLUDING TWO PARITY BITS

SINGLE-ADDRESS INSTRUCTIONS.

FIXED-POINT ARITHMETIC SYSTEM, PROGRAMMED FLOATING POINT SUBROUTINE.

ARITHMETIC UNIT

ADDITION TIME ····· 24 μs (incl. memory access)

MULT.-DIV. TIME ····· 84 μs (" " ")

SQUARE ROOT TIME ····· 300 μs (" " ")

STORAGE SYSTEM

8192 WORDS, COINCIDENT CURRENT MAGNETIC CORES, 12 μs CYCLE TIME

TERMINAL EQUIPMENT

FLEXOWRITER

CRT DISPLAY WITH NUMERIC GENERATOR

PHOTOELECTRIC TAPE READER.

c314-16

Photo by Massachusetts Institute of Technology

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	24	12
Mult	84	74
Div	84	74

Construction, arithmetic unit only
Arithmetic unit consists of transistors and diodes.

Arithmetic mode — Parallel
Multiplication and division operations consist of serially adding or subtracting. Addition and subtraction are parallel operations.

Timing — Synchronous

Operation — Sequential and concurrent

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Magnetic Core	8,192	27/word	12
Magnetic Tape	5×10^5 binary words/tape	24/word	272

No. of units that can be connected	7 Units
No. of characters/linear inch	200 Chars/inch
Channels or tracks on tape	7 Tracks/tape
Blank tape separating each record	0.75 Inches
Tape speed	75 Inches/sec
Transfer rate	15,000 Chars/sec
Start time	5 Millisec
Stop time	1.5 Millisec
Average time for experienced operator to change reel of tape	90 Seconds
Physical properties of tape	
Width	1/2 Inches
Length of reel	1,200 Feet
Composition	0.0015 in mylar

The 7-channel digital tape units are Ampex FR-300 with packing density of 200 bits/inch in each channel. These are operated at 75 in. per second. Two units were installed in August 1960.

INPUT

Media	Speed
Magnetic Tape	15,000 char/sec 6 binary digits/char
Paper Tape	200 char/sec 6 binary digits/char Ferranti Photoreader
Keyboard	Flexowriter
Manual	Toggle switch

OUTPUT

Media	Speed
Magnetic Tape	15,000 char/sec 6 binary digits/char
Paper Tape	135 char/sec 6 binary digits/char Soroban Punch
Keyboard	570 ltrs/min on line Flexowriter
Display with camera	18,000 octal digits/sec Numbers are formed as Lissajou figures from X-Y inputs

Two servo units are connected to the lower accumulator in such a fashion as to provide for program control of elevation and azimuth angle synchro data for a radar antenna.

In June 1960 an alpha-numeric display (using the 6 bit Flexowriter code) was connected to CG 24. It has added photographic facilities. It includes two CRT's. The speed is 75 microseconds per figure or letter.

An input buffer provides for real time input of radar position and range rate data.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	
K1354P11M	1
K1354P7M	1
5965	6
6080	2
6073	7
5651	4
6BL7	1
8013	2
12AX7	2
2D21	2
CRT display circuits	
Diodes	
S347G	21,700
SG22	7,900
HD2085	3,600
Total	33,200
Transistors	
4JD2A6	7,950
2N123	6,250
2N385	2,850
M201Z	875
GT34	500
CK750	320
904A	185
GT83	60
Total	18,930

Magnetic Cores	
S-1 Ferrite	229,376

Component count as of May 1958

CHECKING FEATURES

Fixed

Core memory: parity check on each half word
Magnetic tapes: parity check (IBM mode)
Perforated tapes: modulo 25 check sum.

Optional

Magnetic tapes: Programmer may use error correcting mode. This provides 2 error detection, 1 error correction. The mode gives 3 of the 7 tracks for data.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	4.6 Kw (May 1960)
Power, air conditioner	4.5 Kw (Including Room)
Volume, computer	680 cu ft
Area, computer	110 sq ft
Room size allocated	1,200 sq ft
Capacity, air conditioner	5 Tons
Weight, computer	5,000 lbs

The computer requires 110 sq. feet of floor space. A set of 3 rooms (total area 1200 sq. ft.) is devoted to computer, tapes, maintenance, stock and input buffers. The air conditioner supplies 2500 cu. ft/min. from an 11-inch high plenum underneath the computer proper. The air conditioner services other parts of the building. The 5 ton capacity is an estimated fair proportion. Computer logic power is derived from 400 cycle rotating machinery.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

System is not being produced.

COST, PRICE AND RENTAL RATES

CG 24 was built as part of an experimental prototype system. It cost approximately $1,000,000.

PERSONNEL REQUIREMENTS

Typical Personnel	One 8-Hour Shift
Supervisors	1
Programmers	4
Operators	1
Engineers	1
Technicians	1

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

CG 24 has been operating for about 2 years. It has been on power almost constantly, being operated an average of 8 hours per day.

Faults have been primarily due to connections (Arkless wiring originally unsoldered has been soldered), other contacts and receptacle pins, memory adjustments (generally not component failures), and photo reader (generally not component failures). Qualitatively, it is difficult to assign many (if any) semiconductor failures to aging. Rather, most are traceable to man-made shorts.

ADDITIONAL FEATURES AND REMARKS

Unique system advantages include a very flexible arrangement for receiving and processing long range radar echo data, for directing antenna, and for simulating major parts of receiving and processing equipment.

INSTALLATIONS

Lincoln Laboratory
Massachusetts Institute of Technology
Lexington, Massachusetts

LINCOLN TX 0

Lincoln Test-Experimental Computer Model 0

MANUFACTURER

Lincoln Laboratory
Massachusetts Institute of Technology

Photo by Lincoln Laboratory, Massachusetts Institute of Technology

APPLICATIONS

Manufacturer

An experimental digital computer used to test advance design techniques, including very large core storage and transistor circuitry.

The research reported in this computing system description was sponsored jointly by the Army, Navy and Air Force under contract with the Massachusetts Institute of Technology.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	18
Binary digits/instruction	18
Instructions/word	1
Instructions decoded	25
Arithmetic system	Ring-adder
Instruction type	One address
Number range	Not appropriate

Three instructions are addressable and 1 is microprogrammable.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add time	6	1
Mult time	1,000	1,000
Div time	1,000	1,000
Construction		1,000 transistors
Arithmetic mode		Parallel
Timing		Synchronous
Operation		Concurrent

Computer performs 83,000 additions per second. Mulitply and divide is programmed.

STORAGE

Media	Words	Digits	Microsec
Magnetic Core	65,536	18/word	3
Flip-flop	1	18/word	0.5
Toggle Switch	16	18/word	3

A parity bit is additional. Read-rewrite time is 6 microseconds.

LINCOLN TX 0 and TX 2 Memory Plane Photo by Lincoln Laboratory, Massachusetts Institute of Technology

INPUT

Media	Speed
Photo Reader	250 lines/sec
Flexowriter	Manual
Toggle Switch	Manual

OUTPUT

Media	Speed
Flexowriter	10 char/sec
Display (CRT)	16 microsec/spot

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	440
Tube types	3
Crystal diodes	350
Magnetic cores	1,245,773
Transistors	3,500
Separate cabinets	5

Three major tube types, a small number of others. Most tubes are used in the large memory. The transistors are the Philco L-5122 Surface Barrier Transistor.

CHECKING FEATURES

Parity check on memory systems. Marginal checking is built in.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	10 Kw
Volume, computer	1,000 cu ft
Area, computer	200 sq ft
Capacity, air conditioner	40 Tons
Weight, computer	4,000 lbs

Above figures are approximate. Air conditioner is necessary for memory only.

PRODUCTION RECORD

Number produced	1
Number in operation	1

ADDITIONAL FEATURES AND REMARKS

One picture shows close-up view of magnetic core memory plane and other picture shows random-access core memory, frame of memory-core selection-switch drivers, computer arithmetic element and control element, and computer operating console.

INSTALLATIONS

Lincoln Laboratory
Massachusetts Institute of Technology
Lexington 73, Massachusetts

LINCOLN TX 2

Lincoln Test Experimental Computer 2

MANUFACTURER

Lincoln Laboratory
Massachusetts Institute of Technology

Photo by Lincoln Laboratory, MIT

APPLICATIONS

Computing system is used for scientific research and for the simulation, analysis, and control of real time systems.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	36 + 1 + 1
Binary digits/instruction	36 + 1 + 1
Instructions per word	1
Instructions decoded	64
Arithmetic system	Fixed point (Ones complement binary)
Instruction type	Indexable; Indirect addressing on all instructions
Number range	$-(1 - 2^{-35})$ to $(1 - 2^{-35})$

Instruction word format

1	1	5	6	6	1	17
meta bit	hold bit	configuration reg. no.	op code	Index register	indirect address bit	base address

All fixed programs are in toggle switch or plugboard storage.

Automatic coding includes standard compiler, which provides full symbolic coding facilities.

All four arithmetic registers and the exchange register are addressable as part of memory. There are sixty-four 18-bit parity-checked index registers.

Indirect addressing can be repeated indefinitely.

33 program (instruction) counters are provided, only one of which is used at a time.

Each in-out unit is associated with a program counter. Choice of program counter is determined by in-out unit, by program, and by relative priority of program counters.

Any instruction can specify a configuration of the computer during the execution of the instruction. A 36 bit operand word can be divided into one 36, one 27 and one 9, two 18, or four 9 bit subwords formed from the 9 bit quarters. The 9 bit quarters can be permuted among themselves. Any or all of the subwords can be used simultaneously. For example, two 18 bit multiplications are done by one multiply instruction in less time than one 36 bit multiplication.

Memory Stall

One bit of each computer memory word is used for parity checking. The other is used as a tag bit for program debugging.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	4.8	1.4
Mult	9.6 - 19.2	5 - 17 (9 bit-36 bit)
Div	19.6 - 80.0	17.2 - 75 (9 bit-36 bit)

Construction (Arithmetic unit only)	
Transistors	8,800
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Concurrent

The following table lists the number of thousands of arithmetic operations of a given type which can be executed per sec.

Word Length in Bits	36	27	18	9
Arithmetic	+ 200	200	400	800
Operation	x 50	67	17	400
	÷ 13	17	48	200

Photo by Lincoln Laboratory, MIT

STORAGE

Media	No. of Words	Read-Write Time	No. of Digits/Word	Microsec
Magnetic Core S Memory	65,536	6.4	36 + 1 + 1	3.4
Magnetic Core T Memory	4,096	4.4	36 + 1 + 1	2.2
Toggle switch, plugboard, etc	80	4.8	36 + 1	2.6
Magnetic Core Index Memory	64	3.4	18 + 1	0.6
Magnetic Film Config. Memory	32	0.8	9 + 1	0.3

Magnetic Tape	
No. of units that can be connected	512 Units
No. of lines /er linear inch	330 Lines/inch
Channels or tracks on the tape	10 Tracks/tape
Blank tape separating each record	0 Inches
Tape speed	30-1000 Inches/sec
Transfer rate	3,300-37,500 Chars/sec
Start time	250 Millisec
Stop time	10,000-250 Millisec
Physical properties of tape	
Width	3/4 Inches
Length of reel	7,200 Feet
Composition	Mylar type 189 3M

Tape reels are not changed.

Fixed address system (like drum). Variable read speed.
32 tape unit drives can be treated as 10^{10}-bits of internal storage.
14" NARTB reel.
Recording channels are paired. One pair is used for timing marks, another for block marks, and the remaining three for information. Three lines of information form the standard unit of information, a 9 bit character.

INPUT

Media	Speed
Paper Tape	3000 7 bit lines/sec peak speed
Speed is not constant. Accelerates slowly compared to line width.	
Keyboard	10 6 bit char/sec
Lincoln Writer input	
Analog-Digital Converter	40,000 11 bit samples/sec
Epsco Datrac converter	
Light pen/eye	Manual
Signals selected by operator	
Random No. Gen.	18,000 9 bit words/sec
Radioactive source	
Miscellaneous Input	80 KC
9 channel pulse input to computer from miscellaneous devices.	

OUTPUT

Media	Speed
Paper Tape	180 7 bit lines/sec
Soroban punch	
Xerox printer	20 lines/sec 1300 char/sec
88 characters can be printed in 2 sizes. 6 bit vert. & 9 bit horiz. axes resolution.	
Typewriter	10 6 bit char/sec
Lincoln Writer output	
CRT point display & Camera	10 KC - 40 KC
10 bit resolution in both axes	
Miscellaneous output	Up to 500 cycles
9 channel switch for computer control of low rate devices	
Large board plotter	15 in/sec slew speed
PACE plotter	

Several input-output units can operate simultaneously so long as the time required by all the units operating does not saturate the central computer. Each unit has at most a single-line buffer; whenever a line of data needs to be transmitted to or from the central computer the unit causes the central computer to use its associated program counter. The machine can compute while in-out units are operating.

At peak rate, about 80,000 computer words/sec can be transferred into or out of the computer.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity	Use
Tubes		
6888	69	Clock pulse amplifiers
5998	312	S memory
Z-2177	296	S memory
Misc. Types	88	
Diodes		
CTP592	3,000	Input-output circuitry
1N625	736	Input-output circuitry
Misc. Types	1,488	Input-output circuitry
Transistors		
L5122	26,042	
L5134	31,928	
2N501	320	
2N357	1,016	
Misc. Types	2,227	
Magnetic Cores		
	2,490,880	S memory
	155,648	T memory
	2,432	X memory

All the vacuum tubes are used in the 65,536 word memory and in the generation of the computer clock pulses.

Resistor coupled transistor logic in the central computer operates at a 5 megapulse per second rate.

Thin magnetic film memory contains 320 magnetic spots.

CHECKING FEATURES

Checking features include a single bit odd parity check on all memories, a voltage margin check on all bias voltages, and a manual switching system selects circuits to be checked. A built-in sync system facilitates locating machine errors. A library of test programs are used which check the operation of the computer and which attempt to induce errors.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	20 Kw	25.6 KVA	0.8 pf
Power, air conditioner	17 Kw		
Area, computer		1,500 sq ft	
Area, air conditioner		350 sq ft	
Room size, computer		54 x 29	
Room size, air conditioner		17 x 20	
Capacity, air conditioner		25 Tons	

Cables run through overhead wireways. Air conditioning ducts also runoverhead. An 8 ft high false ceiling is hung to cover these. Otherwise building is standard. Most power supplies are solid state. Principally required for memories.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1
One-of-a-kind research computer	

PERSONNEL REQUIREMENTS

Problem originators are trained to use the computer. Paper-tape preparation facilities and utility programs available to all computer users.

Three engineering assistants and one technician are available to do routine maintenance and to make changes in the computer system.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

As a research machine, TX-2 operating experience is good but though data is kept on machine failures, no reliability figures have been computed.

Basic circuits and components are similar to MIT's TX-0 machine.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include an operating thin magnetic film memory; 65,536 word magnetic core memory. Fixed address magnetic tape system. Multiple-sequence operation of computer and simultaneous operation of input-output units permits considerable flexibility in use of in-out units. Maximum execution time for any one arithmetic instruction can be reduced to one memory cycle time by overlapping instructions and memories.

Unique system advantages include multiple-sequence operation, configuration control over operands, thin magnetic film memory used in control element of computer, and 64 index registers stored in random access magnetic core memory.

The Lincoln Writer input-output unit permits considerable flexibility in communicating with the computer.

FUTURE PLANS

Another 4096 word magnetic core memory will be installed in order to increase opportunities for overlapping operation of memories.

A magnetic tape unit will be installed which will be compatible with units used on many commercial computers.

Input-output units will be added as the needs develop.

A new control console will replace the present console.

INSTALLATIONS

Lincoln Laboratory
Massachusetts Institute of Technology
P. O. Box 73
Lexington 73, Mass.

LITTON C 7000

Litton Industries, Model C 7000

APPLICATIONS

System is designed for real time control systems applications requiring very high computing rates.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	21
Binary digits/instruction	21
Instructions per word	1
Instructions decoded	35
Arithmetic system	Fixed point Two's complement system of arithmetic is used
Instruction type	One address
Number range	-1 to $+1-2^{-20}$
Instruction word format	

00	01 06	07 09	10 20
Break-point	Operation Code	Index Tag	Address

Automatic built-in subroutines include square root and gray code to binary conversion.

Three index registers are included.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	4	2
Mult	26 (Average)	22
Div	46	42

Arithmetic mode	Parallel
Timing	Synchronous
Operation	Sequential

Special hi speed multiplication technique is used. There is extensive overlapping in the execution of sequential instructions resulting in a very high speed computer.

MANUFACTURER

Litton Industries
Electronic Equipment Division

STORAGE

Media	No. of Words	No. of Digits(Binary)	Microsec
Cores	1,280	28,160	4
Magnetic Drum	12,800	281,600	5,000 (Avg)

INPUT

Media	Speed
128 Word Drum Buffer	250 microsec avg to 1st word 4 microsec thereafter
Flexowriter	10 char/sec
Paper Tape	200 char/sec

OUTPUT

Media	Speed
512 Word Drum Buffer	1,000 microsec avg to 1st word 4 microsec thereafter
Flexowriter	10 char/sec

CHECKING FEATURES

Parity checks are built in on all core and drum memory transfer and storage. Program is automatically interrupted when error occurs and is detected.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.950 Kw
Volume, computer	9.5 cu ft
Area, computer	4 sq ft
Weight, computer	320 lbs

LITTON DATA ASSESSOR

Litton Industries Data Assessor System

MANUFACTURER

Electronic Equipments Division
Litton Industries

Photo by Litton Industries Electronic Equipments Division

APPLICATIONS

System is designed for general purpose computing and for special purpose problems, which take advantage of the internal information transfer in the computer. The useful characteristics are dual half word arithmetic (simultaneous operation on two half words), real time input-output functions, large amounts of data comparison, external control and communication, and computer-computer communication.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	32
Binary digits/instruction	32
Instructions per word	1
Instructions decoded	55
Arithmetic system	Fixed point
	30 bits plus sign or two half words each of 15 bits plus sign
Instruction type	One address
Number range	Either $\pm (2^{30} - 1)$ or two half words of $\pm (2^{15} - 1)$

Input-output functions are automatic.

All B-box operations are included within each order. These include choice of B-box and whether the B-box itself should be modified.

Each command associated with information transfer contains stencil bits which allow full word, half word, or shifted half word transfer. In addition, it is possible to transfer a word logically multiplied by a stencil word.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	12	6
Mult	60-102	48-90 (half or full word)
Div	60-102	48-90 (half or full word)

A square root order is included. It takes 96 or 186 microseconds.

Construction (Arithmetic unit only)

Transistors	1,600
Diodes	17,000
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Concurrent

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Cores	1,024	32	6
Drum	2,560	32	6-17,000

Up to eight independent magnetic tape units could be connected to the computer.

INPUT

Media	Speed
Data Link	750 bits/sec
Analog/Digital Converter	20 bits/6 microsec
Control Panel	

Link and converter are programmable.

OUTPUT

Media	Speed
Cathode Ray Tube	20 bits/6 microsec
Control Equipment	30 bits/6 microsec

Outputs are programmable. The input-output equipment specified is for a special purpose application. The input-output buffers can accept serial or parallel information up to a total maximum rate of 32 bits each 6 microseconds. The ability of each input buffer is programmable, but the various functions are controlled by the availability of external data.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

FUTURE PLANS

Type	Quantity	
Diodes	23,000	
	1,000	memory
	16,000	logic
	6,000	clamps on the outputs or inputs of flip-flops or boosters or double inverters
Transistors	3,100	
	275	flip-flops at 4 each
	200	power boosters at 2 each
	800	double inverters at 2 each
Magnetic Cores	34,000	

The basic building blocks of the system are 4 transistor flip-flops, 2 transistor power boosters, and 2 transistor double inverters. In addition, there are several cards of fast adder carry propogation logic. The major number of cards in the system contain diode logic. There are numerous cards which are required for the mechanization of the core memory. Plans include provision of a separate memory for input -output to avoid interference with computation, additional memory modules, and geranium modules with silicon for wide ambient temperature range.

CHECKING FEATURES

There exists a parity bit in each word in core storage. If a parity bit failure occurs, or an incorrect order occurs, the error flip-flop turns on.

Program can be used to interpret error information. Under operator control, an error will either turn off the computer or cause the program to tally and classify such errors.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	1.5 Kw	2.0 KVA	0.75 pf
Volume, computer		21 cu ft	
Area, computer		9 sq ft	
Room size		7 ft x 7 ft x 7 ft high (Suitable for Helihut use)	
Floor loading		60 lbs/sq ft	
Weight, computer		500 lbs	

The computer will work in an environment from 20°F to 100°F, and as such, no air conditioning was planned for the initial installation. Present system operates at 60 cps. A 400 cps model can be made available.

PRODUCTION RECORD

Number in current production	1
Number on order	1
Time required for delivery	6-8 months

PERSONNEL REQUIREMENTS

One operator is required for each shift. The present mechanization contains a self checking program and as it works on a real-time problem, it proceeds automatically. Because of this, a single operator is all that is required.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

ADDITIONAL FEATURES AND REMARKS

The design of the circuits is based upon very conservative techniques in order to assure a high degree of reliability. The worst-case method of analysis has been used to insure that the circuits operate satisfactorily while being subjected to the most adverse combination of component tolerances and parameter variations. In addition, all of the components have been derated with respect to allowable dissipation, voltage, etc. Component characteristics, such as current gain, are based upon history-derived estimate of the end-of-life value.

Provision is made in the Data Assessor for automatic checking. If a parity error should occur in the core memory, or if an incorrect order should be read, the appropriate error flip flop will turn on and this information would be entered into the computer. A switch on the control panel can be set to either stop the computer after an error, or allow the program to analyze the error. The program can be set to determine and tally the various types of errors. The program can then either correct them if they occur rarely or stop the computer and alert the operator if they occur often.

The Data Assessor is mechanized to provide all the error checking information necessary for complete error detection and checking. The amount of error checking performed depends on the type of program used. Outstanding features include self modifying B-box operation, built in stencil in each order, dual half word arithmetic, programmable (serial or parallel) input-outputs, alarm clock, and simplified communication between computer components. The computer operates at the rate of about 75,000 operations per second. Each operation can occur between two sets of independent variables, such as X, Y navigation. Inputs-outputs do not interrupt the program.

LOGISTICS

ONR ERA Logistics Computer

MANUFACTURER

Engineering Research Associates, Inc.

APPLICATIONS

Located at the Staughton Hall, 707 22nd Street, NW, Washington 7, D.C., the system is used for the numerical simulation of naval operations in the area of supply, mathematical studies in the area of matrix games, situations of attrition, and certain kinds of war game studies. System is also used directly as a research instrument in the development of concepts bearing upon data processing operations by the military.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Digits per word	12
Arithmetic system	Fixed point
Instruction type	Three address (approx)
Number range	$-(5.10^{11} - 1) \leqslant N \leqslant (5.10^{11} - 1)$
Instruction word format	

Normal mode of program storage is by way of wired instructions (many address) on a plugboard. A program may be stored internally and decoded by means of a control program wired on a plugboard. This latter method has been little used because of its low speed.

There are 15 registers.

Photo by George Washington University

ARITHMETIC UNIT

Operation	Incl. Stor. Access Microsec
Add	500
Mult	500 - 1000
Div	(Programmed division)

Construction (Arithmetic unit only)	
Vacuum-Tubes	4,500
Condenser-Diodes	5,000
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

System is serial in decimal digits, parallel in bits for each decimal digit.

STORAGE

Media	No. of Words	No. of Dig/Word	Access Microsec
Magnetic Drum	var. 14,000-37,000	12-4	16,000
Magnetic Drum	7,000-80,000	60-4	16,000
High speed registers	15	12	220 Kc Shift rate

Total digit capacities of drums are about 185,000 and 400,000 respectively.

Second drum has usual read and write. The location or absence of a given word may be determined in one revolution by means of one of a system of SEARCH instructions.

INPUT

Media	Speed
Card (collator)	240 cards/min
Paper Tape	200 columns/sec

Paper tape input are Ferranti readers. Card rate is alternating from each of two pockets.

OUTPUT

Media	Speed
Card	50 cards/min
Paper Tape	60 char/sec two

Two paper tape outputs are teletype perforators.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	4,500
Diodes	5,000
Transistors	10,000
Magnetic Cores	3,240 (bits)

CHECKING FEATURES

Most commonly used checking feature is that machine will detect presence of non-numeric binary codes and will stop or branch.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

KVA, computer	19
KVA, air conditioner	22
Volume, computer	910 cu ft
Volume, air conditioner	130 cu ft
Area, computer	130 sq ft
Area, air conditioner	18 sq ft
Room size, computer and air conditioner	918 sq ft
Floor loading	7.4 lbs/sq ft
	86 lbs concen max
Capacity, air conditioner	11 Tons

Computer was installed in a gutted area of building with heavy floor. Further ceiling support was provided. Motor generator set was installed in a small addition to main building. Building was an apartment house.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

COST, PRICE AND RENTAL RATES

Cost/Price for basic system

Computer and one drum	$350,000
Ferranti readers and tape punches	4,000
Total	$354,000

Cost/Price for additional equipment

Input Output buffer	$ 95,000
Second drum (see above)	200,000

Computer and equipment cited is owned by Office of Naval Research.

Rental rates for additional equipment includes $200/ monthly for collator and punch used for Input-Output.

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Analysts	3
Programmers	4
Clerks	2 keypunch operators
Engineers	2
Technicians	2

Operation tends towards open shop.

Method of training used is "write, load and debug."

Additional shift operations are filled in by programming staff or by the hiring on temporary basis of "computer Watchers" when tending is all that is required.

No increase in engineering staff would probably be required if we ran 2 shifts all the time.

Computer is capable of protracted good time.

Personnel cited above is approximation of relatively informal organizational setup.

The engineers cited are capable of work at all levels of electronic engineering and have extensively modified the original computer (delivery February 1953) both logically and in the matter of capacity of certain elements.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Good time 37 Hours/Week (Average)

Operating ratio (Good/Attempted to run time) 0.9

Above figures based on period 1 Jan 56 to 30 Jun 56

Time is available for rent to outside qualified organizations.

Our down time figures would indicate that our "would have run if computer were OK time" would be about 10% of our good time, hence the indicated ratio. During 1958 and 1959 a heavy modification program has reduced good time. Our current (last six months) good time is 16, with a somewhat lower operating ratio, i.e. 0.75.

ADDITIONAL FEATURES AND REMARKS

The search logic as noted above. Given that a certain register contained the word w, one or another of the search instructions would determine its absence, the address of its location)somewhere), or of its "next" location, or of its "first" location in about 16 milliseconds.

FUTURE PLANS

A new adder is being built for this machine.

The operation is serial and digital addition will occur every two drum (shift) clocks instead of during the 7 now used.

Division, 11 decimal digits divided by 11 decimal digits plus signs will be installed.

INSTALLATIONS

The George Washington University
Logistics Research Project
707 22nd Street, N. W.
Washington 7, D. C.

MAGNEFILE B

Magnefile Electronic Data Processing System B

MANUFACTURER

Electronics Corporation of America
Business Machines Division

APPLICATIONS

Inventory control for retail sales department store.
Special purpose, no longer in production.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Decimal
Decimal digits/word	8
Instructions/word	Instructions wired in
Instructions used	7
Arithmetic system	Fixed point
Instruction type	One address

Three addresses are entered simultaneously.

ARITHMETIC UNIT

Add time (exclud stor access)	150,000 microsec
Construction	Vacuum tubes
Basic pulse repetition rate	30 Kc/sec
Arithmetic mode	Serial
Timing	Asynchronous
Operation	Sequential

STORAGE

Medium	Words	Access Microsec
Magnetic Drum	4,040	300,000

INPUT OUTPUT

Medium	Speed
Full Keyboard	4 char/sec
Typewriter	7 char/sec

Photo by Electronics Corporation of America

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	130	6 Types
Crystal diodes	40	
Different plug-in units	10	
Separate cabinets	1	

CHECKING FEATURES

Continuous checking total

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.6 Kw
Area, computer	3.5 ft x 2.5 ft
Weight, computer	400 lbs

COST, PRICE AND RENTAL RATES

Approximate cost of basic system $20,000.

PERSONNEL REQUIREMENTS

One operator required during operation. A service technician is called when needed.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Passed Customer Acceptance Test 15 February 1954.

INSTALLATIONS

B. Altman and Company
Fifth Avenue
New York, New York

MAGNEFILE D

Magnefile Electronic Data Processing System Model D

MANUFACTURER

Electronics Corporation of America
Business Machines Division

APPLICATIONS

Inventory control. No longer manufactured.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Decimal
Decimal digits/word	42
Instructions/word	Instructions wired in
Instructions used	77
Arithmetic system	Fixed point
Instruction type	One address

Three one-address commands are entered simultaneously.

ARITHMETIC UNIT

Add time (exclud stor access)	100,000 microsec
Construction	Vacuum tubes
Basic pulse repetition rate	40 Kc/sec
Arithmetic mode	Serial
Timing	Asynchronous
Operation	Sequential

STORAGE

Media	Words	Access Microsec
Magnetic Drum	8,000	50,000
Magnetic Drum	500	50,000

The larger drum stores 8,000 21 dec dig words.
The smaller drum stores 500 42 dec dig words.

INPUT OUTPUT

Media	Speed
Full Keyboard	Manual (4 char/sec)
Typewriter	10 char/sec

Remote keyboards may be added.

Photo by Electronics Corporation of America

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	140	4 Types
Crystal diodes	240	
Different plug-in units	12	
Separate cabinets	1	

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	1 Kw
Area, computer	5 ft x 3 ft
Weight, computer	700 lbs

PRODUCTION RECORD

Number produced	1

No longer in production

COST, PRICE AND RENTAL RATES

Approximate cost of basic system $50,000. No longer in production.

PERSONNEL REQUIREMENTS

One operator. On call technician.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Passed Customer Acceptance Test 5 August 1953.

INSTALLATIONS

B. Altman and Company
Fifth Avenue
New York, New York

MANIAC I

Mathematical Analyzer Numerical Integrator and Computer Model I

MANUFACTURER

University of California
Los Alamos Scientific Laboratory

Photo by University of California, Los Alamos Scientific Laboratory

APPLICATIONS

University of New Mexico Research Center
Located at University of New Mexico Research Center, 2206 Lomas Blvd., N.E. (Box 181), albuquerque, New Mexico, the system is used for general purpose scientific computations, providing a computer service to faculty and students of the university.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits per word	40
Binary digits/instruction	8
Instructions per word	2
Instructions decoded	36
Binary digits/instruction not decoded	2
Instructions used	35
Arithmetic system	Fixed point
Instruction type	One address
Number range	$-1 \leq n < 1$

ARITHMETIC UNIT

	Exclud Stor Access Microsec
Add time	80
Mult time	1,000
Div time	1,000
Construction	Vacuum tubes
Arithmetic mode	Parallel
Timing	Asynchronous
Operation	Concurrent

STORAGE

Media	Words	Access Microsec
Electrostatic (CRT)	1,024	8 - 16
Magnetic Drum	10,000	50 words in 83,000

Cathode Ray Tube is of the Williams type.

INPUT

Media	Speed
Paper Tape	1,024 words in 48 seconds
Magnetic Tape	1,024 words in 45 seconds

OUTPUT

Media	Speed
Printer (Teletype)	36 words/min
Printer (Anelex)	3,600 words/min
Paper Tape	81 words/min
Magnetic Tape	1,024 words in 45 seconds

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	2,400
Tube types	7
Crystal diodes	500
Different plug-in units	1 Electrostatic
	6 Magnetic Drum
Separate cabinets	4

Type 2BP1 cathode ray tubes (Williams) are used in the storage unit.

CHECKING FEATURES

Check sum on filling storage by paper tape and magnetic tape.
Check sum on filling magnetic drum.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

University of California

Power, computer	35 Kw
Volume, computer	128 cu ft
Area, computer	20 sq ft
Capacity, air conditioner	10 Tons

U of New Mexico

Site preparation include channeled floor for air conditioning and power, ceiling ducts for air conditioning, and a special room for the motor-generators (D.C. supply).

COST, PRICE AND RENTAL RATES

Approximate cost of basic system $250,000.
Approximate cost of high speed printer and magnetic drum $48,000.
Prices include development, construction and overhead.

PERSONNEL REQUIREMENTS

U of New Mexico

System is to be operated and maintained by one person. It is expected to be operating prior to 1 Jan 1961 at the University of New Mexico.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

U of New Mexico

Average error-free running period	5 Hours
Good time	11,493 Hours
Attempted to run time	12,399 Hours
Operating ratio (Good/Attempted to run time)	0.93

Above figures based on period from Mar 52 to Jan 57
Passed Customer Acceptance Test Mar 52
Time is available for rent to outside organizations.
The machine was moved to the University of New Mexico in 1958. Installation was started in 1959.

FUTURE PLANS

U of New Mexico

The machine is being studied by approximately six graduate students at the Master of Science level, with three masters thesis being written on proposed system changes, including, replacing the single channel tape system with a multi-channel system, a logical study of a program interchange between MANIAC I and a NATIONAL 102A, and modifications to the existing adder in the machine.

INSTALLATIONS

University of New Mexico
Research Center
2206 Lomas Blvd. N.E.
Albuquerque, New Mexico

MANIAC II

Mathematical Analyzer Numerical Integrator and Computer Model II

MANUFACTURER

University of California
Los Alamos Scientific Laboratory

Photo by University of California, Los Alamos Scientific Laboratory

APPLICATIONS

University of California, Los Alamos Scientific Laboratory

Located at Los Alamos, N. M., the system is used for studies in automatic programming, symbolic manipulations (e.g., algebra, differential calculus), mathematics, esp. combinatorial and algebraic transformations, Monte Carlo, crystallography, and general applied mathematics.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	48
Binary digits/instruction	24
Instructions per word	2
Instructions decoded	94
Arithmetic system	Fixed and floating point
Instruction type	One address
Number range	2^{112}

Instruction word format

1	2 8	9 10	11 24
Break Point	Order	Index	Address

Automatic coding includes MADCAP (86 characters, full sub- and superscripting). Display quotients are planned.

Registers and B-boxes include 3 B-boxes, a universal register, a storage register and a remainder register.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Mult	180 avg	180 avg
Div	300 avg	300 avg

Construction (Arithmetic unit only)

Vacuum tubes	2,850
Diodes	1,040

Arithmetic mode	Parallel
Timing	Asynchronous
Operation	Sequential

STORAGE

Media	No. of Words	No. of Bin Dig/Word	Access Microsec
Cathode Ray Tube (Barrier Grid)	12,288	49	15 (avg)
Magnetic Cores	4,096	49	2.4

Magnetic Tape

No. of units that can be connected	3 Units
No. of chars/linear inch of tape	300 Char/inch
Channels or tracks on the tape	1 Track/tape
Blank tape separating each record	6 Inches
Tape speed	60 Inches/sec
Transfer rate	18,000 Char/sec
Start time	25 Millisec
Stop time	30 Millisec
Average time for experienced operator to change reel of tape	60 Seconds

Physical properties of tape

Width	0.25 Inch
Length of reel	1,200 Feet
Composition	1 1/2 mil mylar sandwich

Two physical tracks on tape combine to form a single information channel.

INPUT

Media	Speed
Magnetic Tape	270 words/sec
Paper Tape	250 char/sec
Keyboard	Manual

OUTPUT

Media	Speed
Magnetic Tape	270 words/sec
Printer	77,400 char/sec (max)
Punch	60 char/sec
Electric Typewriter	10 char/sec

Printer speed is 900 lines/min.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	5,190
Diodes	3,050
Transistors	1,160
Magnetic Cores	200,700

95% of the tubes are Type 5965. 5% are high power drives.

CHECKING FEATURES

Parity check on electrostatic storage and magnetic tape.
Load sums for identification
(+) Exponent spill
Overflow
(-) Exponent spill

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	37 KVA
Volume, computer	1,000 cu ft
Area, computer	150 sq ft
Capacity, air conditioner	15 Tons

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

COST, PRICE AND RENTAL RATES

The total cost is about $350,000.

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Supervisors	3
Analysts	4
Programmers	8
Coders	2
Clerks	1
Operators	1
Engineers	4
Technicians	4

Operation tends toward open shop.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Average error-free running period	Several Hours
Good time	50 Hours/Week (Average)
Attempted to run time	52 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.96

Above figures based on period from 1958 to present
Time is not available for rent to outside organization.

ADDITIONAL FEATURES AND REMARKS

3 indexing registers (B registers) for automatic, address modification and cycle counting (independent of arithmetic elements).

Semi-automatic exit from sub-routines.

Large base for floating point operation to increase speed of floating point additions.

"Madcap", Mathematical and Descriptions Coding Assembly Program, will translate a series of logical and algebraic statements into a computer ready code, this will use a seven hole tape, standard coding uses five holes. Tape reader can handle either.

INSTALLATIONS

University of California
Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico

MANIAC III

Mathematical Analyzer Numerical Integrator and Computer

MANUFACTURER

University of Chicago
Institute for Computer Research

APPLICATIONS

This system will be used by all interested departments of the University of Chicago.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	48
Instructions per word	1
Instructions decoded	94
Arithmetic system	Floating point
Instruction type	Two address
Number range	
Fraction range	$(1 - 2^{-39})$ to -1
Exponent range	+127 to -127

Instruction word format

1	7	1	5	14	1	5	14
Tag	Operation	Inflector	Modifier	Address	Inflector	Modifier	Address

Registers and B-boxes
- 3 Arithmetic Registers
- 8 Transistor Storage Registers
- 8 Index Registers
- 2 Indicator Registers

Four different types of arithmetic (significant digit floating point, specified point, normalized, basic), all using same number format (exponent-fraction).

Special exponent used to denote absolute zero (essentially zero with exponent -(x).

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	24 + n/2	18 + n/2
Mult	71	65
Div	81	75

n = difference of exponents.

Construction (Arithmetic unit only)	
Transistors	10,000
Condenser-diodes	16,000
Arithmetic mode	Parallel
Timing	Asynchronous
Operation	Concurent

STORAGE

No. of Words	No. of Digits	Access Microsec
8,192	48	1

Plans in progress to include an additional 8,192 words.

Magnetic Tape

No. of units that can be connected	4 Units
No. of char/linear inch of tape	250 Char/inch
Channels or tracks on the tape	8 Tracks/tape
Blank tape separating each record	5 Inches
Tape speed	150 Inches/sec
Transfer rate	37,500 Char/sec
Start time	5 Millisec
Stop time	5 Millisec
Average time for experienced operator to change reel of tape	60 Seconds
Physical properties of tape	
Width	0.5 Inches
Length of reel	2,500 Feet
Composition	Mylar

INPUT

Media	Speed
Paper Tape	350 char/sec
Keyboard (Typewriter)	Manual Alphabetic and numeric
Magnetic Tape	37,500 char/sec

OUTPUT

Media	Speed
Paper Tape	60 char/sec
Typewriter	10 char/sec
Line Printer	600 lines/min
Magnetic Tape	37,500 char/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	20,000
Transistors	12,000
Magnetic cores	500,000

CHECKING FEATURES

Parity on tapes and core storage.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	2 Kw	2 KVA	1.0 pf
Area, computer		64 sq ft	
Room size, computer		25 ft x 30 ft	
Floor loading		50 lbs/sq ft max	
		20 lbs/sq ft	
		50 lbs concen max	
Weight, computer		600 lbs	

Room temperature controlled to 75°F., humidity 40% - 60%. Cable ways under floor, or false floor.

PERSONNEL REQUIREMENTS

Open shop policy.

ADDITIONAL FEATURES AND REMARKS

All arithmetic performed on operands in exponent-coefficient form; several options for sealing of result allow calculation to be performed, "generalized fixed point", "normalized", significance-mode, or multiple-precision as convenient.

INSTALLATIONS

University of Chicago
Institute for Computer Research
Chicago 37, Illinois

MERLIN

MERLIN

MANUFACTURER

Brookhaven National Laboratory

APPLICATIONS

Located at Upton, New York, the system is used for Atomic Energy Commission programs, including areas of physics, chemistry, biology, medicine, reactor studies, acceleration design and meteorology.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits per word	48
Number of binary digits per instruction	48
Number of instructions per word	1
Number of instructions decoded	Approx 90
Arithmetic system	Floating point Fixed point
Instruction type	One address (mostly) Two address (some)
Number range	$2^{-120} - 2^{120}$

Instruction word format

Y	Z	b	b'	m	m'

YZ = command (two hexadecimal characters)
b } B box address for 1st address, 2nd address
b') (4 bits each)
m 1st memory address (16 bits each)
m' 2nd memory address

Automatic built-in subroutines
Square-root

Registers and B-boxes
6 B-boxes
3 shifting and 4 non-shifting registers, the latter for fast access storage, in Arithmetic Section
Pathfinder for subroutine return
16 bit Sense Register

48 bit word has one multi-address instruction. The numerical operand represents number in the form 2^{8e} X: four bits specify magnitude of exponent e, one bit its sign; 40 bits the magnitude of the fractional part X and one bit its sign. Of the remaining two bits of the word (tag bits), one may be automatically detected by control. Fetching of next sequenced instruction begins before completion of operation. MERLIN is patterned after MANIAC II (Los Alamos).

ARITHMETIC UNIT

	Incl. Stor. Access Microsec.	Exclud. Stor. Access Microsec.
Add	8 μs (3.5)	-
Mult.	140 μs	130
Div.	330 μs	320

Construction, arithmetic unit only

Type	Quantity
Vacuum tubes	
5956	800
6197	275
Diodes	
T3G	7,000

Arithmetic mode: Parallel

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec
Electrostatic Barrier Grid Tube	8,192	49	6

INPUT

Media	Speed	
Flexowriter	10 char/sec	Friden
Paper Tape	200 char/sec	Ferranti TR 2
Magnetic Tape	20K char/sec	Ampex FR 300 - 4 units

OUTPUT

Media	Speed	
Flexowriter	10 char/sec	Friden
Paper Tape	60 char/sec	Teletype
Magnetic Tape	20K char/sec	Ampex FR 300
Printer	10 lines (96 char)/sec	Shepard

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity	
Tubes		
5965	2,500	Blocking Osc. Flip Flops and Cathode followers
6197	400	Pulse Drivers
12E1	18	Deflection Amplifiers and Pulse Amps.
0A2	24	Regulators
Diodes		
T3G	16,000	Gating and Switching
T5G	350	Gating and Switching
IN643	150	Gating and Switching
Zenor Diodes		
Various	40	Bias Supplies
Transistors		
2N247	400	Memory Read Amplifier and Buffer
2N393	100	Memory Discriminator
2N344	300	Memory Strobe and Parity
2N1091	20	Emitter Followers
Magnetic Cores		
Various	1,200	Blocking Oscillator and Pulse Transformers

CHECKING FEATURES

Parity check at input/output and memory output. Single bit error correction to be added at memory output.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	40 Kw	45 KVA	0.9 pf
Power, air conditioner	16 Kw	18 KVA	0.9 pf
Volume, computer		1500	cu ft
Area, computer		165	sq ft
Room size, computer		1400	sq ft
Volume, air conditioner		150	cu ft
Area, air conditioner		25	sq ft
Room size, air conditioner		1200	sq ft
Capacity, air conditioner		20	Tons

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

COST, PRICE AND RENTAL RATES

Cost $600,000

PERSONNEL REQUIREMENTS

	One 8-Hour Shift Used
Supervisors	1
Analysts	2
Programmers	7
Clerks	1
Engineers	2
Technicians	3

Operation tends toward open shop.

Formal two week course (1 1/2 hr/day). Individual assistance as required.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Time is available for rent to outside organizations on a qualified basis.

Operating figures are not yet available.

Computer is in final stages of debugging and is available on a limited basis.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include 4 fast access temporary storage registers.

FUTURE PLANS

An additional 8000 words of Radechon memory will be incorporated with a self-correcting code. An 8000 word magnetic core memory will also be added.

Modifications, including specialized input-output equipment, will be undertaken on the basis of specific research requirements.

INSTALLATIONS

Brookhaven National Laboratory
Upton, New York

MINIAC II

MINIAC II

MANUFACTURER

Marchant Calculators, Incorporated
(Now Smith-Corona Marchant, Inc.)
Data Processing Systems Division

Picture by The Atlantic Refining Company, Incorporated, Dallas, Texas

APPLICATIONS

The Atlantic Refining Company
Scientific and engineering. Utilized by the Atlantic Refining Company's Research and Development Department for research and development in oil exploration and production. Scientific and engineering applications include synthetic seismograms, geophone responses, chemical process designs and fluid flow in porous media.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Bin coded and Hexa dec
Digits per word	10 decimal
Digits per instruction	10 decimal
Instructions per word	1
Instructions decoded	71
Arithmetic system	Fixed point
Instruction type	One address

ARITHMETIC UNIT

	Includ. Stor. Access Microsec		Exclud. Stor. Access Microsec
	Average	Maximum	
Add time	11,200	21,200	450
Mult time	24,300	41,400	13,600
Div time	25,600	43,200	14,800
Construction		Vacuum tubes	
Basic pulse repetition rate		300 Kc/sec	
Arithmetic mode		Serial	
Timing		Synchronous (clocking channels on the drum)	
Operation		Sequential	

The add time, excluding storage access, given above, is equivalent to 3 word times. The operand and instruction times are included in all the above values.

STORAGE

Media	Words	Digits	Microsec Access
Magnetic drum	4,096	10 plus sign	1,200-10,000

256 words, 2,500 microsec average access, is optional.

INPUT

Media	Speed
Paper Tape (Flexowriter)	600 char/min (6 channel tape)
Ferranti Photoelectric Reader	300 words/min (limited by loading program)
Keyboard	Manual

OUTPUT

Media	Speed
Paper Tape (Flexowriter)	600 dig/min
Friden Punch	30 char/sec (6 channel)

Spare Flexowriter can also be used for the separate preparation of data and programs.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	850
Tube types	7 cover 95%
Crystal diodes	2,000
Separate cabinets	1

There are 75 types of plug-ins at $10 each.
50% of the machine uses 7 types of plug-ins.
The major types of tubes are the 5963, 5687, 12BH7, 12AT7, 5965, 5915, 2D21.
A cold water supply and a desk for the Flexowriter is included.

CHECKING FEATURES

Timing circuits
Twenty jacks for applying marginal voltages

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	5 KW, 220 volt
Space, computer	91 cu ft, 20 sq ft
Space, air cond.	Dimensions 4.5 x 4.5 x 4.5 ft plus desk
Weight, computer	2,000 lbs
Capacity, air cond.	2 tons

Designed for cooling by water between 60° and 65°F.

PRODUCTION RECORD

Produced	1 Model C and 1 Model II
Operating	1 Model C and 1 Model II
Delivery time	No longer manufactured

COST, PRICE AND RENTAL RATES

Approximate cost of basic system	$85,000
Approximate cost of Flexowriter	$ 2,950
Approximate cost of Spare Flexowriter	$ 2,950

No maintenance contract.

PERSONNEL REQUIREMENTS

	One 8-Hour Shift		Two 8-Hour Shifts		Three 8-Hour Shifts	
	Used	Recom	Used	Recom	Used	Recom
Operators	1	1	1	2	1	2
Typist	0	1	0	1	0	1

Methods of training used: On the Job

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Good time	42 Hours/Week
Attempted to run time	48 Hours/Week
Operating ratio (Good/Attempted to run time)	0.875

Above figures based on period from 26 Feb 60 to 26 Mar 60
Acceptance test: 1 Mar 55
Time is not available for rent to outside organizations.

Magnetic drum replaced in 1958.

Converted from one-address to two-address operation in 1959.

FUTURE PLANS

Incorporation of a Moseley system, to have the following items:
- Tape Translator
- X-Y Recorder
- Character Printer
- Curve Follower

INSTALLATIONS

Atlantic Refining Company
Research and Development Laboratory
4500 W. Mockingbird Lane
Dallas, Texas

MISTIC

Michigan State Digital Computer

MANUFACTURER

Michigan State University

Photo by Michigan State University

APPLICATIONS

Service facility for University staff and students on an open shop basis for general purpose computation.

Used for instructional purposes in several programming and numerical analysis courses which are offered for credit by the University.

Available for use on applicable sponsored research projects.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits per word	40
Number of binary digits per instruction	20
Number of instructions per word	2
Total number of instructions decoded	186, of which 139 are unique
Arithmetic system	Fixed point
Instruction type	One-address
Number range	-1 to $+(1-2^{-39})$

Instruction word format

ORDER		ADDRESS	ORDER		ADDRESS
Type	Variant		Type	Variant	
4 bits	4 bits	12 bits	4 bits	4 bits	12 bits

Two 40-bit shifting registers and one 40-bit fixed register for arithmetic operations.

Two separate 2-bit registers will hold a bank address for 16,384 word core memory, one register each for operands and instructions.

ARITHMETIC UNIT

Operation, Incl stor. access	Microseconds
Add time	100
Mult time	1,000
Div time	1,100
Excl stor. access	
Add time	80
Mult time	980
Div time	1,080
Construction (Arithmetic unit only)	
Vacuum tubes type	Quantity
5844	580
7044	236
5670	120
Arithmetic mode	Serial

STORAGE

Media	Number of Words	Digits per Word	Access Microseconds
Cathode Ray Tube	1,024	40 bin	20
Magnetic Core	16,384	40 bin	20

The MC memory will replace the CRT memory.

INPUT

Media	Speed
5-level Photodiode Paper Tape	300 char/sec
Cards	200 cards/min

Above speeds are maximum. Card decoding is programmed so that input is 100 cards/minute for most applications.

OUTPUT

Media	Speed
Paper Tape	60 char/sec
Teletypewriter	10 char/sec
Cards	100 cards/min, max

Cards are program decoded.
CRT output is under construction.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes

Type	Quan
5844	1,300
5670	650
7044	400
5726	100
Misc.	160
Total	2,610

CHECKING FEATURES

Division algorithm automatically checks for overflow and division by 0.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	18.5 K.W., input to computer
Power, air conditioner	10 K.W., including fan, water pump and cooling tower fan
Volume, computer	500 cu ft
Volume, power supplies	200 cu ft
Volume, air conditioner	150 cu ft
Volume, cooling tower	320 cu ft
Area, computer	75 sq ft
Area, power supplies	30 sq ft
Area, air conditioner	32 sq ft
Area, cooling tower	32 sq ft
Room, computer	12 ft x 18 ft
Room, power supplies	8 ft x 9 ft
Air conditioner	10 Horsepower

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

PERSONNEL REQUIREMENTS

Typical Personnel	One 8-Hour Shift
Supervisors	1
Analysts	2
Programmers	2
Clerks	1
Librarians	1
Operators	1
Engineers	1
Technicians	1

The computer is operated on an open-shop basis so that most of the functions other than direct operation and maintenance of the computer are taken care of by the various users.

INSTALLATIONS

Michigan State University
East Lansing, Michigan

FUTURE PLANS

A 40-bit 16,384 word core memory is under construction and will replace the existing 1,024 word CRT memory in the Fall of 1960.

A CRT output with an attached camera is also under construction which will permit analog output directly from the computer. This will be made available in the Fall of 1960.

MOBIDIC A

Mobile Digital Computer A AN/MYK-1(v)

MANUFACTURER

Sylvania Electric Products, Incorporated

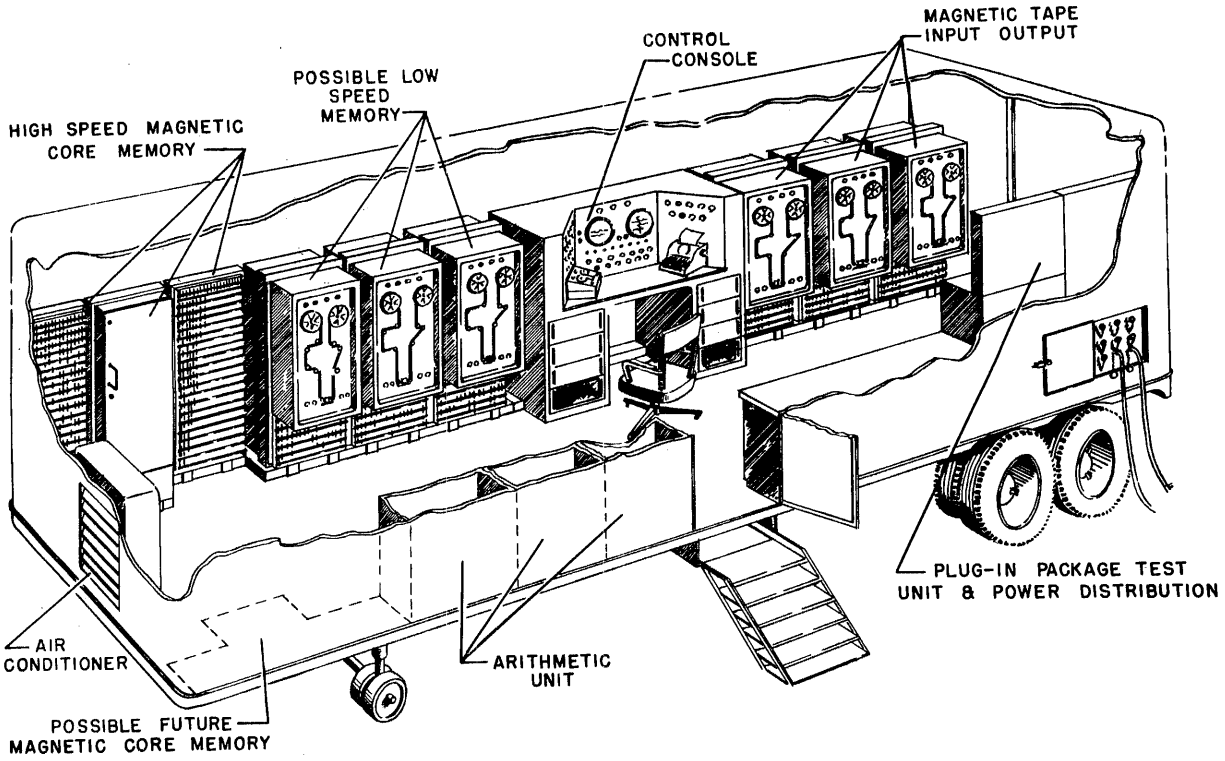


Photo by Sylvania Electric Products, Inc.

APPLICATIONS

Presently located at the Needham Industrial Park, the MOBIDIC "A" is a mobile, highly-reliable, high speed, general purpose computing facility for use by field commanders for combat support data processing, combat control data processing, combat computation, and logistic computations.

The Real Time System consist of Real Time Input-Output registers, both of which are capable of communicating with an external device (including another MOBIDIC) over nine lines (6 data, 1 parity, 2 control). The Input system incorporates a program interupt feature.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	36 plus sign & parity bits
Binary digits/instruction	36 plus spare & parity bits
Instructions per word	1
Instructions decoded	52
Arithmetic system	Fixed point
Assumed binary point at left end of word, between bits 36 & 37	
Instruction type	One address
Some instructions are two address, e.g. load, move, etc.	
Number range	$-(1 - 2^{-36})$ to $+(1 - 2^{-36})$

Instruction word format

Standard Computer Instruction Word

38	37	36 31	30 28	27 16	15 13 12 1
Parity	Spare	Op. Code	Index Reg. Selection	Minor Address	Major Address

Input-Output Instruction Word

38	37	36 31	30 22	21 16	15 13 12 1
Parity	Spare	In-Out Comd	Word-Block Counter	Device Selec-tion	Storage Address

Automatic coding includes the Mobidic Assembly Program.

Registers include 6 in the Central Processor, 4 Index, 2 in the Communications Converter, and 2 in the In/Out Converter.

Instructions consist of 15 Arithmetic, 8 Transfer, 17 Logical, 3 Sense, and 9 Input-Output instructions.

Index Registers are expansible to a total of 7.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	16	8
Mult	86	78
Div	88	88

Construction (Arithmetic unit only)

Transistors	6,000
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Sequential

Mostly sequential, however processing may proceed during input-output operations.

STORAGE

Media	No. of Words	No. of Bits/word	Access Microsec
Core Memory (2)	4096 each	40	8

Expandable to a total of 7 memories.

Magnetic Tape

No. of units that can be connected	63 Units
No. of chars/linear inch of tape	300 Chars/inch
Channels or tracks on the tape	8 Tracks/tape
Blank tape separating each record	1.5 Inches
Tape speed	150 Inches/sec
Transfer rate	45,000 Chars/sec
Start time	1.5 Millisec
Stop time	1.5 Millisec
Average time for experienced operator to change reel	120 Seconds
Physical properties of tape	
Width	1/2 Inches
Length of reel	3600 Feet
Composition	1 mil mylar

The 40 bit word length in storage is made up of:

36 bit magnitude
1 bit sign
1 bit parity
1 busy-bit
1 spare-bit
40 Total in storage

INPUT

Media	Speed
Paper Tape 5 channel 11/16 inch tape	200 char/sec (start-stop) to 270 char/sec
Paper Tape 8 channel 1 inch tape	200-270 char/sec
Real Time Channel character by character	120,000 char/sec
Cards	200 cards/min

The Real Time System was designed to operate with the Collins Kineplex equipment whose speed is 300 characters/sec. or with another MOBIDIC; however, it can operate with any compatible transmission equipment.

OUTPUT

Media	Speed	
Paper Tape 5 channel	100 char/sec	11/16" tape
Paper Tape 8 channel	100 char/sec	1 inch tape
Real Time	120,000 char/sec	char by char
Flexowriter	10 char/sec	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	
SG-225	6,000
Transistors	
2N393	32,000
Magnetic Cores	311,200

CHECKING FEATURES

Checking features include parity on memory transfer and input-output, overflow, non-existant memory, non-existant instruction, and non-existant device (I/O). Marginal checking may also be performed. Diagnostic Routines to check the machine and indicate instruction which fail and aid in the localization of failures are available.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	29.76 Kw	37.2 KVA	0.8 pf
Power, air conditioners	4.64 Kw	5.8 KVA	0.8 pf
Volume, computer	1,440 cu ft		
Area, computer	240 sq ft		
Floor loading	300 lbs/sq ft		
	240 lbs concen max		
Volume, two air conditioners	72 cu ft		
Area, two air conditioners	48 sq ft		
Capacity, two air conditioners	6 Tons		
Weight, computer	12,000 lbs		
Weight, air conditioners	1,200 lbs		

The computer is mounted in a 30 foot van, air conditioning ducts on the right and left ceilings, and the heater duct at floor level behind the I/O converters, Central Processor, and memory units.

Air-conditioning is for operator comfort only.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1
Time required for delivery	18 months

System is being tested and evaluated.

COST, PRICE AND RENTAL RATES

Large computer system such as this one is seldom duplicated from one installation to another. Individual problem and application normally requires unique configuration and special features that establish either purchase or lease price. Upon completion of a feasibility study when the requirements are known, along with a calculated growth, costs could be determined.

PERSONNEL REQUIREMENTS

Training will be dependent on the requirements of the user. However, it is recommended that personnel have a minimum of 4 weeks of formal class room lectures followed, if possible, by closely supervised on-the-job-training.

Number of operating personnel will depend on the requirements of the user.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Time is not available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include ruggedization for field use. System operates between -25°F to 125°F and 0 to 97% relative humidity. It is built on a modular basis, expansible in memory (to 7), I/O converter (up to 4), and I/O equipment (to 63).

Unique system advantages include containment in 240 sq ft. It is a completely mobile, large scale, general purpose system. System is designed for reliability, mobility, flexibility, fixed plant, and strategic installation, with minimum space requirements, and minimum pre-installation cost, such as air conditioning and power. This machine is a member of the Army FIELDATA Family of Computers. It uses the FIELDATA code and is compatible with other FIELDATA machines.

INSTALLATIONS

One MOBIDIC will be installed for the 7th Army Stock Control Center in Germany. Other systems will be installed to cover a wide range of applications.

MOBIDIC B

Mobile Digital Computer B AN/MYK-2(v)

MANUFACTURER

Sylvania Electric Products, Incorporated

APPLICATIONS

The MOBIDIC B is a duplexed general purpose computer being developed for inclusion into a tectical army operation center. The machine's mechanized instruction list was selected for optimized operation in the processing of data rather than for scientific calculations. The two machines may be synchronized together and run as one machine or they may be used separately.

The MOBIDIC B has two real time in-out registers and possible sources of such real time data are radar equipment, weather stations, drone aircraft and other MOBIDICS. This computer is also suited for applications such as message switching centers. One processor receives the incoming message and does the incoming processing and then stores the message in the common mass memory. The second processor would serve as the output message processor, taking the message from the common mass memory completing the processing and transmitting it out. If one machine failed, the second could handle the work at a reduced system speed.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	36 plus sign bit & parity
Binary digits/instruction	36 plus spare bit & parity
Instructions/word	1
Instructions decoded	55 + 9 special subroutine instructions
Arithmetic system	Fixed point
Assumed binary point at left end of word, between bits 36 and 37	
Instruction type	One address
Some instructions are two address, e.g. load, move, etc.	
Number range	$-(1 - 2^{-36})$ to $+(1 - 2^{-36})$

Instruction word format

38	37	36 31	30 28	27 16	15 13 12 1
Parity	Spare	Op. Code	Index Reg. Selection	Minor Address	Major Address

Standard Computer Instruction Word

38	37	36 31	30 22	21 16	15 13 12 1
Parity	Spare	In-Out Comd	Word-Block Counter	Device Selection	Storage Address

Input-Output Instruction Word

Automatic coding includes MOBIDIC Assembly Program.

Registers include 8 in the central processor, 2 in the communications converter, 2 in the In/Out Converter and 7 index registers.

Instructions consist of 15 Arithmetic, 9 Transfer, 18 Logical, 3 Sense, 10 Input-Output, and 9 Special instructions.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	42	34
Mult	88	80
Div	Not mechanized	

Construction (Arithmetic unit only)

Transistors	6,000
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Sequential

STORAGE

Media	No. of Words	No. of Bits/word	Access Microsec
Magnetic Core	8,192		8
Disk	6.25×10^6	8	1×10^6

Expansible to a total of 7 core memories of 4,096 words each

Magnetic Tape

No. of units that can be connected	63 Units
No. of chars/linear inch of tape	300 Chars/inch
Channels or tracks on the tape	8 Tracks/tape
Blank tape separating each record	1.5 Inches
Tape speed	150 Inches/sec
Transfer rate	45,000 Chars/sec
Start time	1.5 Millisec
Stop time	1.5 Millisec
Average time for experienced operator to change reel	120 Seconds
Physical properties of tape	
Width	1/2 Inches
Length of reel	3,600 Feet
Composition	1 mil mylar

INPUT

Media	Speed
Paper Tape 5 channel 11/16 inch tape	200 char/sec (start-stop) 270 char/sec
Paper Tape 8 channel 1 inch tape	200-270 char/sec
Real Time Channel character by character	120,000 char/sec
Cards	200 cards/min

The Real Time System was designed to operate with the Collins Kineplex equipment whose speed is 300 characters/sec. or with another MOBIDIC; however, it can operate with any compatible transmission equipment.

OUTPUT

Media	Speed	
Paper Tape 5 channel	100 char/sec	11/16" tape
Paper Tape 8 channel	100 char/sec	1 inch tape
Real Time	120,000 char/sec	char by char
Flexowriter	10 char/sec	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	
SG225	6,000
Transistors	
2N393	Approx. 30,000
Magnetic Cores	655,360

CHECKING FEATURES

Checking features include parity on memory transfer and input-output, overflow, non-existant memory, non-existant instruction, and non-existant device (I/O). Marginal checking may also be performed. Diagnostic Routines to check the machine and indicate instruction which fail and aid in the localization of failures are available.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	34.2 Kw	42.75 KVA	0.8 pf
Power, air conditioner	6.6 Kw	8.25 KVA	0.8 pf
Volume, computer		690 cu ft	
Volume, air conditioner		72 cu ft	
Area, computer		115 sq ft	
Area, air conditioner		48 sq ft	
Weight, computer		12,600 lbs	
Weight, air conditioner		1,200 lbs	
Capacity, air conditioner		Two at 1.5 Tons each	

Air conditioners are for personnel comfort only

Computer is mounted in a 30 ft van and a shelter of approximately the size of an S-109.

PRODUCTION RECORD

Number in current production	1
Number on order	1
Time required for delivery	18 months

ADDITIONAL FEATURES AND REMARKS

Outstanding features include reggedization for field use. System operates between -250°F to +125°F and 0 to 97% relative humidity. It is built on a modular basis, expansible in memory (to 4), I/O converter (up to 4), and I/O equipment (to 63).

Unique system advantages include containment in 335 sq ft. It is a completely mobile, large scale, general purpose system. System is designed for reliability, mobility, flexibility, fixed plant, and strategic installation, with minimum space requirements, and minimum pre-installation cost, such as air conditioning and power. This machine is a member of the Army FIELDATA Family of Computers. It uses the FIELDATA code and is compatible with other FIELDATA machines.

The 40 bit word length in storage is made up of:

36	bit magnitude
1	bit sign
1	bit parity
1	bit busy-bit
1	spare-bit
40	Total in storage

MOBIDIC C D & 7A

Mobile Digital Computer C, D, 7A AN/MYK-1(v)

MANUFACTURER

Sylvania Electric Products, Incorporated

APPLICATIONS

MOBIDIC C, D, and 7A are mobile highly reliable, high speed, general purpose computing systems for use by the field commanders for combat support data processing, combat control data processing, combat computations and logistic computations.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	36 plus sign & parity bits
Binary digits/instruction	36 plus spare & parity bits
Instruction per word	1
Instructions decoded	52
Arithmetic system	Fixed point
Assumed binary point at left end of word, between bits 36 & 37	
Instruction type	One address
Some instructions are two address, e.g. load, move, etc.	
Number range	$-(1 - 2^{-36})$ to $+(1 - 2^{-36})$

Instruction word format

Standard Computer Instruction Word

38	37	36 31	30 28	27 16	15 13 12 1
Parity	Spare	Op. Code	Index Reg. Selection	Minor Address	Major Address

Input-Output Instruction Word

38	37	36 31	30 22	21 16	15 13 12 1
Parity	Spare	In-Out Comd	Word-Block Counter	Device Selec-tion	Storage Address

Automatic coding includes the Mobidic Assembly Program.

Registers include 6 in the Central Processor, 4 Index, 2 in the Communications Converter, and 2 in the In/Out Converter.

Instructions consist of 15 Arithmetic, 8 Transfer, 17 Logical, 3 Sense, and 9 Input-Output instructions.

Index registers are expansible to a total of 7.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	16	8
Mult	86	78
Div	88	80

Construction (Arithmetic unit only)	
Transistors	6,000
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Sequential

Operation is primarily sequential, however processing may proceed duting input-output operations.

STORAGE

Medium	No. of Words	No. of Bits/word	Access Microsec
Magnetic Core	2 ea (4096) total 8192	40	8

Expansible to a total of 7 magnetic core memories of 4,096 words each.

Magnetic Tape

No. of units that can be connected	63	Units
No. of chars/linear inch	300	Chars/inch
Channels or tracks on the tape	16	Tracks/tape
Blank tape separating each record	1-1/2	Inches
Tape speed	1-150	Inches/sec
Transfer rate	300-45,000	Chars/sec
Start time	3	Millisec
Stop time	3	Millisec
Average time for experienced operator to change reel	120	Seconds
Physical properties of tape		
Width	1	Inch
Length of reel	3,600	Feet
Composition	Mylar	

MOBIDIC C & MOBIDIC D each have (8) tape units while MOBIDIC 7A has 11.

INPUT

Media	Speed
Paper Tape 5 channel 11/16 inch tape	200 char/sec (start-stop) to 270 char/sec
Paper Tape 8 channel 1 inch tape	200-270 char/sec
Real Time Channel character by character	120,000 char/sec
Cards	200 cards/min

OUTPUT

Media	Speed	
Paper Tape 5 channel	100 char/sec	11/16" tape
Paper Tape 8 channel	100 char/sec	1 inch tape
Real Time	120,000 char/sec	
Flexowriter	10 char/sec	char by char

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	
SG225	6,000
Transistors	
2N393	30,000
Magnetic Cores	335,872

MOBIDIC is a completely Solid State computer

CHECKING FEATURES

Parity on memory transfer and input-output, over flow, non-existant memory, non-existant instruction, non-existant device (I/O), marginal checking, and diagnostic programs to check the machine and indicate instructions which fail and aid in the localization of failures.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	44.8 Kw	56 KVA	0.8 pf
Power, air conditioner	9.28 Kw	11.6 KVA	0.8 pf
Volume, computer		2,880 cu ft	
Volume, air conditioner		72 cu ft	
Area, computer		480 sq ft	
Area, air conditioner		48 sq ft	
Weight, computer		7,000 lbs	
Weight, air conditioner		600 lbs ea	
1200 lbs - Total for 1 van			
2400 lbs - Total for 2 vans			
Capacity, air conditioner		1 1/2 Tons	
		18,000 BTU/hr each	

No special site requirements. MOBIDIC C, D, 7A are mounted in two 30' vans. KVA & Kw ratings include air conditioning for two vans. Kw and KVA maximum for entire system. Air conditioning is for operator comfort only. Air conditioners are two per van. All figures are for two vans.

PRODUCTION RECORD

Number produced to date	1 - AN - MYK - 1(v)
Number in current operation	1
Number in current production	3
Time required for delivery	18 months

ADDITIONAL FEATURES AND REMARKS

Outstanding features include reggedization for field use. System operates between -25°F to +125°F and 0 to 97% relative humidity. It is built on a modular basis, expansible in memory (to 7), I/O converter (up to 4), and I/O equipment (to 63).

Unique system advantages include containment in 480 sq ft. It is a completely mobile, large scale, general purpose system. System is designed for reliability, mobility, flexibility, fixed plant, and strategic installation, with minimum space requirements, and minimum pre-installation cost, such as air conditioning and power. This machine is a member of the Army FIELDATA Family of Computers. It uses the FIELDATA code and is compatible with other FIELDATA machines.

The 40 bit word length in storage is made up of:

36	bit magnitude
1	bit sign
1	bit parity
1	busy-bit
1	spare-bit
40	Total in storage

MODAC 404

Mountain Systems Digital Automatic Computer

MANUFACTURER

Airborne Instruments Laboratory, Incorporated (Parent)
Mountain Systems, Incorporated

APPLICATIONS

Statistical and business data processing, accounting, coding and controls.
System is no longer being manufactured.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	6
Decimal digits/instruction	2
Instructions decoded	8
Arithmetic system	Fixed point
Instruction type	One address
Number range	0 to 999,999

Programming system is designed for special application. Operations include addition, subtraction, unit entry, bulk entry and transfer.

Photo by Reader's Digest Association

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add time	25,000	240
Construction		Vacuum tubes
Basic pulse repetition rate		150 Kc/sec
Arithmetic mode		Serial
Timing		Asynchronous
Operation		Sequential

The addition time given above is for the addition of two 6-digit decimal numbers.

STORAGE

Medium	Words	Digits	Access Microsec
Magnetic Drum	20,000	120,000	25,000

Access time given above is average. System stores 500,000 binary digits in 50 milliseconds access time.

Photo by Reader's Digest Association

INPUT

Media	Speed
Paper Tape	200 char/sec
Punched Cards (Rem. Rand Tab)	4 cards/sec

OUTPUT

Media	Speed
Paper Tape	200 char/sec
Punched Cards (Rem. Rand Tab)	4 cards/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	1,000
Tube types	3
Crystal diodes	2,000
Separate cabinets	1

CHECKING FEATURES

Address check

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	3 Kw
Volume, computer	120 cu ft
Area, computer	20 sq ft
Weight, computer	1,500 lbs

PRODUCTION RECORD

Reader's Digest Association

Number produced	1
Number in operation	1

COST, PRICE AND RENTAL RATES

Reader's Digest Association

Approximate cost of basic system $100,000.

System is no longer in production.

PERSONNEL REQUIREMENTS

Reader's Digest Association

Daily Operation	Engineers	Tech and Operators
One 8-hour shift	0	1

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Reader's Digest Association

Good time	6,000 Hours
Attempted to run time	6,188 Hours
Operating ratio (Good/Attempted to run time)	0.97

Figures based on period from Sep 55 to Jan 57

Passed Customer Acceptance Test Sep 54

Additional features include external programming, dual entry to memory with single address and an address check.

System no longer manufactured.

MODAC 410

Mountain Systems Digital Automatic Computer Model 410

APPLICATIONS

Business data processing.
System is no longer being manufactured.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Decimal - Excess 3
Decimal digits per word	10
Arithmetic system	Fixed point
Instruction type	One address
Number range	0 to 10 decimal digits

Program is stored internally and on tape.

ARITHMETIC UNIT

	Exclud Stor Access Microsec
Add time	600
Mult time	7,000
Div time	7,000
Construction	Vacuum tubes, magnetic elements and diodes
Rapid access word registers	50
Basic pulse repetition rate	150 Kc/sec
Arithmetic mode	Serial
Timing	Asynchronous
Operation	Sequential

Computer is serial with buffer storage.

STORAGE

Medium	Words	Access Microsec
Magnetic Drum	5,000	7,500

50,000 decimal digits stored.
Buffer storage in magnetic cores.

INPUT

Media	Speed
Punched Tape	400 char/sec
Punched Cards	600 cards/min

OUTPUT

Media	Speed
Punched Tape	60 char/sec
Punched Cards	600 cards/min

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	600
Tube types	3
Crystal diodes	3,000
Magnetic elements	1,000
Number of different plug in units	5
Number of separate cabinets	2

MANUFACTURER

Airborne Instruments Laboratory, Incorporated
Mountain Systems Incorporated

CHECKING FEATURES

Number checks
Address checks
Odd number check

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	4 Kw
Volume, computer	40 cu ft
Area, computer	20 sq ft
Weight, computer	1,000 lbs

PRODUCTION RECORD

Number produced	1
Number in operation	1

System out of production.

COST, PRICE AND RENTAL RATES

Approximate cost of basic system $120,000.
Price includes input and output equipment described. Other equipment dependent upon specific application.
System is no longer being manufactured.

PERSONNEL REQUIREMENTS

One operator required during operation.

ADDITIONAL FEATURES AND REMARKS

Special translator or converter feature reads an abbreviation on a punched card, looks up corresponding code from a list of 5,000 and punches a code number into the same card at a reading and punching rate of 500 per minute.

High speed tallying feature performs 1,440,000 unit additions per hour into selected registers.

Transactions, from a total of 4,000 categories, can be read at random and added to an appropriate one of 4,000 registers.

System no longer being manufactured.

INSTALLATIONS

Readers Digest Association, Incorporated
Condensed Book Club
Pleasantville, New York

MODAC 414

Mountain Systems Digital Automatic Computer Model 414

APPLICATIONS

Reader's Digest Association, Incorporated
Large scale translation, statistical processing and general purpose computation.
System is no longer being manufactured.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal and alphanumeric
Decimal digits/word	6
Decimal digits/instruction	2
Instructions decoded	12
Arithmetic system	Fixed point
Instruction type	One address (for general purpose applications)

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add time	8,000	288
Mult time	8,000	8,000
Div time	8,000	8,000
Construction	Vacuum tubes and magnetic cores	
Arithmetic mode	Serial	
Timing	Asynchronous	
Operation	Sequential Concurrent for punched cards in any of three modes.	

The multiply and divide times given above include re-record time.

STORAGE

Media	Words	Characters	Access Microsec
Magnetic Drum	6,000	36,000	8,000
Magnetic Drum	4	24	576
Magnetic Cores	2	12	288

INPUT

Media	Speed
Punched Cards	360 cards/min
Paper Tape	

Paper tape is used for report programming and testing.

MANUFACTURER

Airborne Instruments Laboratory, Incorporated (Parent)
Mountain Systems, Incorporated

OUTPUT

Media	Speed
Punched Cards	360 cards/min
Paper Tape	20 char/sec

Punched cards are used for translation and paper tape for reports.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	2,000 (approx)
Tube types	3 (major)
Crystal diodes	3,000 (approx)
Magnetic cores	396

CHECKING FEATURES

Odd-even checks on numerical calculations are used.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	5 Kw
Volume, computer	240 cu ft
Area, computer	40 sq ft
Weight, computer	3,000 lbs

PRODUCTION RECORD

Number produced	1
Number in operation	1

System is no longer being manufactured.

COST, PRICE AND RENTAL RATES

Approximate cost of basic system $150,000.
System is out of production.

PERSONNEL REQUIREMENTS

Daily Operation	Engineers	Tech and Operators
One 8-hour shift	0	2

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Passed Customer Acceptance Test October 1956.
System is no longer being manufactured.

INSTALLATIONS

Reader's Digest Association, Incorporated
Condensed Book Club
Pleasantville, New York

MODAC 5014

Mountain Data Processor Model 5014

MANUFACTURER

Airborne Instruments Laboratory, Incorporated (Parent)
Mountain Systems, Incorporated

APPLICATIONS

Manufacturer
Business data processor. System no longer being manufactured.

Hickok Manufacturing Company, Incorporated
A perpetual inventory, furnishing reports to the Central Planning and Packaging Departments.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	20
Binary digits/instruction	60
Arithmetic system	Decimal-binary
Instruction type	One address, consisting of two parts. Address "A" selects a magnetic drum read-record head and address "B" selects a particular location on the drum.

Photo by Airborne Instruments Laboratory, Inc.

Number range	"A" ranges from 0 to 66 "B" ranges from 0 to 150

ARITHMETIC UNIT

	Microsec
Add time (Includ stor access)	32
Construction	Vacuum tubes, using a combination of trigger pairs, pullers, and cathode followers. A crystal diode matrix is also used.
Arithmetic mode	A combination series-parallel shift register is utilized.
Timing	Synchronous
Operation	Sequential

Three types of pulses are used to control operation.
Serial feed is by use of 5 channel paper tape.
Basic operations are addition, subtraction and "reading out" a balance.

STORAGE

Media	Words	Digits	Access Microsec
Magnetic Drum	10,000	50,000	
Shift Register	1	5	32
Paper Tape			

Paper tape is utilized for permanent storage in order to release the magnetic drum for other purposes.

The magnetic drum is 8 inches long and 7 inches in diameter. There are 66 recording heads. The address system is composed of a relay pyramid and an electronic counter.

INPUT

Medium	Speed
Paper Tape	600 char/min

Above tape is 5-channel tape, which is prepared by an IBM 063 Card-to-Tape Converter or a Flexowriter typewriter.

OUTPUT

Medium	Speed
Paper Tape	600 char/min

Direct to paper tape or via a Flexowriter typewriter.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	535
Tube types	8
Crystal diodes	150
Separate cabinets	4

Crystal diode types used are the 1N35 and the 1N116. Tube types used are the 5965, 5915, 6AN5, 12BH7, 12AX7, 2D21, 5963, and 6AS6. All four cabinets are inter-cabled.

The IBM 063 Card-to-Tape Converter and the Flexowriter are located in an adjoining room. The Flexowriter can be cabled directly to the computer so as to print out in hard copy as the computer is in operation.

CHECKING FEATURES

Checking is performed by using predetermined "heads" and "spots" on the drum and tapes with known answers. A visual check is made.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Volume, computer	120 cu ft
Area, computer	16 sq ft
Four cabinets	2 x 2 x 7.5 ft each
Weight, computer	600 lbs

COST, PRICE AND RENTAL RATES

Hickok Manufacturing Company, Inc.

Approximate cost of basic system	$85,000
Approximate cost of Flexowriter	1,200

Rental rates of IBM 063 Card to Tape Converter ($65.00 plus $6.50 tax)/month.

System is no longer manufactured.

PERSONNEL REQUIREMENTS

Hickok Manufacturing Company, Inc.

One operator and 1 clerk are utilized to operate the system on a one 8-hour shift/week basis. One engineer is utilized for developing methods and procedures.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Average error-free running period	30 Hours
Good time	145 Hours/Week
Attempted to run time	168 Hours/Week
Operating ratio (Good/Attempted to run time)	0.87

Figures based on the last three years.

Passed Customer Acceptance Test July 1954

System is no longer being manufactured.

INSTALLATIONS

Hickok Manufacturing Company, Incorporated
Rochester, New York

MONROBOT III

Monroe Computer Model III

MANUFACTURER

Monroe Calculating Machine Company
Electronics Division

Photo by Monroe Calculating Machine Company, Electronics Division

APPLICATIONS

Air Force Cambridge Research Center
Scientific calculation.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	20
Decimal digits/instruction	10
Instructions per word	1
Instructions decoded	11
Instructions used	11
Arithmetic system	Fixed point
Instruction type	Four address
Number range	$10^{-10} \leq n \leq 10^{10} - 1$

ARITHMETIC UNIT

	Incl Stor Access Microsec
Add time	120,000
Mult time	540,000
Div time	540,000
Construction	Vacuum tubes
Basic pulse repetition rate	10 Kc/sec
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

STORAGE

Media	Words	Access Microsec
Magnetic Drum	100 numbers	15,000
Magnetic Drum	100 instructions	15,000

INPUT

Media	Speed
Keyboard	Manual
Paper Tape	10 dig/sec

OUTPUT

Media	Speed
Typewriter (Flexowriter)	10 dig/sec
Paper Tape (Flexowriter)	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	800
Tube types	4
Crystal diodes	100

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	2.5 Kw
Space, computer	Desk size
Weight, computer	1,000 lbs

PRODUCTION RECORD

Number produced 1
No longer in production.

PERSONNEL REQUIREMENTS

One technician or mathematician is required to operate system.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Good time	28 Hours
Attempted to run time	35 Hours
Operating ratio (Good/Attempted to run time)	0.80

Figures based on period 1 Feb 55 to 1 Sep 56
Passed Customer Acceptance Test 1 Feb 55

Approximately 1 hour/day is required for maintenance, therefore "attempted to run time" is considered to be 40-5, or 35 hours.

INSTALLATIONS

Air Force Cambridge Research Center
Computing Laboratory
Cambridge 39, Massachusetts

MONROBOT V

Monroe Computer Model V

MANUFACTURER

Monroe Calculating Machine Company
Electronics Division

Photo by Monroe Calculating Machine Company, Electronics Division

APPLICATIONS

Computing problems normally encountered by Topographic Troops in surveying operations.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	20
Decimal digits/instruction	10
Arithmetic system	Fixed point
Instruction type	Four address

ARITHMETIC UNIT

	Includ Stor Access Microsec
Add time	120 (approx)
Mult time	540 (approx)
Div time	540 (approx)
Construction	Vacuum tubes
Basic pulse repetition rate	10 Kc/sec
Timing	Synchronous
Operation	Sequential

STORAGE

Media	Words	Access Microsec
Magnetic Drum	300	18,000
Paper Tape		

Access time on drum is for 100 twenty digit numbers. Drum is 6 inches in diameter, 20 inches long and rotates at a speed of 3,550 rev/min.

INPUT

Media	Speed
Keyboard	Manual
Paper Tape (Reader)	570 char/min

OUTPUT

Medium	Speed
Typewriter (Flexowriter)	Reader 570 char/min
	Printer 400 char/min

Photo by U. S. Army Corps of Engineers, Engineer Research and Development Laboratories

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	800 (approx)
Crystal diodes	1
Tube types	5814A, 5726, 5751, 5844, 6005, and 5725

CHECKING FEATURES

Storage selection indicators.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	5 Kw
Area, computer	44 1/2 in x 72 in x 31 in Desk
Weight, computer	1,686 lbs, including Flexowriter

PRODUCTION RECORD

Number produced 1
No longer in production.

COST, PRICE AND RENTAL RATES

Manufacturer
System is no longer being manufactured.
Engineer Research and Development Laboratories
Approximate cost of basic system $86,074.

PERSONNEL REQUIREMENTS

Engineer Research and Development Laboratories
One person required for operation and one person required for servicing unless one person is trained to perform both operation and servicing.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Operating ratio (Good/Attempted to run time) 0.85
Passed Customer Acceptance Test March 1955
Computer has operated for several days without any down time; however, the only actual figure is the 2,069 hours taken from the running time meter.

ADDITIONAL FEATURES AND REMARKS

Pre-addressed tapes
Single cycle operation where program is checked line for line.
Pre-determined automatic sequencing.
Shock-mounted for van installation; mobile.

INSTALLATIONS

U. S. Army Corps of Engineers
Topographic Engineering Department
Engineer Research and Development Laboratories
Fort Belvoir, Virginia

MONROBOT VI

Monroe General Purpose Computer Model VI

MANUFACTURER

Monroe Calculating Machine Company
Electronics Division

Photo by Monroe Calculating Machine Company, Electronics Division

APPLICATIONS

Scientific calculation.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	20
Decimal digits/instruction	10
Instructions per word	2
Instructions used	200
Arithmetic system	Fixed point
Instruction type	Four address
Number range	± xxxxx xxxxx . xxxxx xxxxx

Fixed point is centrally located

ARITHMETIC UNIT

	Incl Stor Access Microsec
Add time	135,000
Mult time	600,000
Div time	600,000
Construction	Vacuum tubes and crystal diodes
Basic pulse repetition rate	10 Kc/sec
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Automatic positioning of numerical results about the decimal point.

STORAGE

Medium	Words	Access Microsec
Magnetic Drum	200	16,670 max

4,000 digits of magnetic drum storage.

INPUT

Media	Speed
Keyboard	Manual
Punched Tape	10 char/sec
Punched Card	17 cards/sec

Punched tape is optional to 60 char/sec.

Standard teletype or Kleinschmidt units for tape processing.

Photo by Monroe Calculating Machine Company, Electronics Division

OUTPUT

Media	Speed
Printed Copy	10 char/sec
Punched Tape	10 char/sec
Punched Card	17 char/sec

Standard teletype or Kleinschmidt units. 60 char/sec. Punched tape and punched card is optional.

CHECKING FEATURES

Parity checks
MAID (Monrobot Automatic Internal Diagnosis) and dual arithmetic and control units.

INSTALLATIONS

Several systems are at U. S. Air Force installations in Japan and Germany. These are under Monroe maintenance. The systems installed in the United States are not under Monroe maintenance.

Howard University

MONROBOT IX

Monroe Calculating Machine IX

MANUFACTURER

Monroe Calculating Machine Company

APPLICATIONS

System is used primarily for billing, and invoice writing.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	62 bits
A plugboard program is used.	
Instructions decoded	16
Arithmetic system	Fixed point
Instruction type	One address
Number range	0 to 10^{18}

System has 15 registers.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	12,000	3,000
Mult	13,500	per decimal digit of multiplier
Div	54,000	per decimal digit of quotient

Construction (Arithmetic unit only)

Vacuum-Tubes	64
Diodes	1,000
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Multiplication is accomplished by manual input of the multiplier digits. Therefore, actual speed is operator limited.

During division the quotient digits are printed, and the actual speed is therefore printer limited.

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec
Magnetic Drum	15	18 decimal dig	12,500 avg

INPUT

Media	Speed
Electric Typewriter	10 char/sec
Plugboard	10 char/sec

Plugboard is used for constants and alphabetic characters.

Typewriter input is operator limited.

OUTPUT

Media	Speed
Electric Typewriter	10 char/sec
Numerical and alphabetic	
IBM 024 Card Punch	10 char/sec
Numerical	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	
Primarily 5965	74
Diodes	
Primarily 1N636	1,000

POWER, SPACE, WEIGHT, AND SITE PREPARATION

KVA, computer	0.75
Volume, computer	32 cu ft
Area, computer	10.6 sq ft
Floor loading	40 lbs/sq ft
	150 lbs concen max
Weight, computer	450 lbs

Site preparation not necessary.

PRODUCTION RECORD

Number produced to date	70
Number in current operation	70
Time required for delivery	3 - 6 months

COST, PRICE AND RENTAL RATES

Computer with Typewriter	$9,650
List of additional equipment	
IBM (024) Intercoupler	$ 500
(IBM 024 - see IBM price list)	

90-day guarantee parts and labor. Service contract price is $500.

PERSONNEL REQUIREMENTS

One clerk is required for each 8-hour shift.

Ordinary typists are trained at customer location in one day.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Ambient temperature to 130°F
Voltage margins, ±25%
Pre-aged tubes used throughout.

ADDITIONAL FEATURES AND REMARKS

Computer has fewer tubes (74) than any other product known to us. Calculation is so fast operator experiences no delay. System handles fractions of any kind, feet, inches, gross, dozen, board feet, etc. Foreign currency such as pounds, shillings, pence, are handled. Step-rate utility billing is automatically performed.

System operates as a decimal machine externally. Input and output conversion are automatic. Decimal shift left and shift right instructions make this possible.

FUTURE PLANS

Punched tape output planned soon.

MONROBOT XI

Monroe Calculating Machine Mark XI

MANUFACTURER

Litton Industries
Monroe Calculating Machine Division

Photo by Monroe Calculating Machine Division

APPLICATIONS

The Monrobot Mark XI is a stored-program, general purpose electronic business computer capable of operation with a wide variety of input-output equipment.

Instruction word format

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Instruction						Address									

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	32 including sign
Binary digits/instruction	16
Instructions/word	2
Instructions decoded	27
Instructions used	27
Arithmetic system	Fixed point; programmed floating point
Instruction type	One address
Number range	0 to $2^{31} - 1$ or 0 to $\pm 10^9$ or 0 to $\pm$ 2, 147, 483, 647

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	9,000	3,000
Mult	34,000	28,000
Div	500,000	500,000

Division is programmed.

Construction (Arithmetic unit only)	
Transistors	190
Diodes	1,675
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

STORAGE

Medium	No. of Words	No. of Digits	Average Access Microsec
Magnetic Drum	1,024	32,768	6,000

INPUT

Media	Speed
Punched Paper Tape	20 char/sec
Electric typewriter	10 char/sec
16-key numeric keyboard	10 char/sec
80-column card	16 col/sec
Teletypewriter	10 char/sec

The machine can accomodate any three of the above input devices simultaneously. Punched paper tape may be any code, 5 to 8 level. Quoted input and output speeds include conversion to and from binary as well as translation of any tape language to machine code. Higher speeds are possible using pure binary input and output.

OUTPUT

Media	Speed
Punched Paper Tape	20 char/sec
Electric Typewriter	10 char/sec
80-column Card	16 col/sec
Teletypewriter	10 char/sec

The machine can accomodate any three of the above output devices simultaneously. Punched paper tape may be any code, 5 to 8 level.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	
5727	10 - 30 (10 tubes/output device)
Diodes	
Primarily 1N636	2,300
Transistors	
Primarily 2N412	383

CHECKING FEATURES

Parity check on input and output.
Parity may be omitted.

Action taken on parity failure depends upon program. With Teletype or other parity-less codes, parity is not used.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.850 Kw	0.940 KVA	0.9 pf
Volume, computer		48 cu ft	
Area, computer		15 sq ft	
Room size		10 ft x 10 ft	
Floor loading		30 lbs/sq ft	
		100 lbs concen max	
Weight, computer		375 lbs	

System requires 15 amp, 110 volt, AC, 60 cps line.

PRODUCTION RECORD

Number produced to date	7
Number in current operation	6
Time required for delivery	6 - 9 months

COST, PRICE AND RENTAL RATES

Cost of computer with operator desk, 1 typewriter, 1 tape reader, and 1 tape punch	$24,500
Additional Equipment	
16-key numeric keyboard	300
Tape Reader	1,250
Tape Punch	700
Typewriter	2,350
Buffer for third device	600

Above prices are approximate.

Monthly rental of computer with operator desk, 1 typewriter, 1 tape reader, and 1 tape punch, including service $700

Maintenance contracting is $1,200/year after 90-day service guarantee.

PERSONNEL REQUIREMENTS

Manufacturer makes a programmers' school available to users. One operator is required for each 8-hour shift. Virtually no operator training is required.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Conservative solid-state design assures long life and wide margins under all but the most extreme operating conditions. Pluggable printed circuit boards provide trouble-free operation as well as ease of maintenance. Monrobot XI operates with full ±25% voltage margins at 110°F ambient.

ADDITIONAL FEATURES AND REMARKS

The Monrobot Mark XI accepts alpha-numeric information in any code from up to three independent input devices and can output information to any combination of three independent devices.

System can simultaneously prepare independent output documents in any format, and can merge transaction and unit record input tapes in any format.

MONROBOT MU

Monroe Multiple-Unit General Purpose Computer

MANUFACTURER

Monroe Calculating Machine Company
Electronics Division

Photo by Monroe Calculating Machine Company, Electronics Division

APPLICATIONS

Item inventory and monetary accounting.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal and sexadecimal
Binary digits/word	96
Decimal digits/instruction	12
Instructions per word	2
Instructions decoded	36
Instructions used	36
Arithmetic system	Fixed point (arbitrarily located)
Instruction type	Three address (modified)
Number range	Variable

Words may be made up of either numeric or alpha-numeric characters.

ARITHMETIC UNIT

	Includ Stor Access Microsec
Add time	8,000
Mult time	68,000
Div time	77,000
Construction	Vacuum tubes and crystal diodes
Basic pulse repetition rate	60 Kc/sec (rapid access) 104 Kc/sec (general storage)
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

STORAGE

Media	Words	Access Microsec
Magnetic Drums	20,000/drum (general storage)	25,000 (avg)
Magnetic Drum	10 (rapid access)	1,600
Magnetic Tape (2)	12,000/unit	

The large capacity drums are for general storage and utilize saturable core reactors for track selection. The number of drums utilized is based upon application requirements.

INPUT

Media	Speed
Keyboard (Flexowriter)	10 char/sec
Keyboard (Model 28 Teletype 12 Units)	6 char/sec
Paper Tape (Ferranti)	200 char/sec
Magnetic Tape	400 char/sec

OUTPUT

Media	Speed
Paper Tape (Flexowriter)	10 char/sec
Printed Page (Flexowriter) and Model 28 Teletype)	10 char/sec
Magnetic Tape	400 char/sec

CHECKING FEATURES

Parity checks
MAID (Monroe Automatic Internal Diagnosis)
System used for malfunction detection and location.

INSTALLATIONS

System was installed for the U. S. Air Force under Contract No. AF33(616)-2158.

NAREC

Naval Research Electronic Computer

MANUFACTURER

U. S. Naval Research Laboratory

APPLICATIONS

General purpose scientific calculation and data processing.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	48
Binary digits/instruction	24
Instructions/word	2
Instructions decoded	44
Arithmetic system	Fixed point
Instruction type	One address
Number range	-1 to +1

Instruction word format

Address				Order	
4	4	4	4	4	4

Half-word, six four-bit sexadecimal characters

Automatic built-in subroutines include punched tape input and output routines and variable length data transfer instructions (2 address).

Automatic coding includes floating point interpretive routines, containing standard mathematical subroutines as basic instructions.

Registers:

7 - 48 bit parallel registers in arithmetic section, including one adder and one inverter of which two are directly programmable.
1 - 48 bit parallel register in control section

Official United States Navy Photo

1 - 16 bit parallel register in control section (program counter)
1 - 48 bit serial - parallel output buffer register
2 - 48 bit multiple use comparator registers
1 - 48 bit core memory information register
1 - 14 bit core memory address register
2 - 48 bit and 1 - 16 bit manual switch registers

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	22	6
Mult	300-600	same (approx range)=450
Div	575-725	same (approx range)=650

Division = 10 per digit (excluding access) for numerator = 0

Construction (Arithmetic unit only)

Type	Quantity
Vacuum tubes	
5687	600
5670	600
6AN5	100
Total	1,300
Transistors	0
Crystal diodes	16,000
Arithmetic mode	Parallel
Timing	Asynchronous
Operation	Sequential

Input-output is partially concurrent

STORAGE

Media	No. of Words	No. of Digits
Magnetic core	16,384	786,432
Memory cycle time is 8 microseconds		
Magnetic drum	8,192	393,216
Maximum drum access is 33,333 microseconds		
Magnetic tape		
No. of units that can be connected	16 Units	
No. of chars/linear inch	600 Chars/inch	
Each line across the tape contains 2 characters of 8 bits each. Packing density = 300 lines/inch.		
Channels or tracks on the tape	16 Tracks/tape	
Blank tape separating each record	.75 Inches	
Tape speed	120 Inches/sec	
Transfer rate	72 KC Chars/sec	
Start time	3 Millisec	
Stop time	2 Millisec	
Physical properties of tape		
Width	1 Inch	
Length of reel	2400-3600 Feet	
Composition	Mylar	

The above information on magnetic tape is preliminary only, as definite plans are now being formulated. The tape system should be installed in the NAREC by July 1961.

INPUT

Media	Speed
Magnetic Tape	120 in/sec
Paper Tape	25-100 in/sec

Dual speed photoelectric reader at 250 and 1000 char/sec using mylar-aluminum foil and paper tape.

OUTPUT

Media	Speed
Paper Tape	60-110 char/sec
High and medium speed paper tape punches	
Magnetic Tape	120 in/sec
Line Printer	

Line Printer will be installed by July 1961.
Speed of 600-1200 lines/minute is anticipated.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity	
Tubes		
5687	600	
5670	600	
6AN5	100	
	1,300	

Does not include electrostatic memory which is being replaced by magnetic core memroy.

Diodes		
1N89	16,000	
SG22	1,800	
DR211	7,000	
1N690	4,000	
650C5	250	Zener Diodes
651C0	350	(Texas Instruments)
651C7	600	
	30,000	

1N89 used in arithmetic section. All others used in magnetic core memory.

Transistors	
2N1478	1,000
2N600	500
2N1122	3,000
2N1123	300
	4,800

All Philco transistors are used in Telemeter Magnetics Core Memory.

Magnetic Cores		
.050 inch x .030 inch	900,000	
Telemeter Magnetics 501-10		
Capacitors	10,000	(core memory)
	3,000	(arith. section)
	13,000	
Resistors	20,000	(core memory)
	7,000	(arith. section)
	27,000	

CHECKING FEATURES

Automatic comparison bit by bit of all transfers between registers in arithmetic and control sections by means of 2 - 48 bit comparator registers.

Magnetic tape system will have conventional parity checks and sense instructions.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	25 Kw
Power, air conditioner	15 Kw
Volume, computer	1,000 cu ft
Area, computer	125 sq ft
Room size, computer	30 ft x 80 ft
Capacity, air conditioner	25 Tons
Weight, computer	5,000-10,000 lbs

Site preparation included concrete trenches in floor for power wiring and coaxial cables. Power includes both M-G sets and electronic power supplies.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

COST, PRICE AND RENTAL RATES

Total system cost approximately $1,500,000.

PERSONNEL REQUIREMENTS

	One 8-Hour Shift	Two 8-Hour Shifts
Supervisors	2	2
Programmers	10	20
Clerks	2	2
Engineers	1	2
Technicians	3	5

Operation tends toward semi-open shop. Includes programmers in central facility and in other groups of the Laboratory. Programmers above includes analysts and coders. The above does not provide for magnetic tape or printer operation. Technicians above includes operators.

Training made available by manufacturer includes in-service programming courses by Research Computation Center for rest of the NRL.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Approximately 1 hour per shift is required for scheduled maintenance.

Operating efficiency (ratio of good time to scheduled operating time) has averaged 85% over the past four years (1956-1960) of full time operation. This is expected to improve considerably in the future due to the current replacement of electrostatic storage by magnetic core storage.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include a special console, which displays the contents of core memory address abd information registers and permits direct manual read and write to core memory locations.

Unique system advantages include computation monitored from control console without loss of time to stop computer at desired location or instruction in many different ways in order to facilitate program and machine checking. Instruction code and layout is very simple to use and remember, yet is extremely powerful and flexible.

Flexowriters are used in parallel to print results of several problems simultaneously. A centralized operating area consists of photoelectric tape readers, high speed punch, Flexowriter and core memory console adjacent to main control console.

FUTURE PLANS

Magnetic core memory installed in October 1960. Magnetic tape system and line printer will be installed by July 1961.

INSTALLATIONS

U. S. Naval Research Laboratory
Washington 25, D. C.

NATIONAL 102 A

National Cash Register Company
Model CRC 102A
Built by former Computer Research Company

MANUFACTURER

National Cash Register Company

Photo by U. S. Army Chemical Center

APPLICATIONS

Manufacturer
General purpose scientific applications

Chemical Warfare Laboratories, U.S. Army Chemical Center
Scientific

U.S. Naval Ordnance Test Station (China Lake)
Data reduction general purpose

U.S. Naval Postgraduate School
Located at Monterey, California, the system is used for scientific applications, including student and faculty research in practically all phases of the physical sciences, for data processing, including weather prediction, and for simulation, including electronics systems and games (business, industrial and military).

Holloman Air Development Center (ARDC)
Trajectory calculations, heat transfer problems, solution of various kinds of linear simultaneous equations and other algebraic equations.

U.S. Air Force School of Aviation Medicine
Located at Brooks Air Force Base, Texas, the system is used for matrix algebra (Covariance, symmetric and non-symmetric mult. and inversion programs, corr), factor analysis (Factoring the correlation matrix and rotating the factor vector), for general analysis statistics (Mean, variance, and st. deviations; and analysis of variance), time series analysis (Circular serial correlation, autocorrelations, periodograms), and for Monte Carlo methods, generating pseudo random fractions (runs, means, frequency).

PROGRAMMING AND NUMERICAL SYSTEM

Manufacturer	
Internal number system	Binary
Binary digits/word	42 (One for timing)
Binary digits/instruction	41
Instructions per word	1
Instructions decoded	27
Instructions used	27
Arithmetic system	Fixed point
Instruction type	Three address
Number range	$-(1-2^{-36})$ to $(1-2^{-36})$

Photo by U.S. Naval Post Graduate School
Official Photograph U.S. Navy

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	19,900	7,400
Mult	37,500	25,000
Div	38,500	25,800
Construction	300 Vacuum tubes 4,000 Diodes	
Rapid access word registers	8	
Basic pulse repetition rate	100 Kc/sec	
Arithmetic mode	Serial	
Timing	Synchronous	
Operation	Sequential	

The speed can be increased by a factor of 8 when a buffer is used.

STORAGE

Media	Words	Microsec Access
Magnetic Drum	1,024	12,500 (avg)
Magnetic Tape	112,800/reel	6,000

Up to 7 tape units may be used with one computer.
Magnetic drum rotates at 40 rev/sec.

INPUT

Media	Speed
Manufacturer	
Flexowriter	Typing Speed
Punched Paper Tape	10 char/sec
Magnetic Tape	1.6 char/millsec
U.S. Army Chemical Center	
Flexowriter	Typing Speed
Punched Paper Tape	10 char/sec
Magnetic Tape	64 words/sec
U.S. Naval Ordnance Test Station	
Punched Paper Tape	10 char/sec
IBM Cards (523 modified)	50 cards/min
U.S. Naval Post Graduate School	
Paper Tape	10 char/sec
Cards	60 cards/min
	240 words/min
Magnetic Tape	60 words/sec
School of Aviation Medicine	
Flexowriter	Typing Speed
Punched Paper Tape	10 char/sec
IBM Cards	50 or 100 cards/min
Magnetic Tape	1.6 char/millisec

OUTPUT

Media	Speed
Manufacturer	
Magnetic Tape	600 char/sec
Flexowriter	10 char/sec
Punched Paper Tape	10 char/sec
U.S. Army Chemical Center	
Magnetic Tape	64 words/sec
Flexowriter	10 char/sec
Punched Paper Tape	10 char/sec
U.S. Naval Ordnance Test Station	
Flexowriter	10 char/sec
Punched Paper Tape	10 char/sec
IBM Cards (523 modified)	50 cards/min
U.S. Naval Post Graduate School	

A digital point is used, which operates independently of computer. No conversion is necessary for plotting. The plotter is manufactured by the California Computer Products Corporation.

Paper Tape	10 char/sec
Cards	60 cards/min
Magnetic Tape	60 words/sec
School of Aviation Medicine	
Flexowriter	10 char/sec
Paper Tape	10 char/sec
Cards	50 or 100 cards/min
Magnetic Tape	600 char/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	400
Tube types	12
Crystal diodes	8,000

U.S. Army Chemical Center

Tube types used include 12AT7, 12BH7, 6BQ7, 5687, 5963, 6080, 5881, and 6AN5. System utilizes 265 tubes and 6,000 diodes and consists of operators console, computer proper, and magnetic tape unit.

CHECKING FEATURES

Duplicate recording on magnetic tape
"Overflow" alarm"
"No command" alarm

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer			
Power, computer		7.7 Kw	
Weight, computer		2,700 lbs	

U.S. Army Chemical Center

Computing system occupies 135 cu ft, air conditioner 48 cu ft. The computing system weighs 3,400 lbs, air conditioner weighs 12,000 lbs. The capacity of the air conditioner is 6 Tons.

U.S. Naval Ordnance Station

System operates a 230v ±5% line, liberates 35,000 BTU/hour. Computer occupies 72 cu ft and 12 sq ft (Dimensions are 30 by 59 by 73 inches).

U.S. Naval Post Graduate School

Power, computer	5.5 Kw	7.7 KVA	0.71 pf
Volume, computer		108 cu ft	
Volume, air conditioner		360 cu ft	
Area, computer		18 sq ft	
Area, air conditioner		36 sq ft	
Room size	Approx	2,800 sq ft	
Floor loading		200 lbs/sq ft	
		700 lbs concen max	
Capacity, air conditioner		25 Tons	
Weight, computer	Approx	2,000 lbs, total	

Lobby section of one of the school buildings was partitioned. False flooring, air conditioning and power were installed in the laboratory section which houses two computers (CDC 1604 and NCR-CRC-102A) and their associated peripheral equipment.

School of Aviation Medicine

Power, computer	5.5 Kw	7.7 KVA	0.7 pf
Volume, computer		72 cu ft	
Area, computer		12 sq ft	
Room size		20 ft x 12 ft	
Floor loading		225 lbs/sq ft	
		60 lbs concen max	
Capacity, air conditioner		5 Tons	
Weight, computer		2,700 lbs	
Air conditioner		central unit	

System required primary power source due to sensitivity to power fluctuations.

PRODUCTION RECORD

Manufacturer	
Produced	16
Operating	16

COST, PRICE AND RENTAL RATES

U.S. Army Chemical Center

Approximate cost of basic system	$70,000
Approximate cost of additional equipment	$25,000
Rental rates for basic system	$ 2,400/month

U.S. Naval Post Graduate School

Computer, 2 tape drives, console, Flexowriter (paper tape reader and punch), point plotter cost approximately $100,000.

Rental rates for additional equipment, to include the 2 IBM 523, IBM 402, IBM 082, and IBM 026 is $600 per month.

Approximately $9,500 per year is paid to the National Cash Register Company for maintenance service.

School of Aviation Medicine

The 102A Computer cost approximately $80,000.
The 126A Magnetic Tape Unit cost approximately $15,000.
Two IBM Summary Punches (No. 523) rent at approximately $2,100 per year.
Air Force personnel perform servicing of the system.

PERSONNEL REQUIREMENTS

U.S. Army Chemical Center

One 8-hour shift requires 1 engineer and 1 technician-operator.

U.S. Naval Ordnance Test Station

One 8-hour shift requires 1 engineer, 2 programmers, and 1 "open shop" personnel.

U.S. Naval Post Graduate School

The computers are available for student and faculty research 24 hours per day. Those students and faculty who have been checked-out on the operation of the computers and peripheral equipment are permitted out-of-hours production runs on the computers. Potentially the school has approximately 1,000 programmer-operators under this system. At the present time the CDC 1604 operates approximately 14 hours per day and the NCR 102A 20 hours per day, 7 days per week.

Course work is given in the Engineering School on programming, operation and applications.

Seminars are given at the school.

School of Aviation Medicine

	One 8-Hour Shift
Analysts	1
Programmers	1
Operators	1
Engineers	1

Operation tends toward open shop.

On-the-job training (OJT) is given.

Gulf Research and Development Company

Central computing section consists of 1 engineer, 1 operator, 1 secretary-librarian, and 5 administrative, numerical analysis and programming personnel, for slightly more than an 8-hour shift.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

U.S. Army Chemical Center

Good time	3,380 hours
Attempted to run time	5,200 hours
Operating ratio (Good/Attempted to run time)	0.65

Figures based on a 2.5 year period
Passed Acceptance Test Jun 54

U.S. Naval Ordnance Test Station

Average error-free running period	80 hours
Operating ratio (Good/Attempted to run time)	0.90

Figures based on period 1 Jan 55 to 10 Nov 56
Passed Acceptance Test 1 Jun 54

U.S. Naval Post Graduate School

Passed Acceptance Test Summer of 1953
Time is not available for rent to outside organizations.

Since August 1958, the NCR 102A has averaged in excess of 100 hours per week operating time and has averaged less than 2 hours per week of forced down-time due to equipment failure. Each working day there is a two hour preventive maintenance period.

School of Aviation Medicine

Good time	36 Hours/Week (Average)
Attempted to run time	40 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.90

Above figures based on period from Fall 54 to 1 Jul 59
Time is not available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

Holloman Air Development Center (ARDC)

Two systems have been in use since 1953. Additional input/output equipment includes 3 magnetic tape units (NCR 128), and 1 summary card punch (IBM 523).

U.S. Army Chemical Center

The three-address system permits ease of programming and coding not present in one or two address systems.

Additional features include: Bit positions available in the structure of commands for flagging internal addresses for automatic coding and repositioning of programmed routines. Logic designed such that automatic links to and from subroutines are accomplished easily. Large storage capacity and three-address commands. Tape unit searches independently of the computer, once the block address is set up. High speed paper tape input reader. A visual display of the control register while computing and when idle. All logical diodes accessible, diodes are of clip-in type, plug-in units replaceable for repair.

U.S. Naval Post Graduate School

The system is used primarily for the education of the officers in the Engineering School. Other computing time after normal training hours is used by government agencies in the Monterey area on a non-interference basis.

The plotter output is considered to be a very valuable part of the system permitting rapid observation of results. The binary information is plotted directly on graph paper, thus avoiding the problem of converting to decimal. The plotter has three plotting symbols.

Gulf Research and Development Company

Auxiliary equipment consists of:
2 NCR 126 Magnetic Tape Units.
Two Flexowriters, each capable of serving as the input-output device for the computer. A third Flexowriter, not modified, for input-output functions.

One IBM 514 Reproducing Punch, modified for use as an output device.

A photoelectric paper tape system based upon a Ferranti reader has been constructed.

Two more one-word recirculating registers have been made addressable, making them correspond roughly to the accumulator and Q-register of a typical one-address computer.

INSTALLATIONS

Holloman Air Development Center (ARDC)
Holloman Air Force Base, New Mexico

School of Aviation Medicine
Randolph Air Force Base, Texas

Chemical Warfare Laboratories
U. S. Army Chemical Center, Maryland

U. S. Naval Ordnance Test Station
China Lake, California

U. S. Naval Post Graduate School
Monterey, California

A. V. Roe, Ltd.
Malton, Ontario, Canada

Great Lakes Pipe Line Company
Kansas City, Missouri

Gulf Research and Development
P. O. Drawer 2038
Pittsburgh 30, Pennsylvania

Polytechnic Institute of Milan
Milan, Italy

Royal Canadian Air Force
Edmunton, Alberta, Canada

NATIONAL 102D

NCR CRC Model 102 D

MANUFACTURER

The National Cash Register Company

APPLICATIONS

Manufacturer

General purpose scientific application

Pitman-Dunn Laboratories

The system is used for general scientific computing, to include trajectories, other differential equations, interior and exterior ballistics, fire control problems, curvefitting, solution of algebraic equations, simulations, etc.

The National Cash Register Company

Located at the Research and Development Division, The National Cash Register Company, Dayton, Ohio, the system is used to support the physical and chemical investigations of the Research and Development Division by processing experimental data originating in the research and engineering laboratories. Work in such fields as logical design, wiring diagrams for logical systems, cam design, and statistical analysis of data are typical of the applications made.

Photo by The National Cash Register Company

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	9 plus 6 bin dig/word
Binary digits/instruction	42
Instructions per word	1
Instructions decoded	27
Arithmetic system	Fixed point
Instruction type	Three address
Number range	$-(1-10^{-9})$ to $+(1-10^{-9})$
or	
	$-(1-2^{-36})$ to $+(1-2^{-36})$

1 Computer, 2 Control Consol, 3 High Speed Paper Tape Reader, 4 Magnetic Tape Units, 5 High Speed Paper Tape Punch

Photo by The National Cash Register Company

ARITHMETIC UNIT

Manufacturer	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	7,800	4,000
Mult	21,100-49,100	15,000
Div	21,100-53,200	15,500
Construction	Vacuum tubes	
Rapid access word registers	8	
Basic pulse repetition rate	100 Kc/sec	
Arithmetic mode	Serial	
Timing	Synchronous	
Operation	Sequential	

STORAGE

Manufacturer Media	Words	Digits	Access Microsec
Magnetic Drum	1,024	43,008	12,500 avg
Magnetic Tape	102,000/reel	918,000/reel	

Pitman-Dunn Laboratories Media	No. of Words	No. of Digits/Word	Min Access Microsec
Magnetic Drum	1,032	14 octal or 9 decimal	390
Magnetic Tape	110,000	Same	

Magnetic tape searches approx. 90"/sec., reads/writes 15"/sec. (approx. 59 words/sec)

INPUT

Manufacturer Media	Speed
Paper Tape (Flexowriter)	10 char/sec
Paper Tape (Photoelectric)	200 char/sec
Magnwtic Tape	600 char/sec
Keyboard (Flexowriter)	Manual
Punched Cards	4,000 char/min

Pitman-Dunn Laboratories	
Keyboard or Paper Tape	6 char/sec
Hi-Speed Tape Reader	160 char/sec
Magnetic Tape	59 words/sec
IBM Card Reader	100 cards/min

Six channel Flexowriter is used. Cards contain 4 words each.

OUTPUT

Media	Manufacturer Speed
Paper Tape (Flexowriter)	10 char/sec
High Speed Punch	60 char/sec
Magnetic Tape	600 char/sec
Punched Cards	4,000 char/min
Pitman-Dunn Laboratories	
Typed Page	6 char/sec
Paper Tape (High Speed)	60 char/sec
Card (IBM)	100 cards/min

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

	Manufacturer
Tubes	425
Tube types	15
Crystal diodes	8,500

CHECKING FEATURES

Manufacturer

Duplicate recording on magnetic tape
"Overflow" alarm
"No command" alarm

Photo by The National Cash Register Company

POWER, SPACE, WEIGHT, AND SITE PREPARATION

	Manufacturer		
Power, computer	7.7 Kw		
Area, computer	250 sq ft		
Weight, computer	2,700 lbs		
Pitman-Dunn Laboratories			
Power, computer	8.2 Kw	11.6 KVA	0.71 pf
Power, air conditioner		61.5 KVA	
Volume, computer		154.5 cu ft	
Volume, air conditioner		2,318 cu ft	
Area, computer		49 sq ft	
Area, air conditioner		206.5 sq ft	
Room size, computer		19 ft x 39 ft	
Room size, air conditioner		11 ft x 25 ft	
Floor loading		84 lbs/sq ft	
		425 lbs concen max	
Capacity, air conditioner		60 Tons 720,000 BTU	
Weight, computer		4,110 lbs	
Weight, air conditioner		6,600 lbs	
Weight, cooling tower		2,500 lbs	

Power includes Input-Output systems.

One 5 KVA and one 10 KVA Sol A transformers are used for voltage regulation. Power outlets for main computer and auxiliary equipment were installed. Air

conditioner services personnel and an analog computer also.

COST, PRICE AND RENTAL RATES

Manufacturer

Approximate cost of basic system	$65,000
Approximate cost of additional equipment	
Magnetic Tape Unit Model 126	$16,000
High Speed Reader Model 160	9,500
High Speed Punch Model 170	5,000
Flexowriter	2,900
Rental rates for basic system	$2,400/month
Rental rates for additional equipment	
High Speed Reader Model 160	275/month
High Speed Punch Model 170	220/month
Flexowriter	150/month

Pitman-Dunn Laboratories

Computer w/console, Flexowriter mag. tape unit, hi-speed reader, hi speed punch, including transportation and installation cost $83,370.

Off-line Flexowriter cost $2,900 additional.

IBM equipment includes 2-523's, 2-026's, 1-082, 1-085, 1-514, and 1-402, which rents at $12,624/year.

Maintenance for purchased equipment is $12,624/year.

PERSONNEL REQUIREMENTS

Pitman-Dunn Laboratories

	One 8-Hour Shift
Analysts	1
Programmers	2
Technicians	1

Photo by the Georgia Institute of Technology

Operation tends toward closed shop.

Methods of training includes basic programming course and use of the programming manuals. Programmers code and run their own problems.

The National Cash Register Company

	One 8-Hour Shift
Supervisors	1
Coders, Programmers & Analysts	3
Technicians	1

Operation tends toward open shop. Individuals may have programs entirely written by department personnel, written by themselves with assistance from department, or written entirely by thwmselves. Individuals desiring running time for a problem most commonly supply their own operator.

Methods of training used includes on-the-job training of department personnel, informal training of other research personnel.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Pitman-Dunn Laboratories

Average error-free running period	4 Hours
Good time	26 Hours/Week (Average)
Attempted to run time	39 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.67

Above figures based on period 1 Apr 59 to 30 Apr 60
Passed Customer Acceptance Test Jan 58
Time is not available for rent to outside organizations.
4 hours of preventive maintenance is performed.

The National Cash Register Company

Good time	28.5 Hours/Week (Average)
Attempted to run time	32 Hours/Week (Average)

High Speed Reader

Operating ratio (Good/Attempted to run time) 0.89
Above figures based on period from Jul 59 to Aug 60
Time is not available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

Pitman-Dunn Laboratories
Outstanding features include 3 address system, which is easy to use.

Photo by The National Cash Register Company

FUTURE PLANS

Pitman-Dunn Laboratories
System expected to be replaced by second quarter Fiscal Year 61 with system comparable with DATATRON 205, IBM 650, or UNIVAC Solid State.

High Speed Punch

Photo by The National Cash Register Company

INSTALLATIONS

Dow Chemical Company
Midland, Michigan

Rice Electronic Computer Center
Georgia Institute of Technology
Atlanta, Georgia

Research and Development Division
The National Cash Register Company
Dayton, Ohio

The National Cash Register Company
Hawthorne, California

Pitman-Dunn Laboratories
Frankford Arsenal
Philadelphia, Pennsylvania

NATIONAL 107

National Cash Register Corporation Model 107

MANUFACTURER

National Cash Register Corporation

Photo by U. S. Naval Academy

APPLICATIONS

Located in Ward Hall, U. S. Naval Academy, the system is used to demonstrate to Naval Academy faculty and midshipmen, automatic calculations using a large data processing/scientific type digital computer.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	11
Decimal digits/instruction	2
Instructions/word	1 + sign
Instructions decoded	22
Arithmetic system	Fixed point
Instruction type	Three address
Number range	$-(1 - 10^{-9}) \leq x \leq 1-$

The excess-three system of binary coded decimal notation is used.

ARITHMETIC UNIT

		Incl Stor Access
Operation Time		Microsec
Add		15,000
Mult		40,000
Div		40,000
Construction (Arithmetic unit only)		
Vacuum-tubes	625	
Diodes	2,040	
Arithmetic mode	Parallel	
Parallel by bit, serial by digit.		
Timing	Synchronous	
Operation	Sequential	

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Drum	11,000	121,000	3,000

Magnetic Tape

No. of units that can be connected	99	Units
No. of char/linear inch of tape	134	Char/inch
Channels or tracks on the tape	10	Tracks/tape
Blank tape separating each record	10	Inches
Tape speed	15	Inches/sec
Transfer rate	2,010	Char/sec
Start time	3	Millisec
Stop time	3	Millisec
Average time for experienced operator to change reel of tape	120	Seconds
Physical properties of tape		
Width	1	Inch
Length of reel	3,600	Feet
Composition	Mylar or Acetate	

All tape must initially be pre-clocked off-line.

INPUT

Media	Speed
Card (IBM)	100 cards/min
Magnetic Tape	15 in/sec, 121 char/in
Paper Tape	120 char/min
Keyboard (Flexowriter)	Manual

OUTPUT

Media	Speed
High Speed Printer	600 lines/min, 120 char/line
Magnetic Tape	15 in/sec, 121 char/in
Cards (IBM)	100 cards/min
Typewriter (Flexo)	120 char/min
Paper Tape	120 char/min

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	800
Diodes	2,500

CHECKING FEATURES

Unwanted Digit
Command Check
Overflow
Conditional Halt

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	208 Volts	3 phase	60 cps
Power, air cond	208 Volts	3 phase	60 cps
Volume, computer	65,774 cu ft		
Volume, air conditioner	126 cu ft		
Area, computer	1,711 sq ft		
Area, air conditioner	18 sq ft		
Room size, computer	1,800 sq ft		
Capacity, air conditioner	15 Tons		
Weight, computer	12,000 lbs		
Weight, air conditioner	1,000 lbs		

Building was modified for computer installation.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

Produced for U. S. Navy Bureau of Aeronautics to their design specifications.

COST, PRICE AND RENTAL RATES

Basic System

Original cost, $1,000,000 to Navy BUAER (original owner). System consists of control console, arithmetic section, high speed printer, 8 magnetic tape units, and memory section.

Additional Equipment

For the IBM 514, IBM 523, IBM 024, the total rent is $108.00 per month (including educational discount 60%).

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Supervisors	1
Operators	2
Technicians	3

Operation tends toward open shop.

Methods of training used is classroom and on-the-job training.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Operating experience over four year period approximately 98% of scheduled production at previous location in Washington, D. C. (Navy Bureau of Weapons).

ADDITIONAL FEATURES AND REMARKS

Outstanding features are block search on tape handles at rate of 600 words/sec, off-line preparation and verification of tape input, and large memory with maximum of 10 word access.

FUTURE PLANS

Addition of X-Y plotter and weapons system simulation for educational purposes.

INSTALLATIONS

U. S. Naval Academy
Weapons Department
Annapolis, Maryland

NATIONAL 304

National Cash Register 304

MANUFACTURER

National Cash Register Company

Photo by National Cash Register Company

APPLICATIONS

Manufacturer

The system is a general-purpose data processing system for industrial, governmental and educational organizations. It is intended for commercial and scientific applications. All commonly-used inputs and outputs, a magnetic tape system with unique characteristics, and flexibility in system organization result in a powerful system with versatility of application.

U.S. Marine Corps, Camp Lejeune

Located on the base, the system is used for USMC personnel accounting.

U.S. Marine Corps, Camp Pendleton

Located at the U. S. Marine Corps, Camp Pendleton the system will be used to maintain current magnetic tape records on approximately one half the Active and Organized Reserve Establishments of the Marine Corps. Weekly, Changed Record Tapes will be forwarded to Headquarters, Marine Corps to overlay Headquarters' Tape Records. Headquarters will prepare personnel reports for itself, Navy Department, and Department of Defense from its Magnetic Tape Files. Meanwhile, this installation will prepare "Field Personnel Reports" for 14 major field commands in the western complex. (DPI, MCB, Camp Lejeune, North Carolina performs the same function for the eastern complex, i.e., the other half of the Marine Corps.) Implementation of the system is scheduled for August 1960.

U.S. Marine Corps, Headquarters

Located at the Arlington Navy Annex, the system is utilized for military personnel accounting.

The three U.S. Marine Corps NCR 304 Data Processing Systems are utilized in an integrated Military Personnel Accounting and Reporting System. The systems located in California and North Carolina servicing the two major Marine Corps bases and reporting to the system located in Washington D. C.

American United Life Insurance Company

Located at 30 W. Fall Creek Parkway, N. Dr. - Indianapolis, Indiana, the system is used to maintain Master Tape Files of policyholders, agents, payroll, general ledger, mortgages, securities, update daily any transactions that affect any master record or file, compute commissions, journalize daily - Maintain accounting controls, balance books of account. Perform premium billing and policy conservation advices, control disbursements, bank reconciliations, and compute dividends, cash values, premiums, reserves, interest, etc.

S. C. Johnson & Son, Inc.

Located at 1525 Howe Street, Racine, Wisconsin, the system is used for order processing, inventory control, accounts receivable, credit and collection, freight allocation, sales statistics, and allied financial reports.

National Cash Register Company, Hawthorne

Located at the National Cash Register's Electronics Division, Hawthorne, California, the system is used for electronic data processing service to business, industry and government. Complete facilities for handling customer created input - punched paper tape and cards. It is used for program check out for 304 customers. The system is used internally by the National Cash Register Company for programming research, automated logical design, and data processing. Back up support for other 304 systems is additional use.

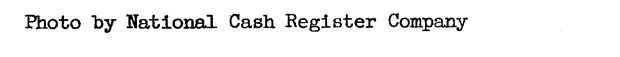


Photo by National Cash Register Company

Bureau of Yards and Docks

Located at the Bureau of Yards and Docks, Washington D. C., the system is used for the management of the Military Construction Program, the inventory of Automotive Equipment, the inventory of Construction Equipment, and for engineering applications.

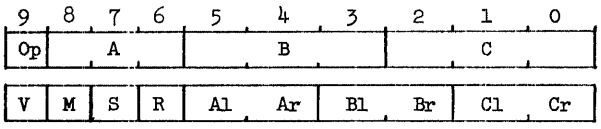
PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary Coded Decimal
Alphanum char/word	10
Alphanum char/word	5 - 60
Words/instruction	1/2 - 6
Instructions decoded	83 one address
	37 three address w/variations
Arithmetic system	Floating point
MICROFLOW provides exponents in range of -50 to + 49 and automatic normalizing of result	
	Fixed point
Automatic alignment takes place	
Instruction type	One address (MICROFLOW)
	(Scientific-type)
	Three address (Multi-address)
	(Business-type)
Number range	$-(1-10^{-10})$ to $+(1-10^{-10})$

Photo by American United Life Insurance Company

Instruction word format

The command structure of the 304 system is unique in a number of aspects. The instructions are basically 3 address plus a number of other functions or capabilities that are built into the execution of the instruction. The basic instruction word format for arithmetical operations such as add, subtract, etc., is illustrated:



Op = Operation Code

A = Address of Operand

B = Address of Operand

C = Putaway or Jump Address

V = Variation & Self-Linking designator

M = Auto-monitor level

S = Combinations of A, B, or C to be relative to Index Register

R = Index Register

Al, Ar = left and right field of A Address

Bl, Br = left and right field of B Address

Cl, Cr = left and right field of C Address

The programmer in translating procedures for the 304 System will use the NEAT (National's Electronic Autocoding Technique) format. The programmer might write the following to add the Old Quantity on Hand to the Number Received to arrive at the New Quantity on Hand:

```
ADD (V) (R) OQOH QREC NQOH
```

The NEAT assembly process will translate the NEAT format into the necessary absolute machine language.

It could be considered that all instructions in the basic 304 Command List are automatic built-in subroutines. There are a number of operation codes that were designed specifically for business data processing such as Edit, Merge, Move, Sift (or table look-up), and Summarize that are powerful instructions and in some cases are self-incrementing.

As an example, the Merge instruction will serve to illustrate the nature of these business-type opera-

Official Marine Corps Photo

Camp Lejeune, N. C.

tions. Specified in NEAT format would be the following mnemonic designators and parameters:

Designate first word, first item, each string
Number of items in each string
Relative position of Major Key (if any), within item
Relative position of Minor Key within item
Number of keys (1 or 2) for the Merge
Length of each item
Specify three exits (Cutoff Merge only)

NEAT (National's Electronic Autocoding Technique) was in operation before the first deliveries of the National 304 System. This system enables systematic organization in the approach to a problem, an assembly-compiler and a complete library of generators, service programs, and subroutines. COBOL or COBOL-like language will become part of the system in a reasonable time.

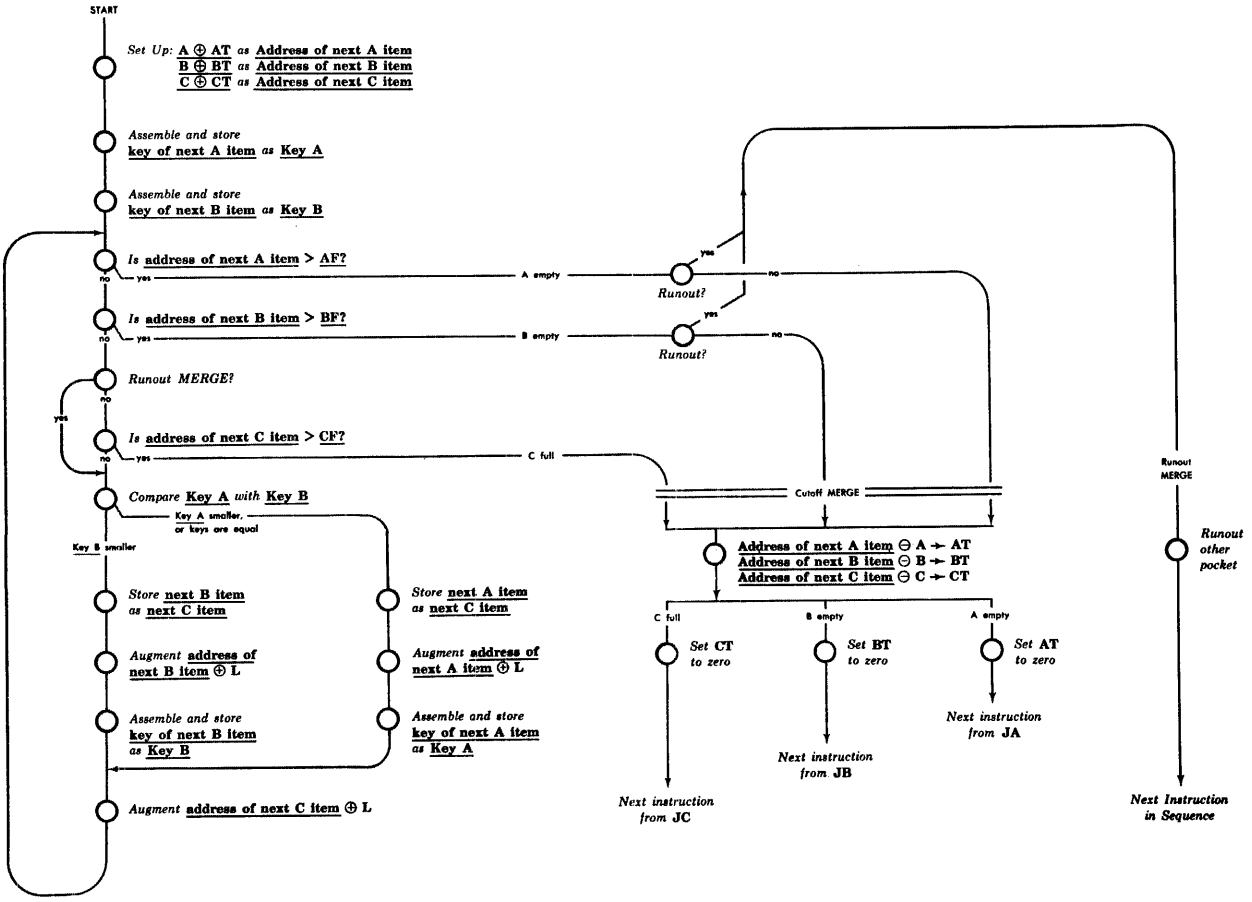
Each instruction may be relative to one of 10 Relative Index Registers. The particular Index Register and the portions of the instruction which are to be relative are specified within the instruction.

ARITHMETIC UNIT

Operation	Incl Stor Access Microsec	Exclud Stor Access Microsec
MICRO-FLOW SINGLE ADDRESS MODE		
Add	120	60
Mult	1,320	1,260
Div	3,480	3,420
BUSINESS-TYPE THREE ADDRESS		
Add	60 (10+R+L)	60 (9+R+L)
Mult	60 (17+R+L+X)	60 (16+R+L+X)
Div	60 (14+R+L+2Q+Y)	60 (13+R+L+2Q+Y)

R = 1 If relative to Index Register
R = 0 If not
L = 2 If self-linking occurs
L = 0 If not
X = Sum plus significant digits of multiplier
Q = Number of digits in quotient
Y = Sum of digits of the quotient

Construction (Arithmetic unit only)
Due to interlaced circuitry, number of elements are included in the total for the 304 Processor.
Arithmetic mode Serial by word, parallel by character
The adder is implemented with two diode-matrix half adders and one diode full adder.
Timing Synchronous in Central Processor
Asynchronous to or from peripheral units



Merge Flow Diagram

Operation — Sequential internally
Concurrent with copy or search of magnetic tape or printing

STORAGE

Media	Manufacturer No. of Words	No. of Alpha-Numeric	Access Microsec
Magnetic Core	2400-4800	24,000-48,000	6/alphanum
Magnetic Tape, per reel	850,000	8,500,000	2 1/2 min

No. of units that can be connected	64 Units
No. of chars/linear inch of tape	200 Chars/inch
Channels or tracks on the tape (including parity and markers)	8 Tracks/tape
Blank tape separating each record	None
Tape speed	150 Inches/sec
Transfer rate (alpha-numeric characters)	30,000 Chars/sec
Start time	3.5 Millisec
Stop time	3.5 Millisec
Average time for experienced operator to change reel	30 Seconds

Physical properties of tape

Width	1/2 Inch
Length of reel	3,600 Feet
Composition	1 mil mylar, laminated

The unique 304 magnetic tape system is composed of sub-systems of National 330 Controllers and National 332 Magnetic Tape Handlers. The Central 304 Processor may handle up to eight 330 Controllers, and each Controller may handle up to eight Handlers to provide an upper limit of 64 Handlers available.

A record on magnetic tape may contain 10 or more words. Multiple variable-length records may be written onto magnetic tape with a single acceleration. The contents of one magnetic tape may be read and simultaneously written onto another tape unit until a desired record is reached. The copying may be shared with computing, printing, input or output. Several copy operations may be in progress simultaneously.

All conditions which may arise during magnetic file operations are automatically detected and identified by the Processor without programmed testing. Then a standard routine, called STEP (Standard Tape Executive Program), will perform all tape management

Production

Photo by National Cash Register Company

operations including:
Repeat in case of error, write "Skip" record after proper number of tries
Repeat, or jump, on busy Handler or Controller
Indicate attempt to use locked-out tape
Alternate Tape Units at end of tape
Tape identification, and label-checking
Memory dump, and rescue points
Log of tape operations
Executive control over sequencing from one program to the next, or overlays

The time-sharing ability of magnetic tape copy allows for convenient file-splitting, or multi-programming of different jobs where reference to the file is for less than every record. Thus, completely independent programs can be written and checked out, then tied together with the timing interlace being performed by the equipment.

In order to improve the efficiency of Magnetic File Operations, any quantity of numeric information may be packed from 6-bit code to 4-bit code with a single instruction. Thus, utilization of tape storage, and transport speed, will both be increased by 50% for numeric information.

When the packed information is brought into memory, a single instruction will reverse the transformation. Only that information requiring arithmetic operation need be unpacked; sorting, table lookup, and all other logical operations, can be performed on packed information.

U.S. Marine Corps, Camp Lejeune

Medium	No. of Words	No. of Digits	Access
Core Memory	2400	10	60/word time

U.S. Marine Corps, Camp Pendleton

Magnetic Core	2400

U.S Marine Corps, Headquarters

Magnetic Core	2400
Magnetic Tape	864,000

American United Life Insurance Company

Magnetic Core	4800
Magnetic Tape	850,000

Official Marine Corps Photo

Camp Pendleton, California

S. C. Johnson & Son, Inc.

Medium	No. of Words	No. of Digits	Access Microsec
Magnetic Core	2400	10	

National Cash Register Company, Hawthorne

Magnetic Core	4800		6/alpha-num char
Magnetic Tape (10 char/word)	1.08 million word/reel		3 min

Bureau of Yards and Docks

Magnetic Core	4800	48,000	60

Magnetic Tape may be considered as storage medium.

INPUT

Manufacturer

Media	Speed	
Punched Cards	2000 cards/min	Photo-electric
Punched Paper Tape	1800 char/sec	Photo-electric
Magnetic Tape	30 Kc	alpha-numeric

Punched Cards and Punched Paper Tape may be handled on-line with the 304 Processor or converted to magnetic tape with the 320 Multi-Purpose Converter.

U.S. Marine Corps, Camp Lejeune

Media	Speed
Magnetic Tape	
Punched Cards	
Flexowriter typing	
Flexowriter Paper Tape	

U.S. Marine Corps, Camp Pendleton

Magnetic Tape	
Punched Cards	
Console Typewriter	

U.S. Marine Corps, Headquarters

Magnetic Tape	
Punched Cards	
Punched Paper Tape	
Flexowriter	

American United Life Insurance Company

Paper Tape Reader	2,000 char/sec
Optical Reader - choice of 3 codes	
Punched Card Reader	2,500 cards/min
90 column cards - read optically	
Magnetic Tape	30,000 char/sec
200 char/in - 3,600' reels	
Console Typewriter	10 char/sec
Modified Flexowriter	

Official Marine Corps Photo

S. C. Johnson & Son, Inc.

Media	Speed
Magnetic Tape	30,000 char/sec
Punched Paper Tape	1,800 char/sec
Punched Cards	2,000 cards/min
Console Flexowriter	10 char/sec

National Cash Register Company, Hawthorne

NCR 380 Card Reader	2,000 cards/min
NCR 360 Paper Tape Reader	1,800 char/sec
Console	10 char/sec
Magnetic Tape	30,000 char/sec

The Paper Tape Reader can handle 6 codes. Three core matrices are on the unit.

Bureau of Yards and Docks

Magnetic Tape	30,000 char/sec
3600 ft = 8.5×10^6 char	
Paper Tape	1,800 char/sec
3 code option, 10 char/in	
Punched Cards	2,000 cards/min
1 card = 80 chars	
Console Typewriter	10 char/sec max.

Manual type-in or paper tape read

OUTPUT

Manufacturer

Media	Speed
Punched Paper Tape	60 char/sec
Line Printer	850-1200 printing 850 alpha numeric 5040 spacing 1200 numeric (lines/min)
Punched Cards	100 cards/min
Magnetic Tape	30,000 char/sec

The Paper Tape Punch or the High Speed Line Printer may be controlled on-line by the 304 Processor or off-line by the 320 Multi-Purpose Converter. The Line Printer may also be controlled off-line by the 322 Printer Converter. Punched cards can be produced off-line using an IBM 523 with source information on magnetic tape and under control of the 320 Converter.

U.S. Marine Corps, Camp Lejeune

Magnetic Tape
Flexowriter typing & punching
Punch Cards
Printer

IBM Type 523 as IBM card output media