REPORT NO. 1115
MARCH 1961

A THIRD SURVEY OF DOMESTIC ELECTRONIC DIGITAL COMPUTING SYSTEMS

Martin H. Weik

This report supersedes BRL Report No. 1010

Department of the Army Project No. 5B03-06-002
Ordnance Management Structure Code No. 5010.11.812

BALLISTIC RESEARCH LABORATORIES

ABERDEEN PROVING GROUND, MARYLAND

B A L L I S T I C R E S E A R C H L A B O R A T O R I E S

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A B E R D E E N P R O V I N G G R O U N D, M A R Y L A N D

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REPORT NO. 1115

MWeik/vjc
Aberdeen Proving Ground, Md.
March 1961

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ABSTRACT

Based on the results of a third survey, the engineering and programming characteristics of two hundred twenty-two different electronic digital computing systems are given. The data are presented from the point of view of application, numerical and arithmetic characteristics, input, output and storage systems, construction and checking features, power, space, weight, and site preparation and personnel requirements, production records, cost and rental rates, sale and lease policy, reliability, operating experience, and time availability, engineering modifications and improvements and other related topics. An analysis of the survey data, fifteen comparative tables, a discussion of trends, a revised bibliography, and a complete glossary of computer engineering and programming terminology are included.

This report supersedes BRL Report No. 1010 (Public Bulletin 111996R, OTS, U. S. Department of Commerce).

ACKNOWLEDGMENT

On behalf of the Computing Laboratory of the Ballistic Research Laboratories, the author wishes to extend his appreciation for the excellent spirit of cooperation displayed by the various representatives of government and industry who have devoted their time and effort in responding to the survey inquiries.

Many valuable suggestions were received from the engineering and mathematical staff personnel of the Computing Laboratory of the Ballistic Research Laboratories.

The Data Systems Research Staff, Office of the Assistant Secretary of Defense, Comptroller, devoted much effort during the conduct of the survey, particularly as pertains to coordination within the Armed Services. It is the expressed intent of the Office of the Assistant Secretary of Defense, Comptroller, to reprint this report at the Government Printing Office, Washington, D. C., for sale and distribution to the public.

The greatest individual assistance was rendered by WAC Staff Sergeant Violet J. Confer. An undertaking as comprehensive as this national survey, requires that a large quantity of data be acquired, correlated, transcribed and checked. Particular attention must be paid to accuracy and detail. We are heavily indebted to Staff Sergeant Confer for the major role she has performed in all phases of preparation of this report. She has been responsible for the general conduct of the survey, the control of communications with respondents, the preparation of correspondence, screening returns, sorting returns, preparing the layout of all pages, and doing all the art work, typing, titles, and photo arrangements.

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CHAPTER I

INTRODUCTION

INTRODUCTION

PURPOSE OF THE SURVEY REPORT

Before any major decision can be made regarding the acquisition, installation, operation, improvement or retirement of computing equipment, first hand technical information must be obtained concerning the characteristics, availability, cost, operational problems, capability and useful life of available systems. Efficient management requires that the experience of others be exploited wherever such exploitation is beneficial. The present trend in the rapidly changing computing and data processing hardware field is toward higher operational speeds, increased memory capacity and reliability, and solid state electrical components, including a widespread use of semi-conductors and the advent of the use of thin magnetic films in standard commercial systems. However, only existing or readily available equipment may be utilized for the immediate solution of scientific and commercial data processing problems.

Many persons in the computing and data processing field continually seek answers to many different questions simultaneously. Some of these questions are: Can present methods, practices and procedures used in a given organization be accomplished by automatic computing and data processing equipment? Will investment in such equipment reduce costs, provide improved service, conserve manpower or save time? When shall existing computing equipment be modified, supplemented or replaced? Of all available equipment, what type of system is best suited for the solution of a given problem or a given group of problems? Is the maximum possible return being obtained from a given investment in computing equipment? Does a given problem require specially built equipment or is a solution to be found with commercially available standard equipment? Should computing equipment be rented or purchased? Should a system be installed "on the premises" or should computer time be purchased elsewhere? The purpose of a surveillance and evaluation program is to provide answers to these and similar questions.

Government agencies, particularly Department of Defense agencies, and their contractors, require the latest technical information concerning computing and data processing equipment in order to properly establish their policy regarding acquisition, installation, operation, improvement and retirement of equipment. The purpose, therefore, of this survey report is to allow government agencies and their contractors to benefit from the results of the computing system surveillance and evaluation program conducted by the Ballistic Research Laboratories.

In 1955, a survey of electronic digital computing systems was conducted by the Ballistic Research Laboratories in order to provide technical data for the evaluation of the then existing computing machine complement of the Laboratories. The results of that survey were made available in BRL Report Number 971, M. Weik "A Survey of Domestic Electronic Digital Computing Systems". The report was well received by persons in government and industry. The U. S. Department of Commerce undertook further printing and distribution of the report under cover of Public Bulletin 111996, Office of Technical Services.

A new survey of electronic digital computing systems was conducted during October, November and December 1956 and January 1957 by the Computing Laboratory of the Ballistic Research Laboratories. The new survey was conducted as part of the continuous surveillance and evaluation program of the Laboratory. The results were published as BRL Report Number 1010, June 1957. This report covered the results of the new survey and superseded BRL Report 971. The U. S. Department of Commerce undertook further printing and distribution of this report also, under cover of Public Bulletin 111996R, Office of Technical Services.

Due to the great interest which has developed in these survey reports, the Department of Defense has co-ordinated this activity among the Armed Services. This report contains the results of a third survey of domestic electronic digital computing systems.

SCOPE OF THE SURVEY REPORT

This report is limited to commercially available and existing operational electronic digital computing and data processing systems manufactured or operated within the United States. Large, intermediate and small scale systems are included, regardless of whether the determination of "scale" is based on size, weight, cost, storage capacity or any reasonable criterion. An attempt has been made to include both general purpose and special purpose equipment. It must be borne in mind that there is no clear-cut line of demarcation between systems designated as special purpose computing machines and certain "on-line" control applications, in which a computer is used to determine operational control-commands, based upon data received by the system from instruments measuring the results of the commands. These systems usually have analog input and output with internal digital computation and transformation of information to and from digital form.

Among the items not covered by this report are analog computing systems, foreign systems or separate computing system components, such as analog-digital converters, separate storage units, arithmetic units, input-output units, and data recording units, except when these are associated with specific complete systems. Many recording media converters, such as magnetic tape-to-card converters, card-to-paper tape converters, etc., are not specifically covered, except again as they are used with specific complete systems. By a "complete system" is meant an electronic digital computing system with input, output, control, arithmetic and/or logical and storage units.

PROCESSING OF THE SURVEY DATA

A consolidated system description was prepared from data made available by the user and the manufacturer. Information concerning each computing system was divided into the following sub-headings:

Applications
Programming and Numerical System
Arithmetic Unit
Storage
Input
Output
Circuit Elements of Entire System
Checking Features
Power, Space, Weight and Site Preparation
Production Record
Cost, Price and Rental Rates
Personnel Requirements
Reliability, Operating Experience and Time Availability
Additional Features and Remarks
Future Plans
Installations

The large volume of technical data processed for this report will make errors unavoidable, particularly in correlating and transcribing information. It will be appreciated if errors are brought to the attention of the Ballistic Research Laboratories. Statements, claims and criticisms were screened as much as possible. Every endeavor was made to insure that the information included in this report is factual. To a large extent certain superlative adjectives used in describing equipment, were deliberately eliminated as a matter of fairness and in order to avoid implication in sales activities.

INTERPRETATION OF THE SURVEY DATA

The interpretation of the data included in this report is perhaps the most difficult aspect of all, therefore much of this activity is left to the reader. In Chapter II, the data are grouped under alphabetically sequenced computing systems descriptions. The charts and tables in Chapter III have been prepared in order to show various relative characteristics, features and trends. A brief analysis and interpretation of the data accompanies these tables. It must be emphasized again that data concerning computing systems taken out of context or disassociated from other related data, can be misleading. Because of this, the information contained in this report, particularly the tabular data of Chapter III, must be used with appropriate caution.

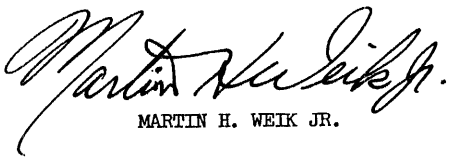
It is recommended that the prepared tables in Chapter III be used only as generalizations to show trends. Data on specific systems should be taken from the systems descriptions rather than from the prepared tables. Further details must be obtained from manufacturers or users directly. This report does not constitute an indorsement of any of the products described within it.

USE OF THE SURVEY REPORT

As has been previously stated, the computing field is a dynamic and rapidly changing one. From a technological point of view, some of the information contained in this report is obsolete. Certain computing systems may be considered obsolete when they are installed. However, in most cases, manufacturers are accepting orders and will continue to produce, the systems described in this report for quite a number of years. Chapter II contains engineering and programming descriptions of 222 different types of computing systems. Persons who are interested in the acquisition of systems will find useful information on applications, cost, personnel requirements, and power and space requirements for specific systems. Operators may find useful suggestions on modifications and improvements. The question of reliability, a particularly difficult one to resolve, has been answered to some extent under the sub-heading: Reliability, Operating Experience and Time Availability. Under each sub-heading, the source of information is given. When a source is not stated, the manufacturer is the source of data.

A List of References and a revised Glossary are given in Chapters IV and V.

It is hoped that enough general and specific technical data have been compiled in the following four chapters to permit anyone involved in the computing and data processing field to draw at least some general conclusions and find answers to the questions which may be occupying his mind at the present time.



MARTIN H. WEIK JR.

CHAPTER II

COMPUTING SYSTEMS DESCRIPTIONS

AF CRC

Air Force Cambridge Research Center Magnetic Computer

MANUFACTURER

Remington Rand Univac
Division of Sperry Rand Corporation

Photo by Air Force Cambridge Research Center

APPLICATIONS

Air Force Cambridge Research Center
Located at AFCRC, Hanscom Field, Mass., the system is used for general purpose scientific computations and as a flexible buffer for transfering data to paper tape.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	10 plus sign
Arithmetic system	Fixed point

ARITHMETIC UNIT

Operation	Incl Stor Access
Time	Microsec
Add	90
Mult	300 to 1,700
Arithmetic mode	Serial by dec dig within word
	Parallel by bit within dec dig
Pulse repitition rate	660 kilocycles/sec
Timing	Synchronous
Operation	Sequential

STORAGE

22,000 decimal digits (2,000 words, each ten digits plus sign). Aluminum drum, plated with nickel-cobalt alloy, spins at 16,500 rpm. Average access time 1.8 milliseconds. Four hundred of the 2,000 words are stored in fast-access bands with average access time of 450 microseconds. Active drum surface is 5 in. in diameter and 3 in. long.

INPUT

AFCRC

Media	Speed	
Paper Tape	180 char/sec	Alphanumeric
Typewriter	10 char/sec	Alphanumeric
Real-time Input	8,000 bits/sec	

OUTPUT

AFCRC

Media	Speed	
Paper Tape	180 char/sec	Alphanumeric
Typewriter	10 char/sec	Alphanumeric
Color Scope	7,700 points/sec	
Can be plotted in 3 colors		
Real-time Output	154,000 bits/sec	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Six hundred miniaturized circuit packages
Magnetic core Ferractors, developed by Sperry-Rand, are used as the basic logical control element for switching and amplifying.
15 Vacuum tubes are used.
All processing and control circuitry is mounted in one cabinet. Primarily solid state design.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

AFCRC

Power, computer	15 KVA, 3 phase, 208 volt, 60 cps
Volume, computer	140 cu ft
Area, computer	500 sq ft
Room size, computer	20 ft x 30 ft x 8 ft
Weight, computer	4,000 lbs

Computer unit is 6 ft high, 6 ft 6 in long and 1 ft 6 in deep. Console is 4 ft 6 in high, 6 ft long, and 3 ft deep. Cooling is by integral fan.

COST, PRICE AND RENTAL RATES

AFCRC

Cost of system is $800,000, including development costs. Development by Remington Rand Univac was sponsored by the Air Force Cambridge Research Center.

Maintenance/service contracting costs are $21,000 per man per year.

PERSONNEL REQUIREMENTS

AFCRC

	Three 8-Hour Shifts	
	Used	Recommended
Supervisors	1	1
Analysts	4	4
Programmers	4	4
Operators	2	3
Engineers	1	1
Technicians	1	3

Operation tends toward open shop.
Method of training used is by apprenticeship.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

AFCRC

Average error-free running period	30 Hours
Good time	126 Hours/Week (Average)
Attempted to run time	140 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.90

Above figures based on period 1 Apr 59 to 1 Apr 60
Passed Customer Acceptance Test Apr 56
Time is not available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

AFCRC

Outstanding feature is its solid state magnetic circuitry with a unique system of logic.

The color scope, the high-speed paper tape punch, and the circuitry for alphanumerics were added to the computer by AFCRC personnel.

FUTURE PLANS

AFCRC

The addition of a core memory of 4,096 words is anticipated. It is expected that this will speed up average computing time by a factor of 5 over minimum latency programming on the drum.

It is planned to improve the paper tape handling capability of the computer by installing newer paper tape readers and punches.

It is planned to expand the input-output capability by installing high-speed magnetic tape units.

INSTALLATIONS

U. S. Air Force
Cambridge Research Center ARDC
Laurence G. Hanscom Field
Bedford, Massachusetts

ALWAC II

Alwac (Axel-Wenner-Gren) Computer Model II

MANUFACTURER

Alwac Computer Division
El-Tronics, Inc.
Formerly Logistics Research, Inc.

Photo by U. S. Navy David Taylor Model Basin

APPLICATIONS

Located at the Aerodynamics Laboratory, Transonic Building, the system is used for wind tunnel data reduction and computation and for solving engineering and scientific problems.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	32 plus sign
Binary digits/instruction	16 or 8, depending on instruction
Instructions per word	0,1,2,3 or 4, depending on order and address combination

Arithmetic system Fixed point
Floating point can be programmed.
Instruction type One address
Some orders do not require an address, but it is basically one address system. An instruction consists of an order and an address (16 binary digits) or an order (8 binary digits). Since this computer follows orders from the first syllable (4 per word) of each of 8 words before following orders from the second syllable, each word could have 4 addresses, 1 order and 3 addresses, 2 and 2, 3 and 1 or 4 orders.
Number range $0 \text{ to } \pm 2^{32} - 1$

ARITHMETIC UNIT

	Exclud Stor Access Microsec
Add	1,000
Mult	32,000
Div	32,000

Construction (Arithmetic unit only)
Vacuum tubes and diodes

Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Input device is parallel.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Magnetic Drum	2,048	32 bits & sign	
Magnetic Drum (Fast Access)	64	32 bits & sign	8,000

Information must be copied into fast access in blocks of 32 words.

INPUT

Media	Speed
Flexowriter Keyboard	10 char/sec (alpha-numeric)
Flexowriter Paper Tape	10 char/sec (alpha-numeric)

OUTPUT

Media	Speed
Flexowriter Keyboard	10 char/sec (alpha-numeric)
Flexowriter Punch	10 char/sec (alpha-numeric)

Computer has programmed format controls.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

	Quantity
Tubes	250
Crystal diodes	3,500
Tube types	5963, 5687, 12AT7 (excluding power supply)

There are 13 different types of plug-in units.

CHECKING FEATURES

Checking features include memory verification, overflow, impossible order code, and automatic sequencing.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	4 Kw
Power, air conditioner	6 Kw
Volume, computer	158 cu ft (incl console)
Volume, air conditioner	44 cu ft
Area, computer	35 sq ft (incl console)
Area, air conditioner	7 sq ft
Room size, computer	240 sq ft
Floor loading	93 lbs/sq ft
	900 lbs concen max
Capacity, air conditioner	5 Tons
Weight, computer	2,100 lbs
Weight, air conditioner	1,000 lbs

Power is 115 V, 60 cycles, single phase. Air conditioner depends on room size and cooling. The 5 Ton air conditioner is used for 2 computers in one room. Area and volume figures include the console, but weights do not.

PRODUCTION RECORD

Number produced to date 2
No longer in current production. Model II has been superseded by the III E. (See ALWAC III E).

COST, PRICE AND RENTAL RATES

System cost approximately $50,000.
Maintenance is performed by our own electronic engineer.

PERSONNEL REQUIREMENTS

This is an old computer, still operable with nominal maintenance required. It is not used in regular production, but for miscellaneous engineering problems where its speed is relatively unimportant.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Average error-free running period	43 Hours
Good time	3,250 Hours
Attempted to run time	4,065 Hours
Operating ratio (Good/Attempted to run time)	0.80

Above figures based on period 7 Jun 54 to 16 Oct 56
Passed Customer Acceptance Test 7 Jun 54

ADDITIONAL FEATURES AND REMARKS

System advantages are order address is automatic, has a decision register, low cost, and ease of maintenance. This machine is no longer in production in favor of an improved model.

INSTALLATIONS

U. S. Navy
Bureau of Ships
David Taylor Model Basin
Washington 7, D. C.

ALWAC III E

Axel Wenner Gren Automatic Computer III E

MANUFACTURER

Alwac Computer Division
El-Tronics, Incorporated

Photo by Alwac Computer Division of El-Tronics, Inc.

APPLICATIONS

Manufacturer

System is used for computer simulation, photogrammetry analysis, on-line engine test data acquisition and reduction, automatic numerical machine tool control, linear programming and general purpose computing.

The Adjutant General, U.S.A.

System is used for analytical statistics such as correlation matrices, matrix algebra, test scoring, item analysis, test selection, and factor analysis.

David Taylor Model Basin

System is used for wind tunnel data reduction and computation, solving engineering and scientific problems, and for the solution of general engineering problems.

Offutt AFB, Nebraska

System is used for Geodesy, i.e. datum conversions, coordinate transformations, range and azimuths, and geodetic position computations; for photogrammetry, i.e. analytical triangulation, photo orientation and rectification; for intelligence reduction; and for library retrieval.

Aeronautical Structures Laboratory

High temperature, structural, fatigue, and loads research projects. Data reduction on check-out, pre liminary, and final test. Results are presented in a form to be tabulated on a 402 and plotted on electroplotters. The answer cards contain fixed information, answers and series of "x" punches to control printing in any of 14 columns. Thus, the results of a test are available in tabular form suitable for inclusion in reports.

Statistical data from fleet flight-maneuver and aircraft landing-loads programs. Motion pictures are made of the airplane approach and landing aboard an aircraft carrier. After the film is analyzed and transcribed on the film-reading system to IBM cards, a versatile computer program fits by a least-square-curve fitting method a polynomial space-time-curve to the airplane motion. Numerical differentiation of this curve is used to obtain velocity and acceleration at different points in the flight path. Altogether 22 landing parameters are obtained from each landing. A further statistical analysis of the parameters is performed to determine probability curves, deviation, skewness, variance, confidence limits and other statistical relationships. For the flight-loads program, information concerning the use of naval airplanes is obtained from flight recorders which make a permanent record of the most important things that happen, structure-wise, to the airplane while it is happening. From this data, airspeed, altitude, Mach number, 3 "G" load factors and 3 accelerations are computed.

Study of structural problems associated with space vehicles. Solution on the computer of nonlinear differential equation with variable coefficients by numerical methods of approximating the required solution.

Bulova Research & Development Laboratories, Inc.

System is used for the numerical solution of systems of ordinary differential equations, optical ray tracing, parameter variation studies, reduction of test data, e.g. curve fitting and auto correlation, spectrum analysis, and probability distribution analysis.

Institute of Gas Technology

System is used for the calculation of mass spectrometer data, gas distribution network analysis, chemical equilibrium studies, and correlation problems involving gas send-out and weather data.

Reliance Electric & Engineering Company

System is used for the design of electric machinery, and associated problems.

Southwestern Computing Service, Inc.

System is used for process equipment design, geophysical data reduction, and miscellaneous research problems.

Photo by U. S. Army - TAGO

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits per word	32 + sign
Binary digits/instruction	16
Instructions per word	2, 3 or 4
Instructions decoded	101 Basic (Many are micro-programmable)
Arithmetic system	Fixed point

Commands normally consider numbers to be integral

Instruction type	One address

Optimum sequencing is built in

Number range	64 bits

Negative numbers are indicated by sign

Decimal input and output are built-in with a single command capable of taking in up to 8 digits.

Several systems are available both for floating point or fixed point operations.

Neumonic interpretive routines as well as symbolic compilers are in use.

There are four registers, viz, a main accumulator 32 bits + sign + recoverable overflow bit, a secondary accumulator 32 bits + sign, an auxiliary register 32 bits + sign, and a 16 bit B-Box Index register.

The first two registers are combined for double precision operations. Also, complete shiftability applies to main accumulator as well as double length accumulator. Auxiliary register is used in multiplication, division, for special floating point assistance commands and masking operations.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	1,000	1,000
Mult	17,000	17,000
Div	17,000	17,000

Construction (Arithmetic unit only)

Vacuum-tubes	132
Diodes	5,000
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Two commands at once are picked off the drum and unless the first command of the pair is an executed jump instruction, a second access to the drum is not required as the next command is held ready for immediate use in a static register.

STORAGE

Manufacturer Media	No. of Words	Access Microsec
Drum	128	0 to 8,000
Drum	8,192	0 to 16,000
Core	32	500
Magnetic Tape		
No. of units that can be connected	16	Units
No. of chars/linear inch of tape	155	Chars/inch
Channels or tracks on the tape	7	Tracks/tape
Blank tape separating each record	0.25	Inches
Tape speed	120	Inches/sec
Transfer rate	20,800	Chars/sec
Start time	9	Millisec
Stop time	7	Millisec
Average time for experienced operator to change reel of tape	60	Seconds
Physical properties of tape		
Width	1/2	Inches
Length of reel	2,400	Feet
Composition	Sandwich Mylar	

Each tape transport has its own search register. Once directed to search for data, the transport is independent of the computer and tape buffer. The tape buffer is a 32-word core storage unit which works between the computer and up to 16 magnetic tape handlers. Individual words within the core buffer are addressable and useable by the computer.

Photo by U. S. Navy - Bureau of Ships

INPUT

Manufacturer Media	Speed
Paper Tape (Flexowriter)	Manual or 10 char/sec
Paper Tape (High-Speed)	180 char/sec
80-Column Cards	100 cards/min
Curve Follower	20 points/sec

Special tie-ins have been made to analog to digital conversion equipment. Speed of entry possible depends upon number system and format arrangement.

Aeronautical Structures Laboratory

Data is prepared for the computer off-line on the following: Five oscillogram reading systems, three film reading systems. Input and output cards are checked for double punch and blank-column on an IBM 101 statistical machine.

OUTPUT

Manufacturer	Speed
Paper Tape (Flexowriter)	10 char/sec
Paper Tape (High-Speed)	60 char/sec
80-Column Cards	100 cards/min
Line Printer	150 lines/min
Magnetic Tape	21,000 char/sec
Plotter	20 points/sec

The line printer used is an IBM type 407. It is completely useable as a standard off-line unit with only a change of plug board.

Aeronautical Structures Laboratory

Off-line the data is tabulated on an IBM 402 alphabetical accounting machine (series 50) or plotted on the two electroplotters which operate at 25 cards/minute.

Institute of Gas Technology

A Western Electric paper tape punch at 50 char/sec is connected to the computer through a buffer.

Photo by U. S. Air Force - Offutt AFB

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Manufacturer Quantity	Remarks
Tubes	780	319 in basic system
Diodes	13,500	5,870 in basic system
		7,630 in additional equipment
Transistors	75	66 tape transport
		9 tape buffer
Magnetic Cores	1,280	

The basic system includes the Power Supply, Memory Unit, and Logic Unit.

Additional Equipment includes the Standard Card Converter, Magnetic Tape Buffer, Magnetic Tape Transport, and the High Speed Paper Tape Console.

Photo by Bulova Research and Development Laboratories

CHECKING FEATURES

Manufacturer

An arithmetic operation overflow alarm is built on. A switch-controlled bit by bit comparison of all data transferred between high-speed loops and main memory can be made.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer	
Power, computer	5 Kw 0.9 - 1.0 pf
Volume, computer	160 cu ft
Area, computer	30 sq ft
Room size, computer	16 ft x 19 ft
Weight, computer	2,690 lbs

Above requirements are for the basic system.

The ideal site requirements are cable troughs, an acoustic ceiling, 75°F room ambient temperature, 4 ft. clearance around computer, a maintenance bench with 2 electrical outlets, and a storage space for spare parts.

The Adjutant General, U.S.A.	
Power, computer	13 Kw
Power, air conditioner	100 KVA
Volume, computer	277 cu ft
Volume, air conditioner	50 cu ft
Area, computer	52 sq ft
Area, air conditioner	8 sq ft in computer room
Room size, computer	500 sq ft
Room size, air conditioner	200 sq ft
Floor loading	91 lbs/sq ft
	140 lbs concen max
Capacity, air condition	12 1/2 Tons
Weight, computer	4,800 lbs

Site preparation included air conditioning and power modifications.

Photo by the Institute of Gas Technology

David Taylor Model Basin

Power, computer	6 Kw	220 V
Power, air conditioner	6 Kw	
Optional, depends on room size and cooling		
Volume, computer	231 cu ft	
Volume, air conditioner	44 cu ft	
Area, computer	45 sq ft	
Area, air conditioner	7 sq ft	
Room size, computer	240 sq ft	
Floor loading	80 lbs/sq ft	
	900 lbs concen max	
Capacity, air conditioner	5 Tons	
Weight, computer	2,200 lbs	
Weight, air conditioner	1,000 lbs	

Area and volume include console and high speed reader but weights do not.

System uses 220 Volt, single phase, 60 cycles, 3 wire. Air conditioner is used for 2 computers in one room.

Offutt AFB, Nebraska

Power, computer	17.5 Kw	0.9 - 1.0 pf
Volume, computer	361 cu ft	
Area, computer	64 sq ft	
Room size	26 ft x 26 ft	
	676 sq ft	
Floor loading	88 lbs/sq ft	
	140 lbs concen max	
Weight, computer	5,630 lbs	

The building is air conditioned. An AC voltage regulator and adequate power outlets are required.

Aeronautical Structures Laboratory

Power, computer	10 Kw	15 KVA
Power, air conditioner	45 Kw	
Volume, computer,	234 cu ft	
Volume, air conditioner	64 cu ft	
Area, computer	47 sq ft	
Area, air conditioner	24 sq ft	
Room size, Computer	20 ft x 16 ft	
Room size, air conditioner	Suspended from ceiling	
Floor loading	100 lbs/sq ft	
Capacity, air conditioner	33 Tons	
Weight, computer	3,200 lbs	

Air conditioner includes peripheral equipment requirements.

The computer facility area 80 feet by 48 feet is partitioned into the following areas:

- Computer and off-line output equipment
- Data reduction (film)
- Data reduction (oscillographs)
- Equipment repair
- Office space

The following was installed: acoustic celotex ceiling, 230V, 100A, 3 phase, outlet for computer, comp. air (90 p.s.i.) with valves and hoses in each area, three power distribution panels 110V, 100A, 1 phase with extensive outlets for the peripheral equipment.

Bulova Research & Development Laboratories, Inc.

Power, computer	7.7 Kw
Volume, computer	185.35 cu ft
Area, computer	38.9 sq ft
Room size	18 ft x 18 ft x 11 ft
Weight, computer	2,864 lbs

Air conditioning is an estimated 5 Tons from central air conditioning system.

Site preparations included soundproofed room, additional air conditioning ducts, and an exhaust fan with hood.

Institute of Gas Technology

Power, computer	7 Kw
Volume, computer	248 cu ft
Volume, air conditioner	37 cu ft
Area, computer	45 sq ft
Area, air conditioner	5 1/4 sq ft
Room size, computer	18 ft x 24 ft
Room size, air conditioner	18 ft x 24 ft
Capacity, air conditioner	3 Tons
Weight, computer	2,500 lbs

Site preparation included a required 220V, 60 cycle, single phase, power line.

Reliance Electric & Engineering Company

Power, computer	7 Kw 7 KVA 0.97 pf
Volume, computer	4,000 cu ft
Area, computer	500 sq ft
Room size, computer	24 ft x 24 ft

Air conditioner is combined with other equipment. Room was designed for electronic tabulating equipment.

Photo by Logistics Research, Inc.

PRODUCTION RECORD

Manufacturer

Number in current production	3
Time required for delivery	1 Month

COST, PRICE AND RENTAL RATES

Manufacturer

Components of Basic System	Cost	Rental/ Monthly
Power Supply, Flexowriter, Monitor Scope, Control Console, Logic and Control Unit, Memory Unit	$76,950	$2,500
Additional Equipment		
High Speed Perforated Tape Console (Punch & Read)	10,950	290
Paper Tape Buffer	26,200	750
Card Converter	24,750	660
Magnetic Tape Buffer	21,000	580
Magnetic Tape Transport	23,100	640

Maintenance

Full-time resident engineer - $15,000 per year.
On-Call - $120/Day plus travel, not to exceed 500 miles.
Scheduled Service - 10% of list price of equipment per year.

The Adjutant General, U.S.A.

Computer (including console and Flexowriter), card converter, and magnetic tape buffer cost $105,000.

Rental rates for additional equipment is a card reader and punch at $140/month.

Maintenance, including parts is $12,000 per year.

David Taylor Model Basin

Cost is approximately $70,000.

High Speed Paper Tape Reader and Punch rents at $260/month.

Maintenance is done by our own electronic engineer.

Offutt AFB, Nebraska

The computer control and arithmetic unit cost $69,950, the modified Flexowriters (2) cost $4,950, and the high speed punch and tape cost $4,950. The card converter cost $22,500, the IBM 514 reproducing punch cost $5,700, the magnetic tape transports (2) cost $46,000, and the magnetic tape buffer cost $18,000.

Maintenance cost $15,000 per annum.

Aeronautical Structures Laboratory

Power supply, logic, magnetic drum, card converter cost $85,000.

Peripheral equipment - five oscillogram and three film reading systems and two electroplotters cost $169,000.

The IBM 514 input-output to computer rents at $1,320 per year.

IBM peripheral equipment-punches, verifier, sorter, statistical machine, reproducing punches, accounting machine, etc. rent at $20,000/year.

ASL does its own maintenance and servicing.

Bulova Research & Development Laboratories, Inc.

The Memory Cabinet (8,196 word drum), Flexowriter, Oscilloscope, Logic Cabinet, Power Supply Cabinet, Control Panel, and Memory Display rents at $2,350/month.

The High Speed Paper Tape, Reader, and Punch rents at $260/month.

Institute of Gas Technology

The basic computer, Flexowriter input and output cost $50,000. The High Speed Paper Tape Reader and Punch, with one word buffer cost $10,000.

Reliance Electric & Engineering Company

The Flexowriter and basic computer, with 4,096 word drum, cost $56,000.

The High Speed Console cost $18,000 and the 8,192 word drum (replacement) cost $12,000.

Maintenance cost $600/month.

Southwestern Computing Service, Inc.

System requires almost no maintenance. We do our own.

PERSONNEL REQUIREMENTS

Manufacturer

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

Training made available by the manufacturer to users includes free training in coding and operation at manufacturing plant. Training in maintenance is by special arrangement.

The Adjutant General, U.S.A.

	Two 8-Hour Shifts	
	Used	Recommended
Supervisors	1	1
Analysts	3	3
Programmers	3	4
Clerks		1/2
Librarians		1/2
Operators	2	2
Engineers	1	1

Specific to needs and problems encountered in this organization (other users may very well require more or fewer of each).

Operation tends toward closed shop.

David Taylor Model Basin

	Two 8-Hour Shifts	
	Used	Recommended
Supervisors	1	1
Programmers	2	3
Operators	3	3
Engineers (Maint.)	1	1

Operation tends toward closed shop.

Methods of training used includes informal instruction. Machine made available to engineers on open shop basis using Floating Point interpretive routines or compilers.

Offutt AFB, Nebraska

	One 8-Hour Shift	Two 8-Hour Shifts	
	Recommended	Used	Recomm
Supervisors		2	2
Programmers		4	4
Engineers	1		

Operation tends toward open shop.

Methods of training used includes on-the-job training.

Aeronautical Structures Laboratory

	One 8-Hour Shift		Two 8-Hour Shifts	
	Used	Recomm	Used	Recomm
Supervisors	2	2		
Programmers		2		
Clerks		1		
Operators	1	1		1
Engineers	1	2		
Technicians	4	4	1	1

Operation tends toward open shop fpr peripheral equipment and closed shop for computer. Some personnel have taken courses in advanced programming, numerical analysis and numerical solutions of differential equations. On-the-job training is used for the technicians and IBM training is used for peripheral IBM equipment.

Bulova Research & Development Laboratories, Inc.

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Analysts	2	2
Programmers	1	2
Operators		1
Engineers	1	1

Operation tends toward closed shop.

Methods of training used includes individual instruction on the job.

Institute of Gas Technology

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Programmers	1	2
Clerks	1	1
Technicians	1	1

Methods of training used includes on-the-job.

Reliance Electric & Engineering Company

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1/2	
Programmers	1	2
Operators	1	1

Operation tends toward closed shop.

Methods of training is mostly on individual basis.

Computer has made a major contribution to our engineering effort. Recognition of this fact is company-wide, and unchallenged.

Southwestern Computing Service, Inc.

	One 8-Hour Shift
Programmers	2
Operators	1

Operation tends towards closed shop.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Manufacturer

Average user reliability figures are 96.4% useful computing time.

The Adjutant General, U.S.A.

Time is available for rent to qualified outside organizations.

The current model of the ALWAC III E (serial 28) was installed so recently that adequate data are not yet available.

David Taylor Model Basin

Good time 46 Hours/Week (Average)
Attempted to run time 52 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.884
Above figures based on period 1 May 59 to 30 Apr 60
Time is available for rent to qualified outside organizations.

Offutt AFB, Nebraska

Average error-free running period 20 Hours
Good time 75 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.94
Above figures based on period Jul 59 to May 60
Time is not available for rent to outside organizations.

Aeronautical Structures Laboratory

Average error-free running period 100 Hours
Good time 72 Hours/Week (Average)
Attempted to run time 80 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.90
Above figures based on period Nov 55 to Apr 60
Passed Customer Acceptance Test Nov 55
Time is available for rent to qualified outside organizations.

In May 1957, after 2,000 hours of good computing time, a card converter, larger memory and new power supply were installed. Since October 1958 the computer has been on a two-shift operation. A new drum was installed in October 1959. As of 1 May 1960, the computer has over 9,000 hours of good computing time.

Bulova Research & Development Laboratories, Inc.

Average error-free running period 2 Weeks
Good time 25 Hours/Week (Average)
Attempted to run time 27 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.926
Above figures based on period 22 Jan 59 to 16 Jun 60
Passed Customer Acceptance Test 22 Jan 59
Time is available for rent to outside organizations.

Above figures include scheduled maintenance. If this time is omitted, the figures are good time 25, attempted to run time 25.5, and operating ratio 0.98.

Institute of Gas Technology

Average error-free running period 80 hrs, approx.
Good time 35 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.875
Above figures based on period from 55 to Present
Passed Customer Acceptance Test 1955
Time is available for rent to qualified outside organizations.

Our records are not set up to obtain the above data accurately.

Reliance Electric & Engineering Company

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 Feb 56 to Present
Passed Customer Acceptance Test Feb 56
Time is available for rent to qualified outside organizations.

Southwestern Computing Service, Inc.

Good time 40 Hours/Week (Average)
Attempted to run time 39 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.975
Above figures based on period from 56 to Present
Time is available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

Manufacturer

Outstanding features include a large internal memory, (Over 16,000 program step storage), built-in-to hardware decimal-binary conversion, a large command structure, fully alpha numeric notation and an index register.

Unique system advantages include automatic decimal-binary conversion on cards, tape transports with independent searchability, and as many as 4 commands per word.

Special recommended procedures for magnetic tape storing includes temperature at 60 - 85°F and humidity at 40% to 60%.

The Adjutant General, U.S.A.

This ALWAC III Ehas been modified to read binary which is quite desirable for the work here. The system, for the cost, is large, flexible, and highly useful. The first ALWAC at the Personnel Research Branch was installed in June 1958. Although it was a useful productive machine, the precent of up time was less than would be desirable. The replacement computer, a larger and improved model, has been installed too recently to evaluate. Up time is expected to be well above 80%.

David Taylor Model Basin

Large memory and powerful logic structure make this system powerful and easy to program. It has an "E" box, it can read any 6-level paper tape, and it has complete program control of input-output operations and format.

Offutt AFB, Nebraska

Outstanding features include hexadecimal numbering system. Tapes are stored in steel filing drawers. The temperature and himidity are controlled to prevent damage to the tapes while in storage.

Bulova Research & Development Laboratories, Inc.

Outstanding features include a large memory, the ability to pack instructions 2 - 4 instructions per word, and built-in decimal-binary conversion.

Due to its small amount of tubes, the ALWAC III E is extremely reliable and easy to maintain.

The ALWAC III E is a general purpose single-address,

serial binary computer. The computer has 86 instructions and one index register. Basic number system for input-output is hexadecimal, using the digits a, b, c, d, e, f, for 10, 11, 12, 13, 14 and 15, respectively, in addition to 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Magnetic tape and punched card equipment is also available.

Institute of Gas Technology

Outstanding features include large memory, rapid input-output, and a large order list.

System advantages includes a single address system which allows two program steps per word.

Reliance Electric & Engineering Company

Outstanding features include a large memory, low cost, and great flexibility. The Flexowriter gives unlimited flexibility in using all kinds of easily prepared forms. The paper tape is convenient for filing and for transmission via Teledata over telephone lines. It is used this way. Low cost made it possible for engineering to get it for its own use without sharing time with others.

Southwestern Computing Service, Inc.

Outstanding feature is reliability.

FUTURE PLANS

Aeronautical Structures Laboratory

To prevent interruptions in data processing, expansion of the facility is planned in stages. The installation of a new computer (with magnetic tape and punched card capabilities) is planned at the same time as the installation of the laboratory's high-speed data-gathering equipment. In the second stage, the existing ALWAC III will be modernized to the equivalent of the ALWAC III-E so that programs and routines can be interchanged. As a final stage, magnetic-tape capabilities will be added to the modernized ALWAC III for further flexibility of operations.

Southwestern Computing Service, Inc.

A faster input from the paper tape reader will be built.

INSTALLATIONS

The Adjutant General, U.S.A.
2nd & T Streets, S. W.
Washington 25, D. C.

David Taylor Model Basin
Washington 7, D. C.

544th Reconnaissance Technical Group
Offutt Air Force Base, Nebraska

Aeronautical Structures Laboratory
Naval Air Material Center
Philadelphia 12, Pennsylvania

Bulova Research & Development Laboratories, Inc.
62 - 10 Woodside Avenue
Woodside 77, New York

Institute of Gas Technology
17 West 34th Street
Chicago 16, Illinois

Reliance Electric & Engineering Company
24701 Euclid Avenue
Cleveland 17, Ohio

Southwestern Computing Service, Inc.
910 S. Boston
Tulsa 19, Oklahoma

AMOS IV

AMOS IV Computer

MANUFACTURER

National Bureau of Standards

AMOS IV

BLOCK DIAGRAM WITH APPROACH VISIBILITY CONFIGURATION

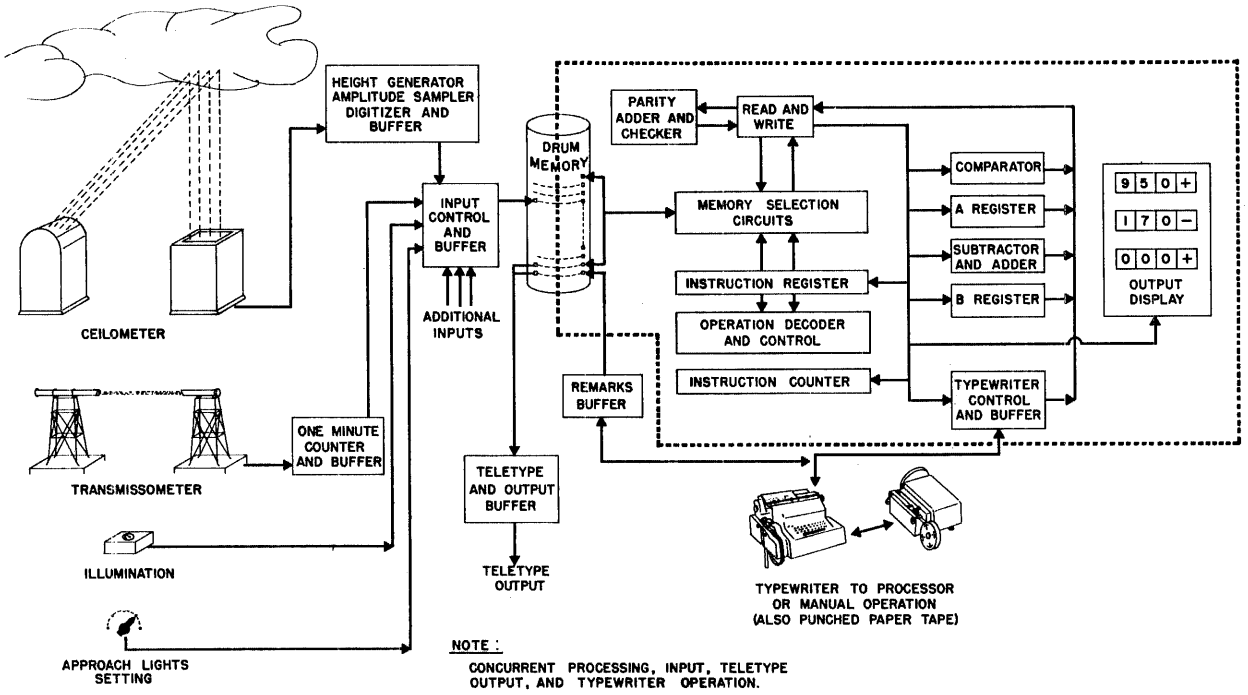


Chart by National Bureau of Standards

APPLICATIONS

The National Bureau of Standards in cooperation with the U. S. Weather Bureau has developed a specialized digital computer for the Weather Bureau to use as a research tool in exploring the concept of the automatic weather station. The AMOS IV Computer receives data from weather-sensing instruments and processes these data through such functions as sampling, comparing, selecting a maximum, and arithmetic operations. The results are transmitted via teletype to a central forecasting station and to other airport weather stations. Values of two quantities recently developed as aids to air safety - runway visual range and approach light contact height - are given by the machine through automatic table look-up.

For a number of years, the Weather Bureau has been appraising the possibilities of an automatic weather station. Such stations could be widely distributed, and would be especially useful in relatively inaccessible locations that are important sources of early data on meteorological activity. The various developmental prototypes of this concept have been called (Automatic Meteorological Observation Station); the current version, containing transistorized packages, is AMOS IV. It is an outgrowth of previous work done by NBS for the Weather Bureau that resulted in a special computer for processing cloud-height signals from a ceilometer. The ceilometer was intended for use with the AMOS III.

Several of the input quantities to the AMOS Computers, such as cloud height and precipitation, cannot be satisfactorily represented by instantaneous values but must be time-averaged. Varying amounts of data processing must therefore be associated with the different instruments measuring these quantities. In the AMOS III concept, several complex units were required for these functions. Although many of the functions were similar, the hardware was not minimized because of a diversity of design that resulted from the isolated development of the individual units. Analysis of the overall system indicated that a considerable reduction could be made in hardware and therefore in maintenance.

In AMOS IV, the automatic weather station is built around a single small, general-purpose computer designed especially for this application. The computer

Photo by National Bureau of Standards

receives data from the input instruments at any desired interval. These data are suitably processed and arranged in a specified order for teletype transmission in a variety of message formats and at various speeds. The computer also operates local and remote displays. Much latitude is available for research into the most desirable form of data processing because of the inherent flexibility of the internally programmed machine.

The machine must accomodate a number of input devices, all furnishing data continuously.

Extensive stored tables are needed for empirically determined data which varies from station to station.

A short word length is sufficient, since the data comes primarily from physical instruments; three digits and sign appear sufficient, relying on double-precision methods for those few cases where needed.

A comparatively slow circuit speed is acceptable, working in conjunction with the magnetic drum, which rotates at a moderate speed for long life and reduced cost.

The machine needs only a limited arithmetic capability, in view of the extensive stored tables; it can perform addition and subtraction, with other operations available through programming.

The machine must transmit teletypewriter messages at high and low speeds, independently of each other and of the data processor.

Provision must be included for operating local and remote displays.

The machine must concurrently process input data, transmit teletypewriter messages, and perform data processing.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	3 plus sign and parity
Instructions/word	0.5
Instructions decoded	21
Instruction type	One address

Photo by National Bureau of Standards

Information word

t_{14}												t_1
Pe	8	4	2	1	8	4	2	1	8	4	2	1	±
Parity	10^2				10^1				10^0				Sign

A "word" in AMOS IV consists of three decimal digits and a sign. Since, in binary notation, a decimal digit can occupy as many as four bit positions, it is necessary to assign four bit positions to each decimal digit. A data word in AMOS IV looks as above.

Photo by National Bureau of Standards

Instruction Word

Word α		Operation			Channel β		
			$\pm$				$\pm$
Data word at even address				Data word at odd address			

The operations are coded in two decimal digits. The $(\alpha,\beta)$of the word upon which the operation is performed is placed in the first two and last two decimal positions of the instruction. The sign at the end of the instruction has no bearing upon the function; the sign at the center of the instruction affects the computer's operation within predetermined modes. (In the future, when the remainder of the drum is activited, the sign at the end of the word will have significance.)

The content of each register is shown on the indicator panel.

IR - Instruction Register. The instruction being performed is stored in this register.

IAC - Instruction Address Counter. The address (α, β) of the next instruction is contained in this register.

FLEX Buffer. This is the intermediate stage for flexowriter input and output. It indicates what is being written or read by the flexowriter.

A Register. This register is used for storage in various operations.
B Register. This register is also used for storage in various operations.
IR - Index Register. The index register, two decimal digits in size, is filled by operation's (60) transferring two digits of the address into it. In the operation of the machine, if an address enters the IR which is "impossible", such as (llxll), the content of the index register replaces the α portion of the address in the IR.

ARITHMETIC UNIT

In addition to an address counter and decoding network for obtaining commutating pulses, the input circuit has a one-word shift register which serves as a buffer between the instruments and the input recording circuit. Data words from sampled instruments are inserted in the register by means of a parallel transfer, up to 13 bits at a time (three decimal digits and sign). The number representation need not be binary-coded decimal, since the computer can perform code conversion, if required.

STORAGE

Medium	No. of Words
Magnetic Drum	10,000

To store data, the machine uses a magnetic drum operating at 1800 rpm that carries 100 general storage channels of 100 words each and has space for 100 additional channels. Several dual-head channels are available for simultaneous read-in and read-out of incoming data, outgoing messages, etc. The magnetic drum provides the extensive storage capacity required for the table look-up involved in the calculations of runway visual range and approach light contact height. About 35 tables are stored on the drum; each table has about 90 three-digit values.

One set of these tables contains the data on runway visual range (RVR), i.e., the distance along the runway visible to a pilot from the point of touchdown - generally 1,000 to 6,500 feet, depending upon runway illumination (natural and artificial) and atmospheric conditions. The primary input for the RVR determination is a transmissometer reading. The computer continuously monitors this reading and "looks up" the proper corresponding value of RVR, which is then displayed locally and inserted into the teletype message.

The other set of tables contains the data on approach light contact height (ALCH), i.e., the height from which the pilot can identify the approach lights. ALCH is affected by background illumination level, atmospheric conditions, and the intensity of the approach lights, which are set in accordance with prevailing conditions. If limiting conditions are indicated by either low clouds, as shown by the ceilometer, or by fog or snow, as sensed by the transmissometer, a value of ALCH based on the interfering factor is obtained. If both factors are present, two calculations are made; the machine then determines and displays the lower value. Since there is a statistical uncertainty in this type of information, two values of altitude are presented. The higher altitude is that at which the pilot has a 20 percent probability of seeing the approach lights; the lower altitude is that at which the probability is 90 percent.

The drum operates at a conservative rate of 1,800 rpm; non-return-to-zero recording is used, with a recording density of 120 bits per inch. Thus, the machine operates at a bit rate of 50 kc.

INPUT OUTPUT

Media
Paper Tape
Keyboard
Various Analog Data Channels
Typewriter

The computer continuously monitors new input data while simultaneously processing data already entered and transmitting messages on command. Among the input quantities which the AMOS IV Computer can handle are temperature, dew point, wind speed and direction, atmospheric pressure, precipitation, transmissivity, and cloud height. Input data can be received directly from the instruments in the simplest possible form, such as analog voltage, current, or resistance; and pulse rate or contact closure. Information may also be received in coded form, such as the Gray binary code frequently used with shaft-position encoders. The nature of the weather instruments and of the quantities measured limits the input data to 2 or 3 decimal digits for the most part; word size is therefore 3 digits plus sign. Double precision methods are available for those few instances requiring greater accuracy. Communication with the machine is via electric typewriter or punched tape.

The method of receiving input data from the weather-sensing instruments is a compromise between the use of separate pre-processing devices and use of the central processor. In order to avoid excessive interruption of the central processor, varying amounts of circuitry have been assembled, depending on the form of the input data, to pre-digest the instrument signals for most efficient use of the processor. Once the data has been prepared in suitable form, generally as contact closures or storage in flip-flop registers, it is entered into the computer via an input-data track on the magnetic drum. This track is equipped with two heads, one addressable by the central processor and the other wired to the input circuitry. Since the track can store 100 words, there is an input capacity of 100 instrument readings, a quantity considerably in excess of present requirements. The address of each word identifies the reading, and the addresses therefore, are used to call out the appropriate subroutines when new data appears in the various word locations. The input devices are sampled sequentially by means of commutating pulses obtained from a decoding network attached to an address counter. It is possible with this scheme to sample any instrument within 1/30 second of the time that a desired reading is obtained. If readings were obtained at the rate of 30 per second, however, the central processor would quickly be overloaded; actually, it is sufficient to sample most instruments at intervals of once per minute or longer. The ceilometer is the most frequent with readings at 6 second intervals.

The teletypewriter outputs involve the buffering of data, which comes from the drum at a high rate, down to the desired message speed. In addition, data words must be reorganized into teletypewriter characters, including the addition of start and stop pulses, and the generation of space and sign characters. Two independent teletypewriter outputs are required, with different codes and message formats. The low-speed output is nominally 100 words per minute, while the high-speed output is in the range of 750 to 1500 words per minute. Several different message lengths are required at the higher speed, requiring that the

circuitry be capable of skipping unwanted portions of the message. Since the messages are to be combinations of data prepared by the computer and alphanumeric remarks and text inserted by hand, several tracks have been allowed on the drum for this information. Certain tracks, addressable by the computer, contain the numerical data. Other tracks may be written into only from the automatic typewriter, and are used for the remarks. These are all dual-head tracks, with one set of heads being used to insert data, either from the processor or the typewriter, while the other set is used to read out the information.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

The computer circuitry is based on transistorized plug-in assemblies designed at NBS for a variety of data-processing applications. These 50-kc packages perform flip-flop, analog switch, and gating circuitry functions, as well as others.

CHECKING FEATURES

Parity. This pushbutton-light indicates when parity has been lost in the memory circuits. AMOS IV operates on an even parity system. As each word is written into the memory, the number of binary "1's" is counted. If the number of 1's is even, a "0" is placed in the parity bit position. If the number of 1's is odd, a "1" is placed in the parity bit position; thus, any word in the memory plus its parity bit contains an even number of 1's in its binary notation.

Upon read-out of a word from the memory, a check is made for this "even 1's" characteristic. If, through an error in the recording process, parity does not check, the parity light is operated and remains lighted until the parity control button is depressed.

This light is a warning light, indicating that some malfunction has occurred in the read process. Depressing the parity button resets the parity system.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

The circuits are designed to permit wide variations from the nominal values of the characteristics and parameters of the components.

The electrical outputs from most of the packages can be short-circuited to ground or to the negative voltage supply without damage to any of the components.

Pin-type connectors with high-pressure contacts are used rather than printed-circuit edge-type connectors.

Signal swings are at least 6 volts, with a collector supply of -12 volts.

All connectors have gold-plated pins.

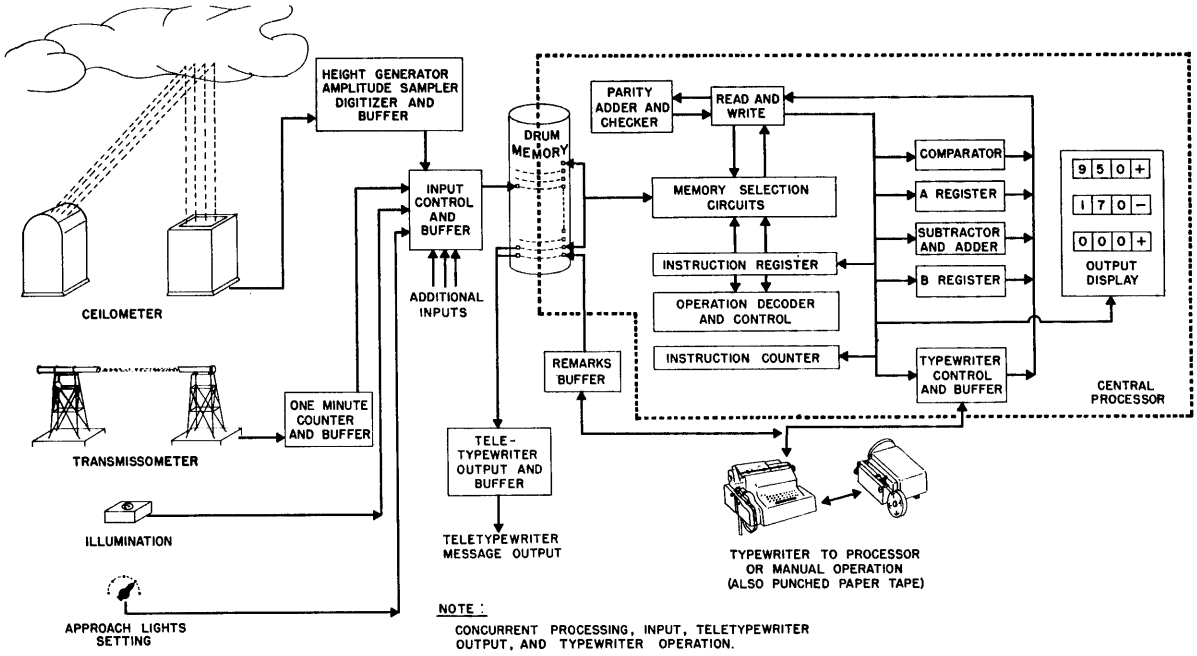
All back panel wiring is by taper pins for ease and convenience in making external connections. Taper pins also eliminate solder joints.

ADDITIONAL FEATURES AND REMARKS

A need for improved reporting of weather data has been brought about by the requirements of modern, high-performance aircraft, together with the advent of high-speed computers for use in weather forecasting. Manual methods of recording meteorological observations introduce an undesirable time delay, increase the chance of error, and limit the frequency of observations. A solution to this problem lies in the use of automatic data processing equipment for the recording, pre-processing, and transmission of the information. Under the sponsorship of the U. S. Weather Bureau, the National Bureau of Standards has developed a specialized computer for use as a research tool in exploring this concept.

INSTALLATIONS

National Bureau of Standards
Washington 25, D. C.



AN/ASQ 28 (v) EDC

AN/ASQ 28 (V) Emergency Digital Computer

MANUFACTURER

International Business Machines Corporation
Federal Systems Division

APPLICATIONS

System is designed and used as a general purpose stored program computer for manned aircraft bombing, navigation and missile guidance subsystem. It may be utilized for real time control of processes of small capacity. The central computer is general purpose while the input-output equipment is special purposes.

Designed and developed under contract no's AF 33 (600)36599 and AF 33(600)41253 as a minimal emergency back-up computer to the main computer of the AN/ASQ-28(V) Bombing, Navigation and Missile Guidance Subsystem of the B-70 aircraft.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	26
Binary digits/instruction	26
Instructions per word	1
Instructions decoded	10
Arithmetic system	Fixed point Sign and Magnitude
Instruction type	One plus one (Operand and next instruction)
Number range	Plus and minus 23 bits accuracy

Instruction word format

S	W1	W2	W3	T1	T2	T3	T4	T5	W1	W2	W3	W4	W5	W6	T1	T2	T3	T4	T5	T6	O1	O2	O3	O4	P
	Operand Address								Next instruction address												Operation				

P = Parity
S = Switching

Registers include a Multiplier-Quotient revolver, an accumulator, and an instruction revolver.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	624	156
Mult	3,744	3,276
Div	3,744	3,276
Construction (Arithmetic unit only)		
Transistors	60 - 5 Types	
Diodes	290 - 6 Types	
Arithmetic mode	Serial	
Timing	Synchronous	
Operation	Sequential	

STORAGE

Medium	No. of Words	No. of Digits/Word	Access Microsec
Drum	Instructions and Constants - 3456 Data - 384	26	Min - 156 Max - 5000

Instructions can be optimumly located to permit a minimum memory access time. Fast intermediate data access time provided by revolvers on the drum.

INPUT

Media	Speed	
Decimal Insert	Random	
Shaft-to-Digital	100 words/sec/device	
Pulse Trains	Variable	
Discrete Signals	Variable	

Manual insert is by 7 decimal digits. 48 instrumental discrete signals may be inserted.

OUTPUT

Media	Speed	
Discrete Signals	Variable	32 instrumented
Decimal Display	Variable	7 Decimal digits
Digital-to-Shaft	100 words/sec/device	
Pulse Train	Variable	

The decimal display is seven digits long. 32 instrumented discrete output signals are obtainable. A high speed input-output processor is provided which performs a number of functions coincidently with the central processor. 48 parameters can be processed at a rate of 4800 operations per second.

System characteristics include updating of digital servo loops, determination of first order clamp for digital servo loop, accumulation and generation of pulse train inputs and outputs, buffering of decimal display word, acceptance of manual insert register word, and reading and decoding of shaft-to-digital encoder inputs.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	4,395
Transistors	592

These figures include the central computer and input-output processor. They do not include special input-output equipment required for special applications.

CHECKING FEATURES

Transfer parity check is built in.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.25 Kw
Volume, computer	1.9 cu ft
Weight, computer	81 lbs

These figures include the central computer and input-output processor. They do not include special input-output equipment required for special applications.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

This equipment is designed to meet stringent reliability requirements for a supersonic military aircraft environment. The ambient temperature range is 0°C to 100°C. All circuits use silicon transistors and diodes and are designed for ultrareliable operation from 0°C to 100°C. Reliable drum readout signals are provided by air floated drum heads.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include replaceable (pluggable) subassemblies, nonerasable drum tracks to prevent accidental destruction of the stored program, intercommunication provided with a main digital computer through a common drum track link, unique high speed input-output processor with a repetition rate greater than the computation cycle of the basic computer, and 48 programmed discrete inputs for program branching and 32 discrete outputs for system control.

Unique system advantages include rugged environmental specifications, high reliability, and flexibility.

AN/ASQ 28 (v) MDC

AN/ASQ 28 (V) Main Digital Computer

MANUFACTURER

International Business Machines Corporation
Federal Systems Division

Photo by International Business Machines Corporation
Subassembly Drawer, containing Printed Circuit Boards

APPLICATIONS

Designed for general purpose stored program computer for manned aircraft bombing navigation and missile guidance subsystem. Applicable to real time control of processes (large capacity). The central computer is general purpose while the input-output equipment is special purpose.
System was designed and developed under contract no's AF 33(600)36599 and AF 33(600)41253 as the central computing element for the AN/ASQ-28(V) Bombing, Navigation and Missile Guidance Subsystem of the B-70 aircraft.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	22 plus sign and parity
Binary digits/instruction	16 including parity
Instructions per word	1
Instructions decoded	14
Arithmetic system	Fixed point Sign and Magnitude
Instruction type	One address

Number range Plus and minus 22 bit accuracy
Instruction word format

P	M	S6	S5	S1	S2	S3	S4	R1	R2	R3	R4	01	02	03	04

P = parity
M = modifier
R1-R4, S1-S6 = address
01-04 = operation

Registers include multiplier-quotient, accumulator, check register, and memory buffer.

An instruction word is read from drum storage 4 bits parallel by 4 bits serial. A constant word is read from drum storage 6 bits parallel by 4 bits serial.

Printed Circuit Board

Photo by International Business Machines Corporation

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	24	24
Mult	264	264
Div	288	288

Construction (Arithmetic unit only)

Transistors	249 - 5 Types
Diodes	2,726 - 6 Types
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Concurrent

The feature of instruction overlap is incorporated which permits the reading of instructions and performing arithmetic operations simultaneously.

STORAGE

Media	No. of Words		No. of Digits/Word	Access Microsec
Cores	1,024		24	24
Drum	26,624	Instructions	16	
	6,656	Constants	24	5,000 avg.

Minimum drum access time is 24 microseconds.

INPUT

Media	Speed
Decimal Insert	Random (Manual) 7 decimal digits
Shaft-to-Digital	100 words/sec/device
Pulse Trains	Variable
Discrete Signals	Variable 96 instrumented

Seven decimal digits are inserted. 96 instrumented discrete signals may be entered.

OUTPUT

Media	Speed
Discrete Signals	Variable
Two Decimal Displays	Variable
Decimal Printer	Variable
Digital-to-Shaft	100 words/sec/device
Pulse Trains	Variable

Eighty instrumented discrete signal outputs are available. The displays and printer utilize 7 decimal digits. A high speed input-output processor is provided which performs a number of functions coincidently with the central processor. 52 parameters can be processed at a rate of 5,200 operations per second. The following characteristics are involved:

Updating of digital servo loops.

Determination of first order clamp for digital servo loop.

Accumulation and generation of pulse train inputs and outputs.
Buffering of decimal printer word.
Buffering of decimal display word.
Acceptance of manual insert register word.
Reading and decoding shaft-to-digital encoded inputs.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Types	Quantity
Diodes	13,076
Transistors	1,697

These figures include the central computer and the input-output processor. They do not include special input-output equipment required for special applications.

CHECKING FEATURES

Checking features include a random error counter, parity and timing check circuitry, and Test Point compare. The random error counter minimizes the effects of random and intermittent errors on system performance. Built in test equipment enables rapid fault location.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.8 Kw
Volume, computer	7.4 cu ft
Weight, computer	Approx 260 lbs

These figures include the central computer and input-output processor. They do not include special input-output equipment required for special applications.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

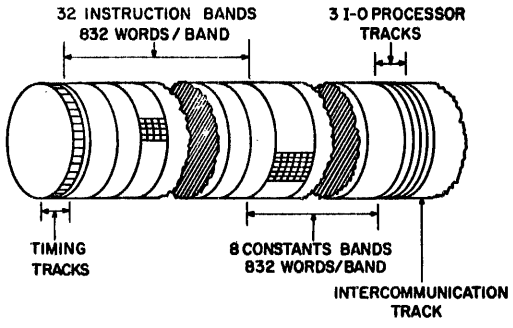
This equipment is designed to meet stringent reliability requirements for a supersonic military aircraft environment. Ambient temperature range is from 0°C to 100°C. All circuits use silicon transistors and diodes and are designed for ultra-reliable operation from 0°C to 100°C. Reliable drum readout signals are provided by air floated drum heads.

ADDITIONAL FEATURES AND REMARKS

Outstanding features are replaceable (pluggable) subassemblies, nonerasable drum tracks to prevent accidental destruction of the stored program, intercommunication provided with an emergency digital computer through a common drum track link, built-in checking circuitry minimizes effects of random and intermittent errors on system performance, a new hardware approach to fault isolation, supplemented by simplified diagnostic programs, which permits rapid location of computer failure, a unique high speed input-output processor with a repetition rate greater than the computation cycle of the basic computer, and 96 programmed discrete inputs for program branching and 80 programmed discrete outputs for system control.

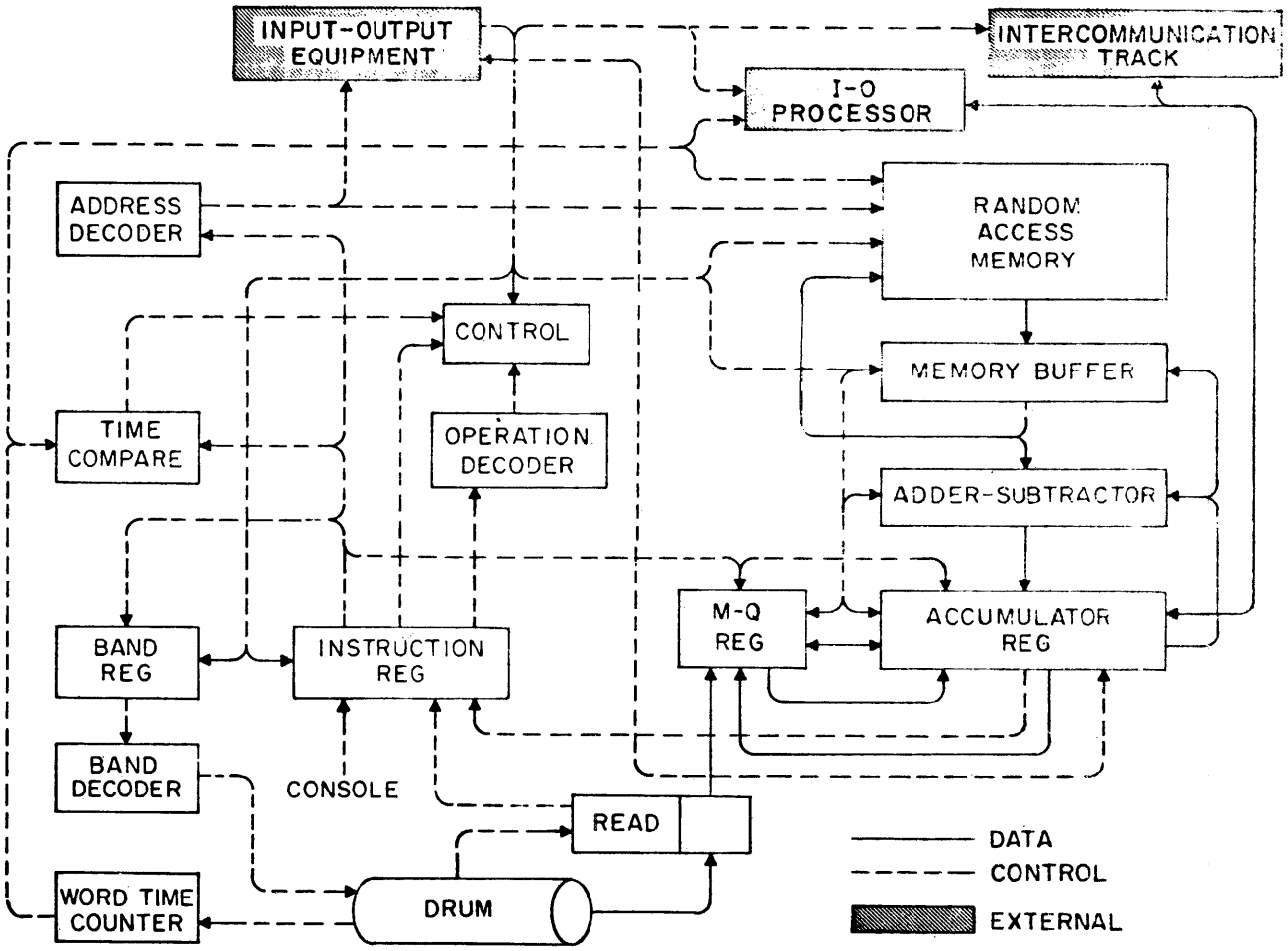
Unique system advantages include rugged environmental specifications, high reliability, flexibility and ease of maintenance.

During normal operation of the bombing, navigation and missile guidance subsystem, a high-speed, parallel computer with both a random access memory and a magnetic drum memory performs all calculations required by the subsystem. If the main computer malfunctions, a moderate speed, serial, all-drum computer automatically assumes control and generates solutions to a simplified problem. Repair of the main computer is then possible without disturbing the remainder of the subsystem.



Main Computer Drum Organization

Diagram by IBM



Flow Diagram of Main Central Computer

Diagram by International Business Machines Corp.

AN/FSQ 7 AN/FSQ 8 (SAGE)

MANUFACTURER

IBM AN/FSQ 7 and 8 (Semi Automatic Ground Environment) International Business Machines Corporation

Photo by Systems Development Corporation

APPLICATIONS

Manufacturer

Real time for Air Defense (SAGE) - Semi Automatic Ground Environment.

The AN/FSQ-7 is a Real Time Digital Computer at the heart of each SAGE Air Defense installation. At electronic speed the computer processes radar data, performs complex computations and displays visually the current air defense situation to Air Force personnel for assigning the appropriate weapons for interception.

System Development Corporation

Located at 2500 Colorado Avenue, Santa Monica, California, system is presently being used for design analysis and development checkout of SAGE computer programs.

PROGRAMMING AND NUMERICAL SYSTEM

Manufacturer

(SAGE is a duplexed computer system. Information quoted is for one simplex computer.)

Internal number system	Binary
Binary digits/word	32 + 1 parity
Binary digits/instruction	32 + 1 parity
Instructions per word	1
Instructions decoded	61
Arithmetic system	Fixed point

Dual arithmetic unit with left and right half

The instruction, set through programming methods, permits binary coded decimal and floating point to be simulated.

Instruction type	One address

Single address with indexing capability

Number range	2^{15} in each half word

Photo by International Business Machines Corporation

Instruction word format

Left Hand Word

P	L S	L 1	L 2	L 3	L 4	L 5	L 6	L 7	L 8	L 9	L 10	L 11	L 12	L 13	L 14	L 15

Right Hand Word

R S	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12	R 13	R 14	R 15

L1, L2, L3:	Index Register Selection Bits
L4, L5, L6, L7, L8, L9, L10:	Instruction Code Bits
L10, L11, L12, L13, L14, L15:	Index Interval Bits
RS through R15:	Data Address
P =	Parity Bit
S =	Sign Bit

Automatic built-in subroutines include Start from Test Memory, Load from Card Reader, Load from AM Drums, Clear Memory, and Master Reset.

Automatic coding includes Compass, Lincoln Utility, and Jovial.

Registers

4 Index Registers
1 Memory Buffer Register
1 "A" Register
1 Accumulator
1 B Register
1 I/O Register
1 Drum Control Register
1 I/O Word Counter Register
1 Program Counter Register
1 Address Register
1 I/O Address Register
3 Memory Address Registers
1 Test Register
1 MI Register

ARITHMETIC UNIT

Manufacturer (Simplex Computer)	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	12	6.0
Mult	16.5	10.5
Div	51.0	45.0
Arithmetic mode	Parallel	
Timing	Synchronous	

Internal computer operations are synchronous. However, input data can be handled at a random rate.

Operation: Sequential and concurrent

The Stored Program computer with sequential execution of programmed instructions. Through the use of buffer storage devices (drums) input, output, arithmetic operations can be accomplished concurrently.

STORAGE

Manufacturer (Simplex Computer) Media	No. of Words	No. of Binary Digits/Word	Access Microsec
Ferrite Memory (Core)	69,632	33	6
Magnetic Drums	135,168	33	10
Magnetic Drums	18,432	24	10

Drum access time is for each consecutive word.

Magnetic Tape

No. of units that can be connected	8 Units
No. of chars/linear inch of tape	248 Chars/inch
Channels or tracks on the tape	6 Data, 1 control Tracks/tape
Blank tape separating each record	0.75 Inches
Tape speed	75 Inches/sec
Transfer rate	18,750 Chars/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	1/2 Inches
Length of reel	2,400 Feet
Composition	Mylar or cellulose acetate base

System Development Corporation

Media	No. of Words	No. of Binary Digits/Word	Microsec
Core	69,632	33	6
Drum	153,600	33	10,000

INPUT

Manufacturer (Simplex Computer)

Media	Speed
Cards	150 cards/min, 24 words/card
Magnetic Tape	3,086 words/sec
Manual Inputs	Random
Automatic Inputs	Random LRI-GFI, Xtell

System Development Corporation

Magnetic Tape	75 feet/sec

248 characters per inch, 1.2 million words per reel. 3,000 words/sec read-write time.

Card	150 cards/min

Hollerith contains 1 instruction word per card. Binary contains 24 instruction words per card.

OUTPUT

Manufacturer (Simplex Computer)

Media	Speed
Printer	150 lines/min
Punch	100 cards/min
Display	Random

Digital Display & Situation Display

Automatic Outputs	Random

TTY, G/AFD, G/A TD, G/G

LRI: Long Range Radar Inputs from distant radar sites are received at random, processed and stored for use by the computer.

GFI: Gap Filler Radar Inputs: A separate element processing and storing data in a manner similar to LRI.

Xtell: Coded Digital messages from adjacent SAGE computers received at random, processed and stored for use by the computer.

TTY: Teletype output capability for computer generated messages.

G/AFD: Ground to Air Frequency Division output capability for computer generated messages.

G/ATD: Ground to Air Time Division output capability for computer generated messages.

G/G: Ground to Ground output capability for computer generated messages to other SAGE computers.

System Development Corporation

Media	Speed
Cards	100 cards/min

Binary is normal output. Hollerith can be outputed.

Tape	25 ft/sec
Printer	150/500/5,000 lines/min

Printer - IBM 717, 720A and SC 5000.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Manufacturer (Duplex)

Type	Estimated Quantity
Tubes	50,000
Diodes	170,000
Transistors	703
Magnetic Cores	4,603,904

CHECKING FEATURES

Manufacturer

Parity, inactivity, overflow, fix programming (Self detecting, error correcting program routine which corrects approximately 95% of all errors without manual intervention.)

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer

All values are for duplex system

Power, computer	750 Kw 0.65 DC Supplies 1.0 Filaments
Volume, computer	337,500 cu ft
Area, computer	22,500 sq ft
Room size	150 ft x 150 ft
Floor loading	150 lbs/sq ft
Weight, computer	275 Tons

Site preparation requirements

Computer plenum, requirements are 150 x 150 x 6 = 135,000 cu ft.

Display system requires additional 35,000 sq ft of floor space.

The Display area has a special hexcel ceiling and controlled blue lighting.

Building is climatically controlled, reinforced concrete construction, no windows.

All power is self-contained within the compound.

The square footage is divided into four separate areas: A Computer, B Computer, Simplex and Maintenance and Programming.

The air conditioning equipment is not provided by IBM.

System Development Corporation

Power, computer	1500 Kw	1875 KVA	0.8 pf
Power, air cond	288 Kw	360 KVA	0.8 pf
Volume, computer	10,450 cu ft		
Volume, air condition	8,500 cu ft		
Area, computer	1,508 sq ft		
Area, air condition	1,250 sq ft		
Room size, computer	100 ft long		
	76 ft wide		
	20 ft high		
Room size, air condition	36 ft long		
	16 ft wide		
	20 ft high		
Floor loading	150 lbs/sq ft		
Capacity, air conditioner	500 Tons		
Weight, computer	113.1 Tons, total		

The building was constructed by the Air Force using specifications furnished by IBM for the specific purpose of housing the computers, power and air conditioning equipment, the space for support equipment (EAM) and operating and maintenance personnel. Above figures are approximate.

PRODUCTION RECORD

Manufacturer

Number produced to date	25 (25 duplex systems equals 50 units)
Number in current operation	23
Number in current production	1
Time required for delivery	16 months

PERSONNEL REQUIREMENTS

Manufacturer

The personnel requirements are dependent upon the intended application and requirements (reliability and shift policy) of the equipment as established by the Air Force. The experience to date would not necessarily be a criteria for all equipment applications.

Training of operators, maintenance personnel, programmers, and customer management is available on the basis of specific contract negotiation.

System Development Corporation

	One 8-Hour Shift		Two 8-Hour Shifts		Three 8-Hour Shifts	
	Used	Recom	Used	Recom	Used	Recom
Supervisors	12	12	14	14	16	16
Analysts	10	10				
Programmers	500	500				
Clerks	11	11	16	16		
Operators	7	10	13	17	19	20
Engineers	10	7	20	14	30	21
In-Output Oper	Covered under Operators					
Tape Handlers	Covered under Operators					

Operation tends toward open shop.

Programming and System training staff.

Five weeks of concentrated programming training and three weeks of associated System training.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Manufacturer

The four years of field operating experience on this equipment has proven it to be reliable. Quality control and sound engineering has contributed to maximum reliability and maintainability.

System Development Corporation

Average error-free running period	13 Hours
Good time	116.76 Hours/Week (Average)
Attempted to run time	120 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	97.3
Above figures based on period	1 Jan 60 to 28 May 60
Passed Customer Acceptance Test	Nov 57

Time is not available for rent to outside organizations.

The total hours on the air is 144 (6 days/week).

The total maintenance hours is 24 hours/week (4 hours/day).

The available operational time = 120 hours/week (20 hours/day).

ADDITIONAL FEATURES AND REMARKS

Manufacturer

Outstanding features include large capacity internal memory, automatic recovery program (self-checking), BOMARC control capability, high reliability, and automatic marginal checking.

Unique system advantages include six or nine tube pluggable unit packaging with printed circuits which enable quick replacement by a spare, visual display capability to assist in tracking and identifying aircraft and assist in selecting and directing weapons, duplex switching to increase reliability.

Tapes used with the AN/FSQ-7 are form the standard IBM commercial product line. The same precautions are applicable in tape handling.

The system is to ensure reliable around-the-clock air defense.

System Development Corporation

Outstanding features include a 16 bit half word arithmetic logic for convenience in two dimensional geometric calculations.

Unique system advantages include a large auxiliary memory in the form of drums, permitting flexibility in the manipulation of complex multi-program systems.

FUTURE PLANS

Manufacturer

It is planned to provide a modest product improvement program for the indefinite future.

INSTALLATIONS

System Development Corporation
2500 Colorado Avenue
Santa Monica, California

AN/FSQ 31 (v)

SAC Data Processing Subsystem AN/FSQ 31 (V)

MANUFACTURER

International Business Machines Corporation
Federal Systems Division

APPLICATIONS

The Q-31-V is a general purpose scientific computing and data processing system control applications.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	48 + 2 parity bits
Binary digits/instruction	48 + 2 parity bits
Instructions per word	1
Instructions decoded	69
Arithmetic system	Fixed and floating point
Instruction type	One address
Number range	

Sign, 11-bit characteristic, and 36 bit mantissa on floating point. Ones complement binary arithmetic, sign + 47 data bits on fixed point.

An automatic coding system has been developed by the customer.

Register and B-boxes include 8 index registers, expandable to 13. 22 internal registers have specific addresses which may be used in the address portion of the instruction, i.e., program register, accumulator "B" register, etc. 4 switch registers have specific addresses. 32 plug-board registers also have specific addresses.

Sixty nine basic instructions are decoded. The use of the operation code modifiers in conjunction with the basic instruction provides the capability of decoding 771,716 effective instructions.

When performing fixed point operations a data word may be treated as a sign plus 47 data bits or may be split into two half words of sign and 23 data bits. These half words may be operated on either with the right or left half only or with both halves at the same time but independently, in the arithmetic section. There are three ways of addressing (a) Real data - the right half of the instruction is the operand to be used. (b)Direct Address - the address portion of the word specifies the location of the data (c) Indirect Address - the address portion of the word specifies the location of another address which may specify the location of the data. This function may be recursive.

There are two basic instruction forms. Form "A" is used for all instruction except the decrement class. Form "B" is used only for the decrement class instructions. The decrement field of the decrement class instruction is the same number of bits in length as the index registers because these instructions work with or on the index registers.

Data may also be handled in 6 bit groups called "bytes" with an ability being provided to manipulate these bytes in many ways. Manipulation of bits within a byte (as specified by the instruction) is also possible.

ARITHMETIC UNIT

Operation Time	Including Storage Access Microseconds Fixed	Floating
Add	2.5	5-27.5
Mult	14-58	14.5-61.5
Div	70	56.5-63.5

Construction (Arithmetic unit only)		
Transistors	9,800	Special MADT
Condensers	19,100	Corning Glass and Mica
Diodes	21,400	
Transformers	2,700	
Resistors	48,200	Special, 5%, carbon
Arithmetic mode	Parallel	
Timing	Synchronous	
Operation	Concurrent	

The instruction times including and excluding memory access are the same because of the overlap of the instructioned coding with the fetch time of the operand. The two level decoding structure permits this.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Ferrite Core	65,536 (expandable to 131,072)	3,276,800 to 6,553,600	2.5
Mag. Drums - Aux. Storage	139,264/drum (max of 557,056)	6,963,200 to 27,852,800	

Magnetic Tape

No. of units that can be connected 24 expand to 48

		Units
No. of char/linear inch of tape	556	Chars/inch
Channels or tracks on the tape	7	Tracks/tape
Blank tape separating each record	0.75	Inches
Tape speed	75	Inches/sec
Transfer rate	41,667	Chars/sec
Start time	3.65	Millisec
Stop time	3.65	Millisec
Average time for experienced operator to change reel of tape	30	Seconds
Physical properties of tape		
Width	1/2	Inch
Length of reel	2,400	Feet
Composition	Acetate, Mylar	

Magnetic Drum access time; maximum 22.5 milliseconds, average 11 milliseconds, minimum 11 microseconds, consecutive transmission 2.75 microseconds/word. A system may be expanded to handle two drum adapters and eight physical drums increasing the maximum storage to 1,114,112 words. Up to 3 of the 24 tape units may be operating on-line as input/output devices simultaneously.

INPUT

Media	Speed
Cards	250 cards/min
Typewriter	Typing Speed
Data Channel	32 microsec/word

There are 12 full words and 12 half words on each input card. The data channel can receive 1/2 word every 16 microseconds.

OUTPUT

Media	Speed
Cards	100 cards/min
Typewriter	600 char/sec
Data Channel	32 microsec/word
Printer	600 lines/min
	132 char/line

The data channel is actually a communications link with a smaller computing system operating as a message switching/processing complex.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity	
Diodes	229,000	Special high speed design
Transistors	138,000	Special MADT Design
Magnetic Cores	3,276,800	Ferrite

CHECKING FEATURES

100% single error detection with the capability of programmed error correction.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer (initial) 109.05 Kw 168 KVA 0.65 pf
Power, computer (expanded)147.47 Kw 227 KVA 0.65 pf
Power, air cond, internal, liq cooled 62.25 Kw
Power, air cond, internal, air cooled 14.00 Kw
Power, air cond, external air cooled 89.89 Kw
Volume, computer 4,825 cu ft
Area, computer 740 sq ft
Area, computer, maint and prog 4,250 sq ft
Area, maint, test and store 1,425 sq ft
Floor loading, structural design 150 lbs/sq ft
Weight, computer, total, SAC initial 105,650 lbs
Capacity, air conditioner, external 23.2 Tons
Site preparation requirements
Power equipment installation consisting of power distribution unit, frequency-converters, and M-G sets for prime power regulation. Maintenance room provisions for a-c regulators shall be installed.
Installation of heat exchanger for liquid cooling purposes.
Compressed air provision for drum units.
Forced air cooling for memory required. Segregated race-way systems (for signal and power) shall be provoded for overhead at a height of 8'-8" and 9'-8" respectively.
Room air conditioning for personnel comfort.
Liquid cooling accommodations for transistorized equipment shall be provided.
Dias is desirable with access ramp and/or stairs due to underfloor cabling requirements for commercial equipment.
Leveling channels shall be installed for uniform floor loading for computer equipment.
Minimum 8 foot door heights have to be provided.
Power Emergency-Off system located within the building should be provided.
Lighting system for equipment installation and maintenance purposes (minimum average of 50 foot-candles illumination at the floor level.)
Adequate administrative office area must be provided.

PRODUCTION RECORD

Number in current production	3
Number on order	3

PERSONNEL REQUIREMENTS

Personnel requirements are established on the basis of reliability and shift requirements established by the user.

Training of operators, maintenance, programmer and customer executive personnel is available on the basis of specific contract negotiation.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System features and construction techniques utilized by manufacturer to insure required reliability include error detection hardware enables 100% single failure detection, specific hardware in the machines used for the FIX error correction concept, where by an intermittent single error may be corrected by programming means, specific hardware connected with FIX is used to isolate a solid failure to a minimum number of circuit elements (Q-Pacs), and circuit design was accomplished utilizing an "End-of-life" technique. Marginal checking capability is provided to enable the operation of the system with marginal voltages. Marginal conditions may be controlled either manually or by program means. Diagnostic Programming Techniques are employed in conjunction with marginal checking to assist in locating circuit elements which have not yet failed but may be about to fail. Operating Experience-Prototype of system is currently under reliability evaluation.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include a very sophisticated instruction list, machine design which permits very efficient usage for either data processing tasks or scientific usage. Semi-variable field ability not usually found with high speed arithmetic operations. Machine desing permits use of many advanced programming techniques, i.e., direct or indirect addressing, single or double indexing, most internal registers are addressable. Ultra reliable design philosophy is used throughout the system. System was designed primarily as a real time control system for a wide range of command and control applications. In addition to a very powerful general purpose computer, the system has facilities for expansion (or contraction) in all storage and input/output area to meet a large variety of real time control and computing demands. Error detection and correction design insure high reliability. The tape utilized on this system is from the standard IBM product line.

Anticipated installation date of first system is the fourth quarter of 1960. The system described here may also be implemented as a completely duplexed installation with very effective communication links from one computer to the other.

FUTURE PLANS

A modest product improvement program is planned.

INSTALLATIONS

Strategic Air Command

AN/FSQ 32

MANUFACTURER

International Business Machines Corporation
Federal Systems Division

APPLICATIONS

General purpose scientific computing and data processing system with emphasis on real-time control applications.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	48 + 2 parity bits
Binary digits/instruction	48 + 2 parity bits
Instructions per word	1
Instructions decoded	69
Arithmetic system	Fixed and floating point
Instruction type	One address

Number range

Sign + 47 data bits fixed point, Sign + 36 bit mantissa 11 bit characteristic floating point.

An automatic coding system has been developed by the customer.

Registers and B-boxes

8 index registers expandable to 13.22 internal registers have specific addresses which may be used in the address portion of the instruction. (i.e., Program register, accumulator "B" register, etc.) 4 Switch registers also have specific addresses. 32 plug-board registers also have specific addresses.

Sixty nine basic instructions are decoded. The use of the operation code modifiers in conjunction with the basic instruction provides the capability of decoding 771,716 effective instructions.

When performing fixed point operations a data word may be treated as a sign plus 47 data bits or may be split into two half words of sign and 23 data bits. These half words may be operated on either with the right or left half only or with both halves at the same time but independently, in the arithmetic section. There are three ways of addressing (a) Real data - the right half of the instruction is the operand to be used. (b) Direct Address - the address portion of the word specifies the location of the data. (c) Indirect Address - the address portion of the word specifies the location of another address which may specify the location of the data. This function may be recursive.

There are two basic instruction forms. Form "A" is used for all instruction except the decrement class. Form "B" is used only for the decrement class instructions. The decrement field of the decrement class instruction is the same number of bits in the length as the index registers because these instructions work with or on the index registers.

Data may also be handled in 6 bit groups called "bytes" with an ability being provided to manipulate these bytes in many ways. Manipulation of bits within a byte (as specified by the instruction) is also possible.

ARITHMETIC UNIT

Operation	Including Storage Access Microseconds Fixed	Floating
Add	2.5	5-27.5
Mult	14-58	14.5-61.5
Div	70	56.5-63.5

Construction (Arithmetic unit only)

Transistors	9,800
Condensers	19,100
Diodes	21,400
Pulse Transformers	2,700
Resistors	48,200

Arithmetic mode	Parallel
Timing	Synchronous
Operation	Concurrent

The instruction times, including and excluding memory access time, are the same because of the overlap of the instruction decoding with the fetch of the operand. Two level decoding structure permits this.

STORAGE

Media			Access Microsec
Ferrite Cores	81,920 expandable to 163,840	4,096,000 to 8,192,000	2.5 (complete memory cycle)
Aux. Storage	139,264 exp. to 557,056	6,963,200 to 27,825,800	
Dator Storage	139,264	6,963,200	

Magnetic Drum access time, Aux. storage maximum 22.5 milliseconds, average 11 milliseconds, and minimum 11 microseconds. Consecutive transmission time is 2.75 microseconds. The dator drum is used with the output system and the data to be sent out must be put on the drum in specific patterns to enable the correct operation of the output system.

Magnetic Tape

No. of units that can be connected	24 Units
No. of chars/linear inch of tape	556 Chars/inch
Channels or tracks on the tape	7 Tracks/tape
Blank tape separating each record	0.75 Inches
Tape speed	112.5 Inches/sec
Transfer rate	62,500 Chars/sec
Start time	3.65 Millisec
Stop time	3.65 Millisec
Average time for experienced operator to change reel of tape	30 Seconds
Physical properties of tape	
Width	1/2 Inches
Length of reel	2,400 Feet
Composition	Acetate or Mylar

INPUT

Media	Speed
Crosstell	1,300 bits/sec 32 channels, max
Long Range Radar	1,600 bits/sec 40 channels, max
Low Data Rate (LDR)	60-75-100 words/min 32 channel max, 5 bits/word
	53-66-88 words/min 6 bits/word
Card	200 cards/min
12 full words and	12 half words/card
Typewriter	Typing speed

OUTPUT

Media	Speed
Ground to Ground	1,300 bits/sec 25 channels max
Ground to Air	1,300 bits/sec 8 channel max
Teletype	Same as LDR 25 channel max
Card Punch	100 cards/min
12 full words and	12 half words/card
Typewriter	600 cards/min
Printer	600 lines/min 132 chars/line

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	305,000
Transistors	201,000
Magnetic Cores	4,096,000

MADT transistors account for a very large percentage of those used.

Type WA diodes (an IBM classification) are used.

CHECKING FEATURES

100% single error detection with the capability of programmed error correction.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer, initial	106.66 Kw 164 KVA 0.65 pf
Power, computer, expand	203.42 Kw 312 KVA 0.65 pf
Power, air cond, expanded, liq	99.45 Kw
Power, air cond, expanded, air	23.80 Kw
Power, air cond, room	222.14 Kw
Volume, computer, initial	6,010 cu ft
Volume, computer, expanded	7,969 cu ft
Area, computer, initial	887 sq ft
Area, computer, expanded	1,161 sq ft
Area, comp, prog, initial	5,632 sq ft
Area, comp, prog, expanded	6,656 sq ft
Area, maint, tape, calibration	4,608 sq ft
Floor loading	150 lbs/sq ft
Weight, computer, initial	132,960 lbs, total
Weight, computer, expanded	181,560 lbs, total

Expanded Q-32 is with 18 tape drives and 10 storage units.

Site preparation requirements

Power equipment installation consisting of Power Distribution Unit, Frequency-Converters, and M-G sets for prime power regulation. Maintenance Room provisions for a-c regulators shall be installed.
Installation of Heat Exchanger for liquid cooling purposes.
Compressed air provision for drum units.
Segregated race-way systems (for signal and power) shall be provided for overhead at a height of 8'-8" and 9'-8" respectively.
Room air conditioning for personnel comfort.
Liquid cooling accommodations for transistorized equipment shall be provided.
Dais is desirable with access ramp and/or stairs due to underfloor cabling requirements for commercial equipment.
Leveling channels shall be installed for uniform floor loading for computer equipment.
Minimum 8 foot door heights have to be provided.
Power Emergency-Off system located within the building should be provided.
Lighting system for equipment installation and maintenance purposes (minimum average of 50 foot-candles illumination at floor level).
Adequate administrative office area must be provided.

PERSONNEL REQUIREMENTS

The personnel requirements are depended upon the intended application and requirements (reliability and shift policy) of the equipment as established by the user.

Training of operators, maintenance personnel, programmers and customer management is available on the basis of specific contract negotiation.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System features and construction techniques utilized by the manufacturer to insure required reliability includes error detection hardware which enables 100% single failure detection and specific hardware in the machine, which is used for the FIX error correction concept, whereby an intermittant single error may be corrected by programming means. Specific hardware, connected with FIX, is used to isolate a solid failure to a minimum number of circuit elements (Q-PACS). Circuit design was accomplished utilizing an "End-of-life" technique. Marginal checking capability is provided to enable the operation of the system with marginal voltages. Marginal conditions may be controlled either manually or by program means. Diagnostic programming techniques are employed in conjunction with marginal checking to assist in locating circuit elements which have not yet failed but may be about to fail. Operating Experience - Prototype of system has been underlying reliability evaluation for approximately two years. No operating experience is available on the full system at this time. Good prototype reliability is reported.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include a very sophisiticated instruction list. Machine design permits very efficient usage for either data processing tasks or scientific usage. The semi-variable field ability is not usually found with high speed arithmetic operations. Machine design permits use of many advanced programming techniques, i.e., direct or indirect adressing, single or double indexing, most internal registers are addressable. An ultra reliable design philosophy is utilized. System was designed primarily as a real time control system for a wide range of command control applications. In addition to a very powerful general purpose computer, the system has facilities for expansion (or contraction) in all storage and input/output areas to meet a large variety of real time control and computing demands.
Error detection and correction design insures high reliability. The tape utilized on this system is from the standard IBM product line.
Anticipated installation date of first system is the fourth quarter of 1960.
The equipment described here may also be implemented as a completely duplexed installation with very effective communications link from one computer to the other. A modest product improvement program is planned.

AN/MJQ 1 REDSTONE

AN/MJQ 1 Missile Firing Data Computer (Redstone)

MANUFACTURER

North American Aviation
Autonetics Division

Photo by U. S. Army Ordnance Guided Missile School

APPLICATIONS

U. S. Army Ordnance Guided Missile School Located in Room 114, Bldg. 3303, OGMS, Redstone Arsenal, Alabama, the primary mission of this system is to solve the Redstone Missile Firing Problem. The computer is currently being utilized to train students in Digital Computer Fundamentals.

U. S. Army Artillery and Missile School Located in Bldg. 900, Gunnery/Cannon/Rocket Dept., Fort Sill, Oklahoma, the system is used for fire control computations.

STORAGE

USAOGMS and USAAMS

Medium	No. of Words	No. of Dig/Word	Access Microsec
Magnetic Disc	4,096	41	15,700

The disc is of beryllium.

INPUT

USAOGMS and USAAMS

Media	Speed
Keyboard (decimal)	Manual
Paper Tape (Teletype)	200 char/sec

Five channel tape is used.

OUTPUT

USAOGMS and USAAMS

Media	Speed
Typewriter (IBM)	9 dec dig/sec
Indicator (Nixie)	

Displays momentarily during printout. Readout capacity is 16 decimal digits, including sign.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

USAOGMS

Power, computer	0.4 Kw	0.9 pf
Weight, computer	155 lbs	

Complete system can be set on top of 2 office size desks. No special air conditioning or special installation requirements are needed.

USAAMS

Power, computer	1.3 KVA
Volume, computer	4.5 cu ft
Area, computer	3.4 sq ft
Floor loading	36.8 lbs/sq ft
Weight, computer	125 lbs

COST, PRICE AND RENTAL RATES

USAOGMS

System cost approximately $80,000.

A van, with air conditioning and power system for field use, cost approximately $80,000.

USAAMS

System cost $66,000.

PERSONNEL REQUIREMENTS

USAOGMS

The system is designed to be utilized in the field with a tactical organization and under tactical conditions. Its sole purpose is computation of the Redstone firing problem.

Personnel required for this system include only military operators and maintenance type personnel.

All training other than on-the-job training is conducted at the OGMS, Redstone Arsenal, Alabama.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

USAOGMS

Figures are based on the period from Sep 58 to Apr 60.

Time is not available for rent to outside organizations.

This machine has approximately 1,000 hours of operating time on it. It is normally used for demonstrations and instructing students in maintenance and programming. A record exists only for the last 482 hours of operation. In this period 88.9 hours were utilized for maintenance. Of this maintenance time listed, many of the hours were spent adjusting and checking out memories for other machines before shipping them to overseas.

ADDITIONAL FEATURES AND REMARKS

USAOGMS

Outstanding features are simplicity of operation, and small size. Maintenance is difficult due to poor documentation and time sharing of components.

FUTURE PLANS

USAOGMS

There are apparently no future plans for this machine. In all probability the machine will be utilized for its present mission as is until the Redstone System is replaced with a newer system.

USAAMS

The Field Artillery Digital Automatic Computer (FADAC), a rugged, lightweight computer for use in the field with artillery units will replace this system.

INSTALLATIONS

U. S. Army Ordnance Guided Missile School
Redstone Section, BM Br., FAM Div.
Redstone Arsenal, Alabama

U. S. Army Artillery and Missile School
Computer Branch, R&R Div.
Fort Sill, Oklahoma

AN/TYK 4v COMPAC

COMPAC (AN/TYK-4v)

MANUFACTURER

Philco Corporation
Computer Division

COMPAC General Purpose Control Panel

Photo by USASRDL

APPLICATIONS

General purpose computer operating as an integral part of a larger weapon system; operation includes field artillery, fire direction, gun data computation and automatic transmission, survey data computation and automatic transmission, and meteorological data reduction, computation and automatic data transmission.

Major component of the Army automatic data processing system.

Major component of an automatic data processing system organized as an integrated subsystem.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits per word	36 plus sign and parity
Number of binary digits per instruction	36 plus spare and parity
Number of instructions per word	1
Total number of instructions decoded	26 with in/out converter, 19 w/o in/out converter
Arithmetic system	Fixed point
Instruction type	One-address
Number range	$-(1-2^{-36})$ to $+(1-2^{-36})$

Instruction word format

Normal Command

Parity	Spare	Op. Code	Index Register	Minor Address	Major Address
38	37	36 31	30 28	27 16	15 1

I/O Command

Parity	Spare	Op. Code	Word Counter	Device Selection	Storage Address
38	37	36 31	30 22	21 16	15 1

Automatic coding COMPAC uses an assembly program

Registers and B-boxes
- Central processor 7 + 4 index = 11 registers
- In/Out converter 1

There are a total of 4 arithmetic, 4 transfer, 6 logical, 3 sense, and 9 input-output instructions. Of the input-output instructions, 7 require the I/O converter.

ARITHMETIC UNIT

Operation time	Inc. Stor. Access Microsec	Excl. Stor. Access Microsec
Addition	24	12
Multiplication	252	240
Division	252	240

Construction, arithmetic unit only
- Transistors: 3,000
- Condenser-Diodes: 7,000

Arithmetic mode: Serial by 6 bits/char
Timing: Synchronous
Operation: Sequential

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

STORAGE

Media	Words	Digits/word	Microsec Access
Magnetic Core	4,096	38	12

Core storage up to 3 additional 4,096-word memories may be added.

Magnetic tape
- Maximum number of units that can be connected to the system: 8 Units
- Maximum number of characters per linear inch of tape: 300 Char/inch
- Channels or tracks on the tape: 16 Track/tape
- Blank tape separating each record: 1-1.5 Inches
- Tape speed: 1 to 150 Inches/sec
- Transfer rate: 300 to 45,000 Char/sec
- Start time: 3 Millisec
- Stop time: 3 Millisec
- Average time for experienced operator to change reel of tape: 30 Seconds
- Physical properties of tape
  - Width: 1 Inch
  - Length of reel: 3,600 Feet
  - Composition: Mylar

Two tracks on magnetic tape are "guard" channels and are not usable.

INPUT

Media	Speed
Paper tape reader memory loader	30 char/sec or 300 char/sec
Keyboard on console	Manual entry speed

OUTPUT

Media	Speed
Paper tape punch/printer	30 char/sec
Communications converter	45 KC
Limited by programming	

Input/Output Device can be added. This enables use of:
- Paper tape reader
- Paper tape punch
- Tape transports
- 120 char line printer
- 24 char line printer
- FIELDATA typewriter

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	
IN-643	3,500
Transistors	
2N706	10,000
Magnetic Cores	156,000
Memory	

CHECKING FEATURES

Parity on memory transfer and input/output; overflow; non-existent memory; non-existent instruction; non-existent device (I/O); marginal checking.

Diagnostic Program.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Volt-Amperes, computer	4 KVA
Space, computer	9 cu. ft.
Weight, computer	200 lbs.

COMPAC has no special requirements. It can be used in the field, on trucks, or in rooms.

PRODUCTION RECORD

Number produced to date	0
Number on order	1
Time required for delivery from receipt of order	12 months

PERSONNEL REQUIREMENTS

Estimated	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Supervisors	1	2	3
Programmers and Coders			
Operators	1-2	2-4	3-6
Technicians	1	2	3

The number of coders and programmers depends on applications.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

The estimated mean time between failures is 101 hours for the COMPAC Central Processor.

ADDITIONAL FEATURES AND REMARKS

Ruggedized for field use, operating from 25°F to +125°F; 0 to 97% relative humidity.

Computer can be expanded into a system with additional memories, input-output converters and communications converters.

It is a member of the Army FIELDATA family of computers. It uses the FIELDATA code and is compatible with other FIELDATA machines.

System uses a communications converter. Operating at 45 Kc, it is limited by programming.

INSTALLATIONS

Mobile with the Army in the field.

AN/TYK 6v BASICPAC

BASICPAC (AN/TYK-6v)

MANUFACTURER

Philco Corporation
Computer Division

Typical Basicpac Computer Arrangement

Photo by USASRDL

APPLICATIONS

Manufacturer

The system is designed for military field use including a variety of logistical, administrative, intelligence, command control, fire support, and miscellaneous activities.

Fairchild Astrionics - Primarily for drone recovery.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits per word	36 plus sign and parity
Number of binary digits per instruction	36 plus spare and parity
Number of instructions per word	1
Total number of instructions decoded	41
Arithmetic system	Fixed point
Instruction type	One-address
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 Command	Word-Block Counter	Device Selection	Storage Address	

Automatic coding BASICPAC uses an assembly program

Registers and B-boxes

Central processor	6 + 4 index = 10 registers
Communications converter	10
In/Out converter	6

There are a total of 8 arithmetic, 7 transfer, 13 logical, 3 sense, and 10 input/output instructions. Of the input/output instructions, 5 require the I/O converter, and one requires the search unit.

The index registers may be increased to a total of 7.

BASICPAC central processor consists of one 4,096 word memory, arithmetic, programming and control units. BASICPAC system may contain one to seven input-output converters, and one communications converter. Each Input/Output converter can handle up to eight I/O devices.

ARITHMETIC UNIT

Operation time, including storage access, microseconds

Addition	22 - 26
Miltiplication	238 - 242
Division	238 - 242

Construction, arithmetic unit only

Transistors	14,000
Arithmetic mode	Serial-parallel 6 bits/char Parallel by bits Serial by character
Timing	Synchronous
Operation	Sequential

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

STORAGE

Media	Words	Digits/word	Microsec Access
Magnetic Core	4,096	38	12

Core storage up to 6 additional 4,096-word memories may be added.

Magnetic Tape

Maximum number of units that can be connected to the system	56 Units
Maximum number of characters per linear inch of tape	300 Char/in.
Channels or tracks on the tape	16 Track/tape
Blank tape separating each record	1-1 1/2 Inches
Tape speed	1 to 150 Inches/sec
Transfer rate	300 to 45,000 Char/sec
Start time	3 Millisec
Stop time	3 Millisec
Average time for experienced operator to change reel of tape	30 Seconds
Physical properties of tape	
Width	1 Inch
Length of reel	3,600 Feet
Composition	Mylar

This system employs the FIELDATA Tape Transport.

These units are connected to the central processor through the I/O converter.

Two tracks on Mag tape are "guard" channels and are not usable.

INPUT

Media	Speed
Paper Tape Reader	30 Char/second
Communications Converter	Approx. 45 KC, rate

Handles up to 8 simultaneous real time input channels

Keyboard on control panel	Manual entry speeds
Mag Tape Transport	45 KC

Communications converter rates limited by programming.

OUTPUT

Media	Speed
Paper Tape Punch	20 Char/second
FIELDATA Typewriter	100 words/min
Page printer	

Must be operated with I/O converter

Communications converter	Approx. 45 KC rate

Handles up to 8 simultaneous real time output channels

Nixie display	

Under program control or operator control

Mag tape	45 KC

COST, PRICE AND RENTAL RATES

Fairchild Astrionics $1,000,000 for 2 complete units.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type No.	Quantity
Diodes	
SG22	750
IN270	200
Transistors	
2N-393	13,500
2N-599	240
2N-341	162
2N-1123	174
2N-501-A	112
Magnetic Cores Memory	156,000

CHECKING FEATURES

Parity on memory transfer and input/output; overflow; non-existant instruction; non-existant memory; non-existant devices (I/O); marginal checking.

Diagnostic Programs.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Volt-Amperes, computing system	22 KVA
Space, central processor	25 cu. ft.
Space, system	500.68 cu. ft.
Area, system	80.10 sq. ft.
Room size, system	S-109 shelter
Air conditioners, two	9,000 BTU/hr, each
Weight, total system, incl air conditioners	4,150 lbs.

BASICPAC system is housed in a S-109 shelter (75 inches high, 79 inches wide, and 146 inches long). Air conditioning is for operator comfort only.

PRODUCTION RECORD

Number in current production	2	Produced	5
Number on order	2	Operation	3
Time required for delivery from receipt of order		12 months	

PERSONNEL REQUIREMENTS

Estimated	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Supervisors	1	2	3
Programmers and Coders	2		
Operators	1-2	2-4	3-6
Technicians	1	2	3

The number of coders and programmers depends on applications.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Estimated mean time between failures:

154 hours for BASICPAC system.

209 hours for BASICPAC central processor.

ADDITIONAL FEATURES AND REMARKS

Ruggedized for field use. Will operate from -25°F to +125°F; 0 to 97% relative humidity.

The system is expansible in that 1 to 6 additional memories may be added, and 1 to 56 I/O devices may be added.

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

Mobile with the Army in the field.

Fairchild Astrionics Division, Wyandanch, N. Y.

AN/TYK 7v INFORMER

Minimal Informer (AN/TYK-7v)

MANUFACTURER

International Business Machines Corporation

APPLICATIONS

System is designed for military field use, including a variety of applications, such as Intelligence, Logistics, and Personnel.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	36 plus sign and parity
Binary digits/instruction	36 plus spare and parity
Instructions per word	1
Instructions decoded	55
Arithmetic system	Fixed point
Instruction type	One address
Number range	$-(1 - 2^{-36})$ to $+(1 - 2^{-36})$

Instruction word format (Operation)

38	37	36 31	30 28	27 16	15 1
Parity	Spare	Operation Code	Index Register Selection	Index Increment	Memory Address

(Input-Output)

38	37	36 31	30 22	21 16	15 1
Parity	Spare	I/O Code	Word or Block Count	Device Addr.	Storage Addr.

Registers and B-boxes

In the central processor there is a total of 10 registers, viz, A Q, Program Counter, Program Counter Store, X, Y, and 4 Index Registers. There is one Input/Output converter instruction register.

The system utilizes a total of 17 arithmetic instructions, 8 transfer, 17 logical, 3 sense, and 10 input-output instructions.

Mobidic Assembly Program may be used.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	20.7	12.7
Mult	392	376
Div	425	400

Construction (Arithmetic unit only)

	Type	Quantity
Transistors	2N696	3,204
Magnetic Cores	4 maxwell	5,799

Arithmetic mode	Parallel
Timing	Synchronous
Operation	Sequential

System operates primarily sequentially, however processing may proceed during input-output operations.

CHECKING FEATURES

Checking features used are parity on memory transfer and input/output, overflow, non-existant instructions, non-existant memory, non-existant devices (I/O), and marginal checking. Diagnostic programs are available.

STORAGE

Media	No. of Words	No. of Digits/Word	Microsec
Core	4,096	38	8
Disk File	3,750,000	38	150,000

Additional Core Storage may be added up to 6 more 4,096 memories.

Magnetic Tape

No. of units that can be connected	16 Units
No. of characters/linear inch	300 Chars/inch
Channels or tracks on the tape	16 Tracks/tape
Blank tape separating each record	1-1.5 Inches
Tape speed	1-150 Inches/sec
Transfer rate	300 to 45K Chars/sec
Start time	3 Millisec
Stop time	3 Millisec
Average time for experienced operator to change reel	30 Seconds
Physical properties of tape	
Width	1 Inch
Length of reel	3,600 Feet
Composition	Mylar

Two tracks on magnetic tape are "guard" channels and are not useable.

INPUT

Media	Speed
Magnetic Tape	45,000 char/sec
Disk File	69,000 char/sec
Paper Tape	30 char/sec
Console	Manual entry speed

OUTPUT

Media	Speed
Paper Tape Punch	20 char/sec
FIELDATA Typewriter	100 words/min
Magnetic Tape	45,000 char/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity	Use
Diodes	6,314	Switching Units
Transistors	10,789	Power Amplification
2N696		
2N697		
2N1253		
Magnetic Cores		
Tape	10,861	Logical Elements
Ferrite	163,840	Core Storage

PERSONNEL REQUIREMENTS

	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Supervisors	1	2	3
Programmers	1		
Coders	1		
Operators	1-2	2-4	3-6
Technicians	1	2	3

Number of programmers and coders depends on application.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.312 Kw	0.445 KVA	0.7 pf
Volume, computer		21.0 cu ft	
Area, computer		4.1 sq ft	
Room Size		S-109 shelter	
Floor loading		110 lbs/sq ft	
		440 lbs concen max	
Weight, computer		440 lbs	
Weight, air conditioner		158 lbs	
Capacity, air conditioner		3/4 Ton	

System is installed in S-109 shelter. Air conditioning is for operator comfort only.

PRODUCTION RECORD

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

ADDITIONAL FEATURES AND REMARKS

System is ruggedized for field use, will operate from -25°F to +125°F, 0 - 97% relative humidity, and has the ability to select desired information from files without "knowing" the exact location of the information. Pulse Magnetic Logic is used. This machine is a member of Army FIELDATA family of computers. It uses the FIELDATA code and is compatible with the FIELDATA machines.

INSTALLATIONS

International Business Machines Corporation
Neighborhood Road
Kingston, New York

Photo by International Business Machines Corporation

AN/USQ 20

AN/USQ 20 Navy Tactical Computer

MANUFACTURER

Remington Rand Univac
Division Sperry Rand Corporation
Univac Park
St. Paul 16, Minnesota

Photo by Remington Rand Univac

APPLICATIONS

Designed as a Navy tactical data system computer, it is used for scientific, general purpose, data processing, on or off-line.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	30
Binary digits/instruction	30
Instructions per word	1

Arithmetic system	Fixed point
Instruction type	One address
Instruction word format	

F Function Code	J Branch Cond. Des.	K Operand Interp. Des.	B Index Designator	Y Operand Designator	(The operand or the address of the operand destination
6-bits	3-bits	3-bits	3-bits	15 bits	

Automatic built-in subroutines includes automatic recovery.

A compiler is available.

Registers and B-boxes include A - 30 bit addressable accumulator, Q - 30-bit addressable logical function register, and B^1 - B^7 - seven (7) 15-bit index registers (B-boxes).

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	16	9.6
Mult	35.2 - 112	35.2 - 112
Div	112	112

Construction (Arithmetic unit only)	
Transistors	1,900
Diodes	5,700
Arithmetic mode	Parallel
Timing	Asynchronous
Operation	Sequential

STORAGE

Media	No. of Words	No. of Digits	Cycle Time Microsec
Magnetic Core	32,768	30	8
Plugboard	16	30	8

INPUT

Media

Keyboard (Flexowriter)
Paper Tape
Magnetic Tape
On-line analog to digital converters
Specifications not yet finalized.

OUTPUT

Media

Hi-Speed Printer
Typewriter (Flexowriter)
Paper Tape
Magnetic Tape
On-line digital to analog converters
Specifications not yet finalized.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	33,787
Transistors	10,265
Magnetic Cores	983,040

For 32,768 30-bit words.

CHECKING FEATURES

All program checked (No internal checking).

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	2.5 Kw	3.1 KVA	0.8 pf
Power, air condit	2.0 Kw	2.2 KVA	0.9 pf
Volume, computer		60 cu ft	
Area, computer		27 sq ft	
Weight, computer		2,320 lbs	

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

PERSONNEL REQUIREMENTS

Training made available by the manufacturer to the user includes written publications on description, theory, operation and maintenance. Orientation courses, conducted by Training Department, Field Service staff personnel, will be given to assist in maintenance of computers at site.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include real time clock, automatic recovery, repeat mode, extremely versatile input-output logical function capabilities, and wide environmental limits.

Unique system advantages include large hi-speed core memory, versatile instruction repertoire, hi-computing speed (less than 14 microseconds per instruction, average), and asynchronous type of operation.

INSTALLATIONS

Remington Rand Univac
Division of Sperry Rand Corporation
Univac Park
St. Paul 16, Minnesota

ASC 15

Advance System Controller Model 15

MANUFACTURER

International Business Machines Corporation
Federal Systems Division

Welded Encapsulated Module

Photo by International Business Machines Corporation, Federal Systems Division

APPLICATIONS

Computer is used in airborne guidance and control systems and is capable of a number of guidance system monitoring and check-out functions (ground operations). System is similar to the computer being developed by IBM for use in the Titan Guidance Subsystem.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	27
Binary digits/instruction	9
Instructions per word	3
Instructions decoded	22
Arithmetic system	Fixed point
Instruction type	Two address (modified)
Number range	2^{24}

Instruction word format

A computer instruction consists of the following nine bits: FFFFF, TTTT. Every operation can be considered a transfer of the contents of the F (from) address to a location specified by the T (to) address memory.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	312	156
Mult	2,028	1,872

High speed Mesa transistors are used in the arithmetic unit.

Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

There are two independent arithmetic elements (Adder and Multiplier). Addition and multiplication can be performed simultaneously.

STORAGE

Medium	No. of Words	No. of Bits	Access Microsec
Magnetic Drum	3,840	99,584	5,000

Thin Shell Magnetic Drum - Air-floated read-write heads.

INPUT

Media	Speed
Optisyns (hi-speed)	6,400 positive increments/sec 3,200 negative increments/sec (Accelerometer and attitude)
Optisyns (lo-speed)	100 increments/sec (real-time)
Discrete Inputs	As programmed (740 in number)

OUTPUT

Media	Speed
3 Ladder	As programmed (± 6 volts 64 increments)
12 Discrete	As programmed
1 Digital	5 bit parallel

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

High speed Mesa transistors are used.

CHECKING FEATURES

There is a built-in check to determine whether computer is out of synchronization.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.150 Kw
Volume, computer	Between 2 and 3 cu ft

A fan provides 100 cu ft/min of air at a pressure rise of 2" water above atmospheric pressure.

Weight, computer	Under 100 lbs

Computer logic is packaged in welded encapsulated modules.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System is designed for a mean time to failure of 1,000 hours.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include welded encapsulated module packaging, built to conform to missile environmental specifications, dual arithmetic units, and high reliability (MTF greater than 1,000 hours).

Unique system advantages include minimal addressing, which requires only 9 bits per instruction, and a number of system monitoring and control functions.

ATHENA

ATHENA

MANUFACTURER

Remington Rand Univac
Division of Sperry-Rand Corporation

Photo by Remington Rand Univac
Division of Sperry-Rand Corporation

APPLICATIONS

Primary application is as a missile guidance computer. It is a special purpose, on-line machine that runs synchronized with the guidance system.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/ word	24
Binary digits/instruction	17
Instructions per word	1
Instructions decoded	34
Arithmetic system	Fixed point (fractional)
Instruction type	One address
Data Registers	
Accumulator	
Quotient	
Exchange	
Steering	
Acceleration	
Discrete	
Display	
Control Registers	
Tape Assembly	
Drum Transfer	
Program Control	
Program Address	
Tape Disassembly	
Input Data Control	
Input Constants Control	

ARITHMETIC UNIT

	Exclud Stor Access Microsec
Add	40
Mult	520
Div	1,000
Construction (Arithmetic unit only)	
Transistors	800
Diodes	4,000
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Sequential

STORAGE

Media	No. of Words	No. of Bin Digits/Word	Access Microsec
Magnetic Drum	8,192	17	
Magnetic Core	256	24	40

Magnetic Tape

No. of units that can be connected	1	Unit
No. of chars/linear inch of tape	200	Chars/inch
Channels or tracks on the tape	7	Tracks/tape
Blank tape separating each record	0.75	Inches
Tape speed	24	Inches/sec
Transfer rate	4,800	Chars/sec
Start time	3,000	Millisec
Stop time	3,000	Millisec
Average time for experienced operator to change reel of tape	60	Seconds
Physical properties of tape		
Width	0.5	Inches
Length of reel	2,400	Feet
Composition	Mylar	

The magnetic drum contents cannot be altered by a program instruction.

The magnetic tape unit is a system monitor only.

INPUT

Medium

Paper Tape

Reader can introduce information to the magnetic drum or the simulator.

OUTPUT

Media

Magnetic Tape

Tape unit can record computational results along with input data.

Paper Tape

Punch can record program information from magnetic drum or core storage.

Printer

Printer can record 8 decimal or octal digits.

The simulator is a combination input-output device used to check computer operation.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	33,000
Transistors	7,500
Magnetic Cores	7,680

CHECKING FEATURES

Checking features include add, divide and shift overflow invalid instruction. Checking may optionally be performed by a simulator.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	5.5 Kw	10 KVA	0.55 pf
Volume, computer		2,860 cu ft	
Area, computer		370 sq ft	
Room size		36 ft x 24 ft	
Capacity, air conditioner		5 Tons	
Weight, computer		21,000 lbs	

Power requirement based on actual measurement.

PERSONNEL REQUIREMENTS

Written publications on description, theory, operation and maintenance; orientation courses conducted by training department; staff of the manufacturer's field service personnel assist in maintenance of the computer on site.

ADDITIONAL FEATURES AND REMARKS

The outstanding feature is reliability.

BENDIX CUBIC TRACKER

BENDIX G-15D and MTA-2 p/o AN/GSQ-29(x1-1)

MANUFACTURER

Computer Division
Bendix Aviation Corporation
and
Cubic Corporation

APPLICATIONS

Systems are located at Tyndall Air Force Base, Cape San Blas, and Carabelle, Florida. Tracking Stations at Cape San Blas and Carabelle develop direction cosines measured from x & y base lines for up to three targets, and a frequency correction word for each target transmitter. Information is transmitted via data link to computing site at Tyndall. Data words are automatically converted to G-15D word length and written directly on computer drum. Program converts direction cosine information to (x,y,z) position and controls automatic position plot of two of the three targets. A command word is generated at the computer site to instruct the program which target trajectories to plot, the change being controlled by transmission of a release signal from one target (interceptor) and a burst signal from a second target (missile). Burst also causes the program to compute the vector miss distance from the 3rd target (drone) to the missile in the velocity vector coordinate system of the drone, and the scalar escape distance between the missile and the interceptor in the MATTS (AN/GSQ-29) coordinate system. Program modifications also permit computation of x, y, z coordinates of any or all targets either on a sample by sample basis (basic sample rate is 20/sec) in non-real time, or at a rate of approximately one sample/sec either real or non-real time.

Though the system was basically designed for scoring air-to-air missile firings it has also been successfully used to track missiles fired from the ground.

Modifications made to the G-15D to permit on-line data processing were accomplished so as to also permit general purpose use of the computer. Part of the high speed punch facility was utilized for an additional long memory line for format conversion and automatic data entry, and the DA-2 circuitry was modified in a minor way to permit data to be written on the M16 and M17 long lines separately.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Computer Drum long line	108	3,132	19,500 avg
Computer Drum 4 wd. line	4	116	504 avg
Computer Drum 2 wd. line	2	58	270 avg
Computer Drum 1 wd. line	1	1	270

INPUT

Media	Speed
Photo Tape Reader	200 hex char/sec
MTA-2 (Bendix)	427 hex char/sec
300,000 words/unit	
max of 4 units	
IBM Typewriter Modified Manual	
Matts Buffer & Input Register	

Buffer "reads" incoming data at rate of 20 samples/sec max, stores twelve 19 bit cosine words and six 10 bit calibrate words at 3kc bit rate, "write" data onto computer drum at 110kc clock rate under automatic control of computer and converts words into computer word length of 29 bits. Maximum time between end of "read" and start of "write" 19,500 microsec. (1/2 drum rev). Write time = 4860 microsec (18 word times). Input register automatically reads one word onto computer Early Buss under program control. Maximum access time is 4 wt (1080 microsec including ready test.

OUTPUT

Media	Speed
Photo Tape Punch	17 hex char/sec
MTA-2	427 hex char/sec Max. of 4 units
IBM Typewriter	8 hex char/sec
Output Register	270 microsec/word Under program control

Minimum program time for (x, y, z) plot of two targets via output register is 16 word times (4320 microsec) including transfer from storage and transfer to output register. Output register operates automatically under computer control.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	4.3 Kw	4.5 KVA	0.95 pf
Power, air conditioner	6 Kw	7.5 KVA	0.80 pf
Volume, computer	60 cu ft		
Volume, MTA-2	30 cu ft		
Volume, MATTS System	130 cu ft		
Volume, air conditioner	192 cu ft		
Area, computer	10 sq ft		
Area, MTA-2	6 sq ft		
Area, MATTS System	18 sq ft		
Area, air conditioner	24 sq ft		
Room size, system	Van 30 x 8 x 7.5 ft		
Room size, air conditioner	4 x 6 x 8 ft		
Floor loading, system	45 lbs/sq ft		
Weight, computer	450 lbs		
Capacity, air conditioner	6 Tons		

Parking pad is approximately 30 x 10 ft
Power is 220 v, 60 cycle, 3-wire, 80 amps.

COST, PRICE AND RENTAL RATES

Components distribution

Computer Site

(1) Data Handling
(2) Data Link (GFE)
(3) Tape Recorders
(4) Computer and Typewriter
(5) MTA-2
(6) D/A Converters (3 ea)
(7) Plotting Boards (2 ea)

Tracking Sites

(1) Tracking System
(2) Data Handling
(3) Tape Recorders (2 ea/site)
(4) Data Link (GFE)

Airborne Transmitters

(1) Interceptor
(2) Target
(3) Missile

Maintenance available on system through Cubic Corp.
Maintenance available on computer through Bendix Computer Division.

PERSONNEL REQUIREMENTS

	One 8-Hour Shift		Two 8-Hour Shifts		Three 8-Hour Shifts	
	Used	Recom	Used	Recom	Used	Recom
Supervisors-Programmers	1	1	1	1	1	1
Engineer-Operator	3	4	3	8	0	12

Operation tends toward open shop.

Methods of training used includes formal classroom plus on-the-job training under qualified personnel, teaching operation and maintenance. Customer personnel (USAF), includes 1 Supervisor, 2 Programmers (Computer Operators) and 10 Technicians.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Average error-free running period 40 Hours
Good time 12 Hours/Week (Average)
Attempted to run time 12.1 Hours/Week (Average)
Operating Ratio (Good/Attempted to run time) 0.99
Above figures based on periodl Mar 60 to 1 Aug 60
Date this system passed customer acceptance test: undergoing acceptance tests.

Time is probably available to other AF organizations on an availability basis.

ADDITIONAL FEATURES AND REMARKS

System utilizes GP computer for special purpose application yet permits utilization of computer for GP applications by merely rotating a switch.

System measures spatial position to 50 parts/million, less than 40 ft. error in vector miss distance.

Special purpose system utilizing GP computer system designed for scoring air-to-air missile firing, with latitude in design to permit modification to other related applications.

FUTURE PLANS

Replacement of electro-mechanical servo system and data handling system at tracking sites with Cubic Electronic Digital Phase Meters.

INSTALLATIONS

System distributed between Tyndall AFB, Cape San Blas, and Carabelle, Florida.

BENDIX D12

Bendix D12 Digital Differential Analyzer

MANUFACTURER

Bendix Computer Division of Bendix Aviation Corp.

Photo by Griffiss Air Force Base

APPLICATIONS

Manufacturer

Solution of differential equations.

Statistical Services Div., Hq RADC, Griffiss AFB

The system is used for the solution of scientific problems, involving differential-integral equations (orbits, trajectories, Bessel functions, etc).

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	8
Arithmetic system	Fixed point
Number range	-5.0000000 to +4.9999999

As this system is a digital differential analyzer, usual digital computer instructions are not used. The computer employs a semi-fixed program.

ARITHMETIC UNIT

		Microsec
Add time (exclud stor access)		43
Construction	Vacuum tubes	
Basic pulse repetition rate	200 Kc/sec	
Arithmetic mode	Serial	
Timing	Synchronous	
Operation	Sequential	

Decimal digits are treated serially, whereas their binary codes are held in parallel.

STORAGE

Manufacturer Media	Words	Binary Digits
Magnetic Drum	550	22,000

Access times are not relevant because of the fixed program.

Griffiss AFB		
Magnetic Drum	240	8 plus sign

This system has 60 integrators.

INPUT

Manufacturer Media	Speed	
Paper Tape	6 dig/sec	
Griffiss AFB		
Paper Tape	6 dig/sec	
Typewriter Keyboard	Manual	
Curve Follower (Attachment)	20 dig/sec	(Imperical Input)

OUTPUT

Manufacturer

Media	Speed
Typewriter	10 dig/sec
Graph Plotter	20 dig/sec, 100 steps/inch

Griffiss AFB

Typewriter (IBM)	10 dig/sec
Paper Tape	10 dig/sec
Graph Plotter	20 dig/sec, 100 steps/inch

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	700
Tube types	6
Crystal diodes	2,200
Separate cabinets	2

CHECKING FEATURES

Overflow in addition
Prescribed code as a result of addition

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer

Power, computer	7.5 Kw
Power, air conditioner	105 cu ft 25 sq ft
Weight, computer	2,000 lbs

A desk is provided in addition to the computer console proper.

Griffiss AFB

Power, computer	7.5 Kw
Volume, computer	125 cu ft
Area, computer	42.5 sq ft
Room size, computer	400 sq ft

Located on false floor. Air conditioner is shared with other equipment.

PRODUCTION RECORD

Manufacturer

The Bendix D-12 is no longer in production and is manufactured only when a customer's needs can not be met by any other equipment. The DA-1 used with the G-15D General Purpose Computer System is based on the D-12 and uses the memory of the G-15D for combined GPC and DDA operation. The DA-1, while low-priced, is therefore equipped with 108 integrators and 108 constant multipliers.

COST, PRICE AND RENTAL RATES

Manufacturer

Approximate cost of basic system $55,000, including one graph plotter unit.
Approximate cost of additional equipment $8,035 for unit for interconnecting two computers.

Griffiss AFB

The basic computer cost $48,000.
The extra coding unit, graph plotters and curve follower cost $20,000.

PERSONNEL REQUIREMENTS

Griffiss AFB

System requires one engineer and 1 operator. Operation tends toward closed shop. Method of training includes the use of maintenance manuals and on-the-job training.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Manufacturer

Good time	500 Hours
Attempted to run time	600 Hours
Operating ratio (Good/Attempted to run time)	0.83
Passed Customer Acceptance Test	1 Aug 54

Griffiss AFB

Average error-free running period	40 Hours
Good time	1,000 Hours

Above figures based on period 15 Mar 56 to 1 Nov 56.
Passed Customer Acceptance Test 15 Mar 56

ADDITIONAL FEATURES AND REMARKS

Manufacturer

The system is unusually easy to code and operate, since it is a fixed code machine.

INSTALLATIONS

Products Division
Bendix Aviation Corporation
Mishawaka, Indiana

Wright Air Development Center
Wright-Patterson Air Force Base
Dayton, Ohio

Redstone Arsenal
Huntsville, Alabama

Lockheed Aircraft Company
Marietta, Georgia

Griffiss Air Force Base
Rome, New York

BENDIX G15

Bendix G15

MANUFACTURER

Bendix Corporation
Bendix Computer Division

APPLICATIONS

Manufacturer
General purpose and scientific computing.

U. S. A. Artillery & Missile School, Ft. Sill
Located in Bldg. 900, Gunnery/Cannon/Rocket Dept., Fort Sill, Oklahoma, the system is used for cannon and rocket research studies.

U. S. A. Command and General Staff College
Located in Room 345, Bell Hall, USACGSC, the system is used for curve fit analysis of nuclear data for instructional and operational purposes, various conversion tables, and production of data for tables of precomputed nuclear target analyses (Weapon Selection Tables).

U. S. A. Engineer District, Little Rock
Located at 300 Broadway, Little Rock, Arkansas, the system is used for reservoir and flood routing, earthwork quantities for embankments and highways, stability analysis for dams and walls, traverse closure in surveys, moment distribution, reinforced concrete design - cantilever wall, and pile foundation design.

Photo by North American Aviation, Inc.

U. S. A. Engineer District, Los Angeles
Located at the Los Angeles District Office, the system is used for engineering computations in the fields of surveying, soils, hydrology, hydraulics, structural design and miscellaneous engineering applications.

U. S. A. Map Service, Americas Division
Located at Army Map Service, Americas Division, 6500 Brooks Lane, Washington 25, D. C., the system is used for geodetic, astronomic, and photogrammetric computations.

U. S. A. Ord. Frankford Arsenal - ORDBA-6230
Located at Frankford Arsenal Bldg. 220-1st floor, the system is used for optical design - 95%, and miscellaneous technical - 5%.

U. S. A. Ordnance Mission, White Sands Missile Range
Located at the Structures Branch, the system is used for calculation of structural response, stress analysis calculations in structural members, processing of structural data collected from missile range firings, processing of structural data collected from laboratory tests of structural items, calculations involving simulations of missile systems, and research

into transient loading at missile structures. This computer is to be used to reduce the engineering time required for structural analyses calculations resulting from measurements collected during missile range operations and structural laboratory testing.

U. S. A. Snow Ice Permafrost Research Establishment

Located at 1215 Washington Ave., Wilmette, Illinois, the system is used for engineering analysis.

U. S. N. Air Development Center

Located at the Aeronautical Computer Laboratory, Johnsville, Pa., the system is used for scientific computations and scientific data processing.

U. S. N. Bureau of Weapons

Located in Temporary "W" Bldg., Room 2W91, 18th & Constitution Avenue, N. W., Washington, D. C. the system is used for the solution of scientific problems only.

U. S. N. Charleston Shipyard

Located at the Design Division, Planning Department, the system is used for polemast stress analyses, longitudinal strength calculations, transverse strength calculations, shear and moment curves for simply supported beams, A.C. power analysis, A.C. lighting analysis, angle-arc analysis, list and stability calculations, natural frequency of resilient mounts, inclining experiments, weight and moment calculations, lighting system fixtures analysis, moment distributions, star tracker, trochoidal wave, curve expansions, and properties of simply supported beams.

Photo by Naval Supersonic Laboratory, MIT

U. S. N. Engineering Experiment Station Annapolis

Located in Building 113 the system is used for noise spectrum analysis, magnetic fields-data reduction and statistical analysis, bearings computations, harmonic tables computation, thermoconductivity-regression analysis, "one-shot" type engineering problems, and training of station personnel.

U. S. N. Hydrographic Office, Suitland

Located at the Geodetic Computing Unit, Survey Branch, Chart Construction Division, system is used for position determination, triangulation computations, electronic aids to navigation computations, statistical studies, astro and azimuth computations and distance computations.

U. S. N. Mine Defense Laboratory

System is used as an on line computer in a navigation system to provide positional data on a real time basis.

U. S. N. Missile Center Point Mugu

System is used for the solution of engineering problems, particularly those of guided missile design and analysis, and satellite and probe trajectories.

U. S. N. Supersonic Laboratory, M.I.T.

Located at 560 Memorial Drive, Cambridge, Mass., system is used mainly for on line processing of experimental wind tunnel data; e.g. force and moment aerodynamic tests, pressure distribution tests, heat transfer testing, nozzle block calibration, and strain gage balance calibration.

Photo by U.S.A.F. Patrick AFB

U. S. Bureau of Reclamation, Salt Lake City
Located at 32 Exchange Place, Salt Lake City, Utah, the system is used for representative civil engineering computer applications in design, office engineering, project development and construction contract administration work, such as earthwork volumes for roads, canals, borrow pits, multiple linear correlation-forecasting runoff, drain spacing analysis, triangulation and traverse computations, operation studies for reservoirs and related facilities, water surface profiles, and flood routing through a reservoir.

Illinois Division of Highways
Located at the Illinois Division of Highways, Bureau of Research and Planning, State Office Building, Springfield, Illinois, the computer is used for computation of highway cut and fill quantities and pertinent earthwork design data, moment influence line ordinates for 3 and 4-span continuous beams, bridge deck elevations adjusted for dead load deflections, traverse closure and coordinate adjustment, areas, etc., earthwork embankment stability analysis, rectangular and circular column analysis, azimuth determination from sun observation, geodetic position from State plane coordinates and vice versa, and highway letting cost distribution.
This computer is used for the solution of engineering problems only, - problems which require a relatively small amount of input data, but a great amount of complex mathematical computation.

Michigan State Highway Department
Located on the 8th Floor of the S. T. Mason Building, Lansing, Michigan, the system is used by the Michigan State Highway Department, Road Design Division, for earthwork computations, vertical alinement computations, circle-circle, circle-line intersections,

Photo by Michigan State Highway Department

traverse closure computations, and storm sewer design. It is used by the Traffic Division for traffic pattern classification and loadometer. It is used by the Bridge Design Division for circular bridge geometry, vertical alinement, pier design, composite beam design, plate girder design, slab and screed data for the straight bridge, straight bridge elevations, abutment design, and 3, 4, and 5 span girder calculations. The system is also used for bid checking.

AiResearch Mfg. Co. of Arizona
Located at 402 South 36th Street, Phoenix, Arizona, the system is used for test data reduction for gas turbines, starters, pneumatic controls, engineering design problems for various aircraft components, and engineering research problems relative to aircraft and missile components.

Bendix Aviation Corp., Eclipse-Pioneer Division
Located at Plant One, Teterboro, N.J., the system is used for the numerical solution of differential equations, amplitude and polar angles of complex rational functions to facilitate Bode and Nyquist stability analysis, and inverse interpolation programming to find the roots of transcendental equations.

Bendix Radio Division, Bendix Aviation Corp.
Located in the Engineering Bldg., Towson, Md., the system is used for all sorts of scientific, physical problems. The majority have to do with radar systems development.

Bendix Systems Division, The Bendix Corporation
Located at the Data Processing and Display Dept., Bendix Systems Div., Ann Arbor, Michigan, the Bendix G-15A Computer is used in conjunction with CRT Display equipment for the COMPAC Contract. This general purpose computer has been modified for real-time cathode ray tube display of simulated air traffic raids against radar environments.

Dow Chemical Company
Located at the Dow Chemical Company, Engineering Dept., Bldg. B-1201, Room 3129, Freeport, Texas, the system is used for chemical engineering (distillation, heat exchange, flow of fluids, absorption), for mechanical engineering (piping flexibility), for civil engineering (surveying), and for other engineering problems.

Ebasco Services Inc.
Located at 2 Rector Street, New York 6, New York, the system is used for economic calculations, electrical calculations (electric power fields), steam turbogenerator and associated mechanical calculations, pipe stress, and structural analysis.

Fellows Gear Shaper Company
Located in the Engineering Dept., River Street, Spring-

Photo by U. S. Army Engineers, Los Angeles District

field, Vt., the system is used for calculation of all data pertaining to gear shaper helical and spur cutters, master gears, shaving tools, cams, form ground cam cutters, pitch lines of non-circular gears, analysis of gear errors (Fourier coefficient method). The system is used also for the calculation of forces and stresses in molding machines.

Ford Instrument Company
Located in the Engineering Laboratory No. 11, 31-10 Thomson Ave., LIC, N. Y., the whole number machine (G-15D) is used for the solution of equations for nuclear reactor models, cam design, missile and orbital trajectories, on line instrument data processing and data reduction, digital computer design simulation, and solution of matrix (10 x 10) equations for electrical network. The Digital Differential Analyzer is used for nuclear reactor design, inertial platform response, and simulation of navigational systems.

General Mills, Inc., Mechanical Division
Located at 2003 E. Hennepin Ave., Minneapolis 13, Minn., the system is used for data reduction and engineering analysis.

Hercules Powder Co., Applied Mathematics Div.
Located at the Company Home Office, Wilmington 99, Del., the system is used for the solution of engineering problems in distillation calculations, heat transfer calculations, pipe sizing, personnel forecasting, and project accounting. Other applications include multiple correlation, mass spectrometer calculations, rocket trajectory calculations, and specific impulse calculations.

International Harvester Company
Located at 5225 So. Western Blvd., Chicago 9, Illinois, the system is used in engineering design for aerodynamic analysis, thermodynamic analysis, stress analysis, and engine simulation, in data reduction for engine test cell data, in cost reduction for materials handling, and in statistics for regression analysis.

Humble Division, Humble Oil & Refining Company
Located at the Humble Houston Research Center, 3120 Buffalo Speedway, Houston, Texas, the system is used for the study of applicable numerical techniques for predicting the movement of fluids through the pores of reservoir rocks, for the study of applicable techniques for predicting and optimizing drilling operations, for the study of techniques for well log interpretation, and for miscellaneous computation associated with numerous other endeavors in our field of activity.

Lockwood, Kessler & Bartlett, Inc.
Located at One Aerial Way, Syosset, N. Y., the system is used for structural analysis and design, highway

Photo by U. S. Naval Engineering Experimental Station

design and supervision, and surveying and photogrammetry.

The Martin Company
Located at the Manufacturing, Engineering, and Research Dept., Machine Planning Section, Baltimore, Md., the system is used for numerical control, for the manufacture of punched tape to operate numerical control milling machines. It is also used to compute various engineering and mathematical problems.

North American Aviation, Inc., Missile Division
Located at 12214 Lakewood Boulevard, Downey, Calif., the system is used for stability and control, vibrations and flutter, thermodynamics, aerodynamics, preliminary design, trajectory calculations, research and special compilers to prepare tape for airborne computers and ground checkout equipment.

The Ohio Oil Company
Located at Robinson, Illinois, the system is used for mass spectrometer calculations, refinery yield structure, refinery economic studies, linear programming (gasoline blending), gas chromatograph calculations, curve fitting, regression analysis, heat exchanger calculations, and equilibrium flash vaporization calculations.

RCA Service Company, Pan American World Airways
Located at Room 3-059, Bldg. 989, Patrick Air Force Base, Florida, the system is used for mathematical analysis and research in engineering problems and physical sciences such as investigations of mathematical models used in reducing data acquired by various optical and electronic instrumentation, derivation of physical relations in such fields as refraction, geodesy, celestial mechanics, etc., statistical analysis and error propagation studies, and mathematical solutions of a general nature such as solutions of systems of equations, transformations, etc.

Gulf Coast Division, Sun Oil Co., Beaumont
Located at 1096 Calder, Beaumont, Texas, the system is used for reservoir engineering and economic evaluations, reservoir simulation, geophysical calculations, civil and mechanical engineering calculations as applied to petroleum drilling and production technology.

Sun Oil Company Richardson
Located at 503 N. Central Expressway, Richardson, Texas, the system is used for reservoir engineering, differential equations of fluid flow, chemical engineering process calculations, statistical studies, and for data processing of laboratory results.

Vitro Laboratories
Located at 200 Pleasant Valley Way, West Orange, New Jersey, the system is used for analytical studies involving solution of differential equations, matrix

Photo by The Martin Company, Baltimore

algebra, statistical analyses, and general studies.

Pacific Union College Data Processing Laboratory

Located at the Nelson Memorial Library, Pacific Union College, Angwin, California, the system is used as an educational laboratory facility for classes in computer programming and numerical analysis, punched card accounting, research and mathematics, chemical kinetics, nuclear physics, and business management.

Pomona College

Located in the Physics Laboratory, the system is used for the teaching of digital computer techniques and scientific research applications.

Schellenger Research Laboratory, Texas Western College

Located in the Computer Section, the computer is presently being used in contract work for White Sands Missile Range, White Sands, New Mexico. Of particular importance is the SOTIM (Sonic Observations of Trajectories and Impacts of Missiles) program. In addition, applications in acoustics and electronics, particularly problems of sound refraction, calibration, and data reduction, are common.

University of Delaware

Located at the Computing Center, Evans Hall, University of Delaware, the system is used for calculations for research, sponsored and unsponsored (70%), classroom use for coding instruction and demonstration (20%), and for commercial work (10%).

PROGRAMMING AND NUMERICAL SYSTEM

Manufacturer	
Internal number system	Binary
Binary digits/word	29
Binary digits/instruction	29
Instructions/word	1
Instructions decoded	125
Arithmetic system	Fixed point (Fractional)
Instruction type	Two address (Modified)
Number range	-2^{57} to $+2^{57}$ (double precision)

Photo by U. S. Army Map Service

Instruction word format

P	Prefix - Normal Command or Deferred
T	Word Time of Operation
BP	Break-Point Halt
N	Location of Next Command
C	Characteristic Operation
S	Source Line
D	Destination Line
S/D	Single or Double Precision

Automatic built-in subroutines include multiply and divide.

Automatic coding includes an algebraic compiler and symbolic assemblers.

Humble Oil

A floating point interpretive system is customarily used. This system permits use of 864 words of storage for commands and operands. It includes indexing and auxiliary storage on a magnetic tape system.

ARITHMETIC UNIT

Manufacturer

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	540	270
Mult	2,430 to 16,700	

Time range for multiply and divide represents range between single decimal digit precision and maximum precision.

Construction (Arithmetic unit only)	
Vacuum-tubes	50 Approx.
Short tracks used on drum.	
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Photo by U. S. Army Map Service

STORAGE

Manufacturer

Medium	No. of Words	No. of Bin/Dig	Access Microsec
Magnetic Drum	2,176	63,104	14,500 avg 540 min

Magnetic Tape	
No. of units that can be connected	4 Units
No. of char/linear inch of tape	57 Char/inch
Channels or tracks on the tape	6 Tracks/tape
Blank tape separating each record	0.5 Inches
Tape speed	7.5 Inches/sec
Transfer rate	427 Char/sec
Start time	15 Millisec
Stop time	15 Millisec
Average time for experienced operator to change reel of tape	150 Seconds
Physical properties of tape	
Width	0.5 Inches
Length of reel	3,600 Feet
Composition	Mylar

All installations require the use of magnetic drum storage.

The following installations utilize magnetic tape storage:

USA AMS	Hercules Powder
USA C and G SC	Humble Oil
USA Ord WSMR	The Martin Company, Baltimore
USN Bu Weap	North American
USN EES	Ohio Oil
USN MC Pt Mugu	SUNOCO Richardson
USN SL MIT	Vitro Labs
AiResearch	Pacific Union College
Fellows	Pomona College
General Mills	Univ of Del

INPUT

Manufacturer Media	Speed	
Typewriter	8 char/sec	(Full alphanumeric)
Card Reader	100 cards/min	(Full alphanumeric)
Paper Tape (Optional)	400 char/sec	(Sexadecimal)
Paper Tape (Standard)	250 char/sec	(Sexadecimal)

All installations utilize paper tape input and output.

Photo by U. S. Army Map Service

All installations utilize the typewriter (Flexowriter) input and output.

The following installations utilize punched cards for input-output.

Michigan SHD	North American
General Mills	Pacific Union College
Hercules Powder	

OUTPUT

Manufacturer Media	Speed	
Typewriter	11 char/sec	(Numeric)
	8.5 char/sec	(Alphanumeric)
Cards	100 cards/min	
Line Printer (IBM 402)	100 lines/min	(80 char/line)
Paper Tape (Standard)	17 char/sec	(Sexadecimal)
Paper Tape (Optional)	60 char/sec	(Sexadecimal)

The graph plotter can be driven by the computer at 200 increments/second and 100 increments/inch or by the digital differential analyzer at 34 increments/second.

The following organizations utilize the line printer:

AiResearch	Pacific Union College
North American	

The following organizations utilize the graph plotter:

USN SL MIT	Bendix Radio

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type		
Tubes		
Computer	Approx. 450	(Mostly dual triodes)
DDA	Approx. 75	
Card Coupler	Approx. 310	
Diodes		
Computer	Approx. 2,500	
DDA	Approx. 800	
Card Coupler	Approx. 1,100	
Transistors	16	(In typewriter coupler)

All logic is mounted on plug-in packages.

CHECKING FEATURES

Several test commands are available.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer

Power, computer	3.5 Kw	0.98 pf
Volume, computer	31 cu ft	
Area, computer	6 sq ft	
Room size, computer	8 ft x 8 ft	
Floor loading	160 lbs/sq ft	
	250 lbs concen max	
Weight, computer	1,000 lbs	

110 V, 50a, 60 cycle line.

No special air conditioning is required if adequate ventilation is provided and approved by contractor.

USA C and G SC

Power: Install 110 volt, single phase, three-wire system.

Air conditioning: If room is small or poorly ventilated, install hood or air conditioner. If room is large enough, no air conditioning required. Heat from computer is 14,300 BTU/hr, and from magnetic tape unit is 2,200 BTU/hr.

USA Eng LRD

Permanent installation will be in a Federal building now under construction. Temporary quarters will provide 8 ft high partitions open above to 14 ft 6 in. ceiling of masonry building. Window-unit type A/C (220 V.) to be installed in outside wall.

USA Eng LAD

Installation of 110-volt, single-phase, three wire system (third wire for equipment ground). Installation of air conditioners through window opening and 220-volt circuit.

USA MS

No unusual site preparation.

USN Bu Weap

Installation of adequate power lines, and acoustics material on walls.

USN CS

Provided metal partition enclosure in drafting room; also provided single 115 volt 50 ampere line.

USN EES

Special air-conditioning air ducts were installed to bring in cooled air from another part of the building.

USN MC Pt Mugu

Installation of 50 amp line. Installation of recirculating fans.

USN SL MIT

Computer installed in large air conditioned area.

US B of R

Installed 50 amp., 110 volt line from source. Installed hood, 18 inch duct and squirrel cage vent fan with 3/4 hp. motor. Cut window in outside wall for installation of air conditioners. Added drywall partition and door.

Michigan SHD

Sufficient ventilation should be provided to keep ambient room temperature below 80 degrees F. A 50 ampere line is recommended, which includes 2.0 amps for HSPR-5 or 7 and 2.9 amps for 35-4. All equipment requiring external power operates from a 110 volt, single-phase, three wire system, the third wire is an equipment ground. A 220 volt, three-wire, single-phase system will not be acceptable.

AiResearch

Power, computer	10 Kw	10 KVA	1.0 pf
Volume, computer	30.5 cu ft		
Area, computer	6.0 sq ft		
Room size, computer	32 x 25 x 10		
	(No specific requirement)		
Floor loading	160 lbs/sq ft		
	240 lbs concen max		
Weight, computer	965 lbs		

No special preparation except power requirements and voltage regulators.

Bendix Radio

Addition to existing air conditioning system only.

Bendix Systems

System is presently operated in an air conditioned environment, but has been operated successfully without air conditioning. No special site preparation required.

Ebasco

Installed power supply for computer.

Fellows

Room divided from general engineering room by removable panels, about 1/2 glass, 1/2 wood, approx. 7 ft high. No other preparation necessary. (Uses 110 volt line).

Ford Instrument

Requires 50 amp. wiring for single phase, 115v, 60 cycle power.

General Mills

Constant voltage transformer required.

Hercules Powder

No special precautions required in normal office building except raised floor for weight distribution. Have separate 200A. 3 wire 220V. power supply. One computer (110V) on each side. Excess heat removed by exhaust hoods.

International Harvester

Transformer installed to convert 440 AC to 110 AC in order to be able to carry a 40 amp fuse on a 110V line.

Humble Oil

One 115 volt 50 amp. overload protected circuit.

L, K, and B

Installed one ceiling exhaust fan. Installed wire mesh (2 in. high) in place of floor board.

The Martin Company Baltimore

2 in. x 4 in. wood frame, glass and sheet celotex walls, celotex ceiling of 12 in. x 12 in. perforated blocks, cement and tile floor (basement). Temperature and humidity controlled room. Power Distribution - 110V for computer and lighting, 440 (3) phase for air conditioner.

North American

Site is air conditioned but need not be for the operation of the equipment provided room temperature is approximately 75°F.

Ohio Oil

50 amp, 110V circuit.

RCA - PAWA

50 amp., 110V supply. $50^{\circ} <$ room temperature $< 80^{\circ}$ (Ideal temp., 77°).

SUNOCO Beaumont
Installation of 110 volt, 50 amp., single phase, three wire system.
SUNOCO Richardson
Installation of ventahood.
Vitro Labs
Installation in accordance with manufacturer's recommendations.
Pacific Union College
No special modifications were necessary for the installation of this equipment with the exception of a ventilating air duct to remove air warmed by the computer.
Pomona College
115 volts, 50 amp outlet. Local air conditioner installed in false ceiling.
Texas Western
50 amp, 110 volt, 3 wire line.

PRODUCTION RECORD

Manufacturer	
Number produced to date	Over 300
Number in current operation	Over 300
Time required for delivery	1 to 2 months

COST, PRICE AND RENTAL RATES

USA AMS
Basic System
$1,485 per month.
Additional Equipment
Magnetic Tape Unit - $270 per month.
USA C and G SC

Basic System	Purchase	Monthly Lease
G-15 Computer w/alphanumeric typewriter	$51,000	$1,530
MTA-2 Magnetic Tape Unit	6,800	270
	$57,800	$1,800
Additional Equipment		
Punch Card Coupler CA-2	$19,500	$582
Graph Plotter PA-3	2,500	130

Maintenance is part of lease price. This includes parts and labor. If computer is purchased, a maintenance contract may be entered into at the following rates:

G-15 Computer	$500/month
MTA-2 Tape Unit	50/month

USA Eng LRD

Additional Equipment	Cost
20-inch carriage w/pin-feet platen	$ 400
Clary Model 148.067/703 Add-Punch	1,900

Basic System
$1,530 per month rental rate.
USA Eng LAD

Basic System	Cost	Monthly Rental
Main frame including typewriter	$49,500	$1,485
Additional Equipment		
Flexowriter	2,900	

Computer maintenance included in rental price.
Flexowriter - 1 yr. warranty. Service contract $150 per year thereafter.
USA MS
Bendix G15D Basic Computer $49,500 full purchase price.
Flexowriter: $3,144 full purchase price.
Weekly scheduled maintenance and immediate repairs by Bendix Computer: $6,000/annum.
USA Frankford Arsenal
Computer and typewriter - $1,485 per month.
USA Ord WSMR
G-15D General Purpose Computer $1,530 per month.
MTA-2 Magnetic Tape, DA-1 Digital Differential Analyzer, Graph Plotters - Total: $895 per month.
USA Snow Ice Perma
Bendix G-15D and typewriter $1,485/month.
USN ADC
Cost of basic system: Approximately $50,000.
USN Bu Weap
Bendix Maintenance Contract $6,000 per year.
USN CS
Rental for G-15D Basic Unit: $1,485 per month.
USN EES
Rental rates for prime shift: G15D Bendix, $1,530 per month; MTA 2 magnetic tape units, $540 per month; PR-2, $130 per month.
USN HO Suitland
Main frame and typewriter rents for $1,485 per month.
USN MDL
$48,000 for computer only.
USN MC Pt Mugu
Basic computer cost $49,500.
Digital Differential Analyzer (DA-1) cost $13,700.
Magnetic Tape cost $6,800.
USN SL MIT
G-15A, special input unit, 2 MTA-2, 2 off line Flexowriters cost $82,000.
Plotters and shift register cost $25,000.
Do own maintenance.
US B of R
Flexowriter cost $3,060.
Computer, Bendix G15D rents for $1,485 per month.
Flexowriter rents for $150 per month.
Flexowriter maintenance is $150 per year.
Illinois D of H
Additional Equipment
Flexowriter cost $2,800.
Basic System
$1,485 per month.
Michigan SHD
Additional Equipment
2 Flexowriters at $2,900 each.
Basic System
Bendix G-15D Computer and electric typewriter $1,485 per month.
Additional Equipment

IBM 523	$85/month
Bendix CA-2 Card Converter	450/month
IBM 024	38/month
IBM 056	48/month

AiResearch
G-15 Computer, $1,524/month; Total Systems $4,590 per month.
Rental Rates for Additional Equipment

4	Magnetic Tape Units at $270	$1,280
1	Bendix CA-2, Card Converter	850
1	IBM 402 Printer	400
2	IBM 523 Summary Punch at $100	200
1	IBM 082 Sorter	65
1	IBM 519 Reproducer	150
2	IBM 026 Key Punch at $60	120
	Total Rent for Month for Additional Equipment	$3,065

Bendix Eclipse-Pioneer
Cost for Basic System
$50,000 per G-15A general purpose digital computer
Cost for Additional Equipment
$10,000 per Digital Differential Analyzer.

Bendix Systems

Computer purchased by U. S. Air Force for $32,980 (used price).

A technician has been trained to perform the preventative maintenance necessary on this piece of equipment.

Dow Chemical

Computer and typewriter $1,485/month.

Ebasco

$1,485/month + tax, including maintenance.

Fellows

	Cost
Basic Computer	$49,500
Magnetic Tape Unit	6,800
DA-1	5,000

DA-1 has gone up to $13,700 now.

We do our own maintenance and servicing.

Ford Instrument

Rental for Basic System

Computer and printer $1,500 per month

Rental for Additional Equipment

Differential Analyzer 625 per month

General Mills

Basic System	Cost	Rental
Computer and typewriter	$50,000	$1,485/mo.
Additional Equipment		
4 Magnetic Tape Units	$6,800	$270/mo.
1 DA-1 Differential Analyzer	13,700	550/mo.
1 Card Coupler w/IBM 523 Summary Punch	19,500 +	674/mo.
1 DA-2 Digital Plotter	2,500	100/mo.

Bendix Maintenance Contract ; $700/month for purchased installation.

Hercules Powder

G-15D rents for $1,485 per month (each unit).

CA-2 Rents for $450/month and MTA-2 for $270/month (each unit).

International Harvester

G-15A General Purpose Computer rents for $1,485/month.

Humble Oil

G-15A costs $45,000.

2 Potter Magnetic Tape Transports cost $10,000.

Maintenance is performed by Humble.

L, K, and B

Computer cost $49,500.

Computer rents for $1,485/month (including maintenance and service).

North American

Total installation equivalent cost $191,500.

Total installation equivalent rental $6,100/month.

Basic G-15D cost - $49,500.

Basic G-15D rental - $1,500/month.

Maintenance by Bendix $500/month.

Ohio Oil

Rental for Basic System

Computer plus typewriter for control + input - output $1,485/month.

Rental for Additional Equipment

Magnetic Tape Unit, $270/month x 2 = $540/month.

RCA - PAWA

Rental for Basic System

$1,530/month (176 hours).

SUNOCO Beaumont

Bendix G-15 cost $60,000.

Bendix G-15 rents for $1,530 per month.

Maintenance by Bendix service engineer included in lease contract.

SUNOCO Richardson

Cost for Basic System

Bendix G-15D Computer and IBM typewriter $49,500.

Cost for Additional Equipment

2 Magnetic Tape Units $6,800 each

1 Flexowriter 3,000

Bendix G-15D Computer and IBM typewriter rents for $1,485 per month.

2 MTA $540/month

1 Flexowriter 165/month

Maintenance service contract: $600/month (included in lease proce).

Pacific Union College

	Cost
G-15	$50,000
Two magnetic tape units	22,000
CA-2 Card Converter	15,000
	Rental
IBM 402 514026182	$ 325/month

We do our own maintenance.

Pomona College

G-15D cost $32,000.

MTA-2 cost $ 7,000.

Texas Western

Typewriter, paper-tape punch, photo-electric reader $1,300.50/month, including maintenance/service.

Univ of Del

G-15D cost $29,700 (after 40% educational contribution).

MTA-2 magnetic tape unit cost $6,800.

Maintenance service $360.month (after 40% educational contribution).

PERSONNEL REQUIREMENTS

Manufacturer

	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Supervisors	1	1	1
Analysts			2
Programmers	2	4	6
Operators	1	1	2

Training made available by the manufacturer to the user includes programming and operation training at no cost to the user.

The G-15 Computer is generally used as an open shop computer, thus many engineers and mathematicians utilize the equipment as a tool for solving their problems.

USA C and G SC

1 Programmer, 1 Operator; formal classes of instruction are given by Bendix personnel at our request. Individual training or assistance is given by our computer room personnel as required.

USA AMS

1 Supervisor-analyst, 2.5 programmers, 6 coders; open shop; courses by Department and manufacturer.

USA Eng LRD

A number of engineers from technical sections of the District will be trained in the use of Intercom 1000; open shop.

USA Eng LAD

1 Supervisor, 1 analyst, 2 programmers, 1 clerk, 1 operator; manufacturer's courses and on-the-job continuation training.

USA MS

1 Supervisor, 1 programmer (2 recommended), 1 operator; open shop; supervisor is also analyst, programmer, and coder, programmer is also analyst and coder; computer personnel selected on basis of geodetic and mathematical experience, attend three week course in programming and operation given by Bendix Computer.

USA Frankford Arsenal

Operators are any one of 4 engineers, 1 technician; closed shop; operations tend toward closed shop because of work load involved, little formal training is needed for operation of machine.

USA Ord WSMR

75 Engineers; open shop; factory representatives gave a four week class in machine language programming of GS-15D and DA-1 Digital Differential Analyzer, one week course given to selected engineers in an interpretative programming method (Intercomm 1000).

USA Snow Ice Perma

1 Analyst, 1 programmer, 1 operator; Bendix School for machine language, train own employees for "Intercomm" Interpretive system.

USN ADC

Personnel shared with IBM 650 RAMAC; closed shop; standard Bendix courses, on-the-job training.

USN Bu Weap

1 Programmer; open shop; Bendix prepared instruction courses.

USN CS

We have no full time computer group. We operate an open shop. All engineers and technicians have access to the machine. This is a scientific type computer and is used solely to solve scientific problems. The Design Division Administrative Branch, is responsible for the administrative scheduling of time, records, reports, and maintenance of the computer. The technical codes have certain experts that take the lead in training and programming. Initially 3 engineers were trained by Bendix Computer Firm. The trained operators in turn indoctrinate and train others.

USN EES

1 Supervisor, 1 programmer, 1 operator; open shop; Intercom - 1000 classes on station were attended by 74 employees, eight employees attended three-week course in machine language at Bendix office in Washington, D. C.

USN HO Suitland

1 Supervisor, 7 scientific personnel use facility as required; on-the-job training.

USN MDL

Personnel as required for project work load. Programmers trained by Bendix Corp.

USN MC Pt Mugu

1 Supervisor, 4 programmers; open shop; school (by manufacturer), simplified coding (by manufacturer and this organization).

USN SL MIT

Two 8-hour shift: 1 supervisor, 2 programmers, 3 engineers, 1 input-output operator; closed shop; programmers and operators attend Bendix Computer Division courses in programming and/or computer logic, when used for on line work, the operators must be able to repair the computer in the event of breakdown. This is made necessary by the cost of wind tunnel time.

US B of R

1 Supervisor, 2 programmers, 1 operator, 1 tape handler are used. Same recommended, plus 0.5 clerk and 1 more tape handler, for data tape preparation on 2 Flexowriters; manufacturer's programming courses and on-the-job training are used.

Illinois D of H

1 Supervisor, 2 programmers, 1 operator, 1 in-output operator are used, recommended same. Programmers attend a 3-week, 8-hr. day programming school. Others receive on-the-job training.

Michigan SHD

1 Supervisor, 2 programmers, 1 operator, 1 engineer, 1 in-output operator are used, recommended same plus 2 more programmers; closed shop; training: Bendix Computer 3 week machine language programming school, Bendix Computer 1 week card converter programming school, on-the-job training in machine language programming and interpretive programming routines, IBM 1 week key punch operator school, and on-the-job training in computer operation and accessory equipment.

AiResearch

1 Supervisor, 5 programmers, recommended same; closed shop; Bendix Computer Division sponsored training program. On-the-job training by Bendix representatives and supervisor.

Bendix Eclipse-Pioneer

1 Supervisor, 1 analyst, 2 programmers, 2 technicians; closed shop; bachelor's degree with a major in mathematics is the minimum requirement for a programmer. Master's degree absolute minimum requirement for analyst; on-the-job training through programming simple practical problems.

Bendix Radio

1 Supervisor, 2 programmers; closed shop; on-the-job training.

Bendix Systems

One 8-Hour Shift: 1 programmer, 1 coder, 1 operator, recommended same; closed shop; this facility is operated closed shop because it is being used exclusively on one contract; programmers are sent to a class at Bendix Computer Division's Customer Training Center.

Dow Chemical

One engineer is responsible for the computer operation and spends approximately 60% of his time in computer operation and programming. Other individual engineers use computer as occasions arise. No non-salary personnel involved.

Ebasco

Training includes manufacturer programming courses and our own classes.

Fellows

1 Supervisor, 1 programmer, 1 clerk; recommended same; closed shop; supervisor and programmer took 3 weeks course at Bendix plant.

Ford Instrument

Open shop; courses given by Bendix (manufacturer and lessor), in-plant training by personnel familiar with operation of computer.

General Mills

0.5 Supervisor, 2 analysts, 4 programmers; recommended full time supervisor plus 2 more programmers; open shop; self-taught interpretive programming, periodic classes in machine language (installation sponsored).

Hercules Powder

0.5 Supervisor, 1.5 analysts, 4 programmer-coders, 0.5 clerk, 0.5 operator are used; recommended 1 supervisor, 2 analysts, 5 programmer-coders, 1 clerk, 1 operator; open shop; training is informal and internal.

International Harvester

1 Supervisor, 1 analyst, 1 programmer, 5 engineers, 2 technicians are used; 5 more engineers and 6 more technicians are recommended; open shop; in operating on an open shop basis we have only one non-supervisory person assigned to the computer. He does not spend full time at the machine. Operation is on a first come first served basis except that no service is given our technical personnel as far as machine usage is concerned. We do assist, on request, with numerical analysis and the development of service routines. The personnel noted above are indicative of the number and kinds of people utilizing the computer; a 4 hour training course in an interpretive system is given to all technical employees. No basic language is taught at all except to one programmer.

Humble Oil

Three 8-Hour Shift: 1 supervisor, 2 analysts, 3 programmers, 0.5 operator, 0.5 technician; open shop; a Bendix G-15 D drum computer system is maintained and operated by the Petroleum Engineering Section of the Production Department of the Humble Division. This installation is similar to the one described here.

The purpose of the work done is in part to put into practice developments made here in the Production Research Division; assistance to potentially interested users by personnel responsible for the system.

L, K, and B

1 Supervisor, 1 programmer, 1 clerk, recommended same; closed shop; attending a programming course.

The Martin Company Baltimore

1 Supervisor, 2 programmers, 1 operator, recommended same; open shop; manuals.

North American

1 Supervisor, 4 programmers, 1 operator, 6 engineers, 1 in-output operator; engineers from all groups are given classes in programming. They may write their own programs and operate the machine if desired. A staff of 10 engineers and mathematicians are available for those groups of engineers who request assistance.

Ohio Oil

2 Programmers, 1 operator; on-the-job training and training classes conducted by the lessor.

RCA - PAWA

1 Supervisor, 1 clerk recommended; open shop; personnel desiring programming instructions are trained by Bendix Computer instructiors in the use of the Intercom 1000 system.

SUNOCO Beaumont

1 Supervisor, 6 engineers, 1 technician; closed shop; all members of the Reservoir Analytical Section can operate and write programs for the computer; programming classes and applications.

SUNOCO Richardson

1 Supervisor, 7 programmers, 1 operator; open shop.

Vitro Labs

1 Supervisor, 2 programmers, 1 in-output operator; closed shop; attendance at Bendix training course.

Pacific Union College

1 Supervisor, 2 programmers, 2 coders, 1 technician; open shop; informal apprenticeships and formal class instruction.

Pomona College

Open shop; classes conducted etc. Interpretative systems used extensively.

Texas Western

1 Supervisor, 2 programmers, 2 operators, 1 tape handler; open shop; informal short classes in programming and computer operation.

Univ of Del

0.5 Supervisor, 0.5 clerk; 1 supervisor and 1 clerk recommended; open shop; open shop training from manuals with minimal formal instruction in large classes.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

USA AMS

Average error-free running period 100 Hours
Good time 38.8 Hours/Week (Average)
Attempted to run time 40.0 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.970
Above figures based on period from May 58 to Jun 60
Passed Customer Acceptance Test May 58
Time is not available for rent to outside organizations.

USA C and G SC

Average error-free running period 2 - 3 Weeks
Good time 35 Hours/Week (Average)
Attempted to run time 36 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.97
Above figures based on period 1 Apr 60 to 19 Aug 60
Passed Customer Acceptance Test 31 Mar 60
Time is available for rent to qualified outside organizations.

Computer is available for other agencies if time available on an 8-hour day basis.

USA Eng LAD

Good time 43.8 Hours/Week (Average)
Above figure based on period 1 Jan 59 to 31 Dec 59
Passed Customer Acceptance Test 1 Mar 58
Time is not available for rent to outside organizations.

43.8 hours per week shown above as "good time" is the average hours per week the computer was functioning properly excluding time during regular and emergency maintenance. Emergency maintenance amounted to approximately 3 percent of total time. Most of emergency maintenance was due to malfunction of the computer typewriter.

USA MS

Average error-free running period 1 Month
Good time 41.1 Hours/Week (Average)
Attempted to run time 42.5 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.97
Above figures based on period 1 Jan 59 to 1 Jan 60
Passed Customer Acceptance Test Nov 57
Time is not available for rent to outside organizations.

USA Frankford Arsenal

Good time 37.7 Hours/Week (Average)
Attempted to run time 37.9 Hours/Week (Average)
Operating ratio 0.9947
Above figures based on period 3 Jan 59 to 9 Apr 60
Passed Customer Acceptance Test 30 Dec 58
Time is available for rent to qualified outside organizations.

Time is made available to outside organizations for certain problems.

USA Ord WSMR

Good time 29 Hours/Week (Average)
Attempted to run time 30 Hours/Week (Average)
Operating ratio 0.97
Above figures based on period 1 Feb 60 to 13 May 60
Passed Customer Acceptance Test 21 Jan 60
Time is not available for rent to outside organizations.

Machine is in restricted area from a security standpoint.

USA Snow Ice Perma

Good time 36 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio 0.90
Above figures based on period from Oct 58 to present
Passed Customer Acceptance Test Oct 58
Time is not available for rent to outside organizations.

USN Bu Weap

Good time 42 Hours/Week (Average)
Attempted to run time 42 Hours/Week (Average)
Operating ratio 0.99
Above figures based on period 1 Jul 59 to 1 Jul 60
Passed Customer Acceptance Test 16 Aug 57
Time is not available for rent to outside organizations.

USN CS

Operating ratio 0.95
Above figures based on period 22 May 59 to present
Passed Customer Acceptance Test 22 May 59
Time is not available for rent to outside organizations.

Average number of hours per week that we attempt to use this computer varies from 25 to 48 hours. It has been our experience that the machine is operable 95% of the time and down 5% of the time.

USN EES

Operating ratio 0.96
Above figure based on period 12 Nov 59 to 31 Jul 60
Time is not available for rent to outside organizations.

System is operated full time.

We now schedule computer for three 8-hr. shifts:
Prime Shift - Debugging and "one-shot" type problems.
Second Shift - Operator types in data
Third Shift - Unattended computation and type-out.

USN HO Suitland

Good time 40 to 60 Hours/Week (Average)
Attempted to run time 40 to 60 Hours/Week (Average)
Operating ratio 0.95
Above figures based on period from Jan 58 to Apr 60
Time is not available for rent to outside organizations.

USN MDL

This computer was purchased for a special application and its maintenance requirements varies from the normal because of the extreme environment conditions to which it has been exposed.

USN MC Pt Mugu

Average error-free running period 40 Hours
Good time 48 Hours/Week (Average)
Attempted to run time 50 Hours/Week (Average)
Operating ratio 0.96
Above figures based on period 1 Apr 60 to 30 Apr 60
Passed Customer Acceptance Test 29 Jun 59
Time is not available for rent to outside organizations.
Time available to outside organizations if they have programming personnel. The simplified coding system in general use allows wide-spread knowledge of programming. No rental is involved in this time.

USN SL MIT

Average error-free running period Two Days
Operating ratio 0.90
Above figures based on period from Mar 56 to present
Passed Customer Acceptance Test Mar 56
Time is available for rent to qualified outside organizations.

US B of R

Good time 36 Hours/Week (Average)
Attempted to run time 39 Hours/Week (Average)
Operating ratio 0.91
Above figures based on period 1 Jul 59 to 1 Jul 60
Passed Customer Acceptance Test 5 Nov 58
Time is not available for rent to outside organizations.

Illinois D of H

Good time 36 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio 0.90
Above figures based on period 1 Jan 59 to 1 Jan 60
Passed Customer Acceptance Test Sep 56
Time is not available for rent to outside organizations.

Michigan SHD

Good time 50.25 Hours/Week (Average)
Attempted to run time 55.83 Hours/Week (Average)
Operating ratio 0.90
Above figures based on period 3 Jan 60 to 3 Apr 60
Passed Customer Acceptance Test Sep 56
Time is not available for rent to outside organizations.

AiResearch

Good time 34 Hours/Week (Average)
Attempted to run time 36 Hours/Week (Average)
Operating ratio 0.944
Above figures based on period 1 Oct 59 to 1 May 60
Passed Customer Acceptance Test Basic System 15 Sep 60
Time is not available for rent to outside organizations.

Bendix Eclipse-Pioneer

Good time 32 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio 0.80
Abive figures based on period 1 Jan 60 to 1 May 60
Time is not available for rent to outside organizations.

Bendix Radio

Good time 38 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio 0.95
Above figures based on period from May 59 to Apr 60
Time is available for rent to qualified outside organizations.

Bendix Systems

Average error-free running period 20 Hours
Good time 35 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio 0.88
Above figures based on period from Oct 58 to May 60
Passed Customer Acceptance Test 30 Oct 58
Time is not available for rent to outside organizations.

Dow Chemical

Good time 38 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio 0.95
Above figures based on period from Nov 57 to Sep 60
Passed Customer Acceptance Test Apr 58
Time is not available for rent to outside organizations.

Fellows

Good time 43.5 Hours/Week (Average)
Attempted to run time 43.5 Hours/Week (Average)
Operating ratio 0.997
Above figures based on period 15 Jan 60 to 15 Apr 60
Passed Customer Acceptance Test Jul 57
Time is not available for rent to outside organizations.
We schedule 1 1/2 hours per week for preventive maintenance. In the last 3 months, we have had 1 1/2 hours of unscheduled "down" time.

Ford Instrument

Average error-free running period 8 Hours
Good time 34 Hours/Week (Average)
Attempted to run time 36 Hours/Week (Average)
Operating ratio 0.94
Above figures based on period 1 Jan 60 to 26 Aug 60
Time is not available for rent to outside organizations.
4 hour preventive maintenance operation scheduled each week.

General Mills

Good time 60 Hours/Week (Average)
Attempted to run time 60 Hours/Week (Average)
Operating ratio 1.0
Above figures based on period from Aug 58 to present
Passed Customer Acceptance Test 1 Jan 57
Time is available for rent to qualified outside organizations.

Hercules Powder

Average error-free running period About 3 Days
Good time 52.4 Hours/Week (Average)
Attempted to run time 54.5 Hours/Week (Average)
Operating ratio 0.96
Above figures based on period 1 Dec 59 to 29 Feb 60
Passed Customer Acceptance Test Jan 59
Time is not available for rent to outside organizations.

International Harvester

Good time 34.3 Hours/Week (Average)
Attempted to run time 36 Hours/Week (Average)
Operating ratio 0.95
Above figures based on period 1 Mar 60 to 4 Jun 60
Passed Customer Acceptance Test 1 Mar 60
Time is not available for rent to outside organizations.

Humble Oil
Average error-free running period 18 Hours
Good time 140 Hours/Week (Average)
Attempted to run time 163 Hours/Week (Average)
Operating ratio 0.86
Above figures based on period from Aug 56 to Jan 60
Passed Customer Acceptance Test Sep 55
Time is not available for rent to outside organizations.

This system has been found sufficiently reliable to operate unattended nightly and for complete weekend periods.

L, K, and B
Good time 39 Hours/Week (Average)
Above figure based on period from Nov 57 to Apr 60
Passed Customer Acceptance Test Nov 57
Time is not available for rent to outside organizations.

The Martin Company Baltimore
Average error-free running period 40 Hours
Good time 30 Hours/Week (Average)
Attempted to run time 36 Hours/Week (Average)
Operating ratio 0.833
Above figures based on period 1 Jan 59 to 1 Jan 60
Passed Customer Acceptance Test 5 Sep 56
Time is available for rent to outside organizations.

North American
Good time 79 Hours/Week (Average)
Attempted to run time 80 Hours/Week (Average)
Operating ratio 0.988
Above figures based on period 1 Jun 59 to 1 May 60
Passed Customer Acceptance Test Aug 58
Time is available for rent to outside organizations.

Ohio Oil
Good time 61.19 Hours/Week (Average)
Attempted to run time 64.25 Hours/Week (Average)
Operating ratio 0.9524
Above figures based on period 1 Jan 59 to 1 Jan 60
Passed Customer Acceptance Test May 58
Time is not available for rent to outside organizations.

SUNOCO Beaumont
Good time 79 Hours/Week (Average)
Attempted to run time 84 Hours/Week (Average)
Operating ratio 0.9405
Above figures based on period 16 Feb 60 to 29 Aug 60
Passed Customer Acceptance Test 16 Feb 60
Time is not available for rent to outside organizations.

SUNOCO Richardson
Good time 59.1 Hours/Week (Average)
Attempted to run time 60.8 Hours/Week (Average)
Operating ratio 0.972
Above figures based on period 1 Aug 60 to 2 Sep 60
Time is not available for rent to outside organizations.

Vitro Labs
Good time 36 Hours/Week (Average)
Attempted to run time 38 Hours/Week (Average)
Operating ratio 0.947
Above figures based on period 1 Jul 59 to 1 Jul 60
Time is available for rent to outside organizations.

Pacific Union College
Good time 48 Hours/Week (Average)
Attempted to run time 47.5 Hours/Week (Average)
Operating ratio 0.99
Above figures based on period from Dec 58 to May 60
Time is available for rent to qualified outside organizations.

Pomona College
Good time 30 Hours/Week (Average)
Attempted to run time 30.5 Hours/Week (Average)
Operating ratio 0.98
Above figures based on period from Sep 58 to present
Passed Customer Acceptance Test Sep 58
Time is available for rent to outside organizations.

Texas Western
Good time 36-40 Hours/Week (Average)
Operating ratio 0.96
Above figures based on period from Feb 59 to Apr 60
Time is available for rent to outside organizations.

Univ of Del
Good time 55 Hours/Week (Average)
Attempted to run time 57 Hours/Week (Average)
Operating ratio 0.96
Above figures based on period from Sep 57 to Aug 60
Passed Customer Acceptance Test 15 Sep 57
Time is available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

Manufacturer

Outstanding features include low cost, expandability through such accessories as magnetic tape, punch card, paper tape units, plotter, etc., reliability (better than 95% average uptime for all units installed), fast delivery, access to hundreds of programs through users exchange organization, applicability for both business and scientific problems, and nationwide service facilities.

Unique system advantages include simplified programming systems like Intercom, Pogo, Autopoint, Algebraic Compiler, etc., expansion simplified by merely plugging accessories into the back of the computer, all input, output is fully buffered, permitting computation during input-output operations, and alphanumeric input-output.

USA C and G SC

The "Intercom 1000" system has been devised by Bendix as a programming system that can be learned in two days. It takes care of decimal point location and provides simple control over various machine functions.

The machine hardware of the G-15 contains a most versatile and powerful command structure. Coupled with this is one of the most completely buffered input-output systems offered on any computer.

Magnetic tape labelling is not a problem, since only one or two tapes are used. Paper tape program storage is handled by labeled storage boxes. Duplicate tapes are kept in a fire proof vault. This includes paper tape copies of data on magnetic tape.

We have found the computer easy to use and operate. Maintenance of the machine is handled from Kansas City, Missouri, which is about forty-five miles distant. Service has been very prompt, and the machine is well maintained.

USA Eng LAD

Outstanding features include flexibility in programming.

USA MS

Outstanding features include very versatile programming features in machine language and very simple programming in interpreter-compiler system.

Unique system advantage is that it lends itself readily to open shop operation.

Master tapes of all programs are maintained in case of destruction of any operational tape.

USA Ord WSMR

Outstanding features: reliable, easy to program with interpretive routine.

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage include: placed over cooling tunnel for building air conditioning system and all electrical plugs are disconnected at night.

USN CS

Outstanding features are relatively easy to program, simple to operate, versatile, and expandable.

Labeled canned storage with operating instructions enclosed, copies of all programs filed and cross indexed.

USN EES

Outstanding features are interpretive system (Intercom 1000) can be learned in approximately 4 hours and there are also other interpretive and compiling systems available.

Unique system advantages are inexpensive and active users exchange organization.

Guards check computer room when computer runs unattended during the night and weekends.

USN MC Pt Mugu

Outstanding features include digital differential analyzer capabilities.

Ordinary storage facilities are used for storage of magnetic tape.

Michigan SHD

Outstanding feature is its low cost compared to the computer's capacity.

AiResearch

Outstanding features include flexibility of operation and low rental cost.

Unique system advantages are the variety of input-outputs accepted.

Bendix Systems

This machine has been modified to provide optional input-output from the drum storage to external registers. System enables real-time display of output data on cathode ray tube display unit.

Fellows

Outstanding features are small size, inexpensive, self-contained, fits into our Engineering Dept. routine easily.

Unique system advantages include ability to add peripheral equipment as needed. Reliability - machine often runs all night unattended on long problems.

No special procedures are in effect for tape storage. Tape is left on machine. Only one reel required for our problem.

Ford Instrument

Outstanding features are flexible command structure, convenient minimum access coding, low price (unfair to compare with more modern systems). Just about outdated by newer Bendix and other manufacturers' models, but still good.

Hercules Powder

Outstanding features include flexibility, variety of input-output equipment.

International Harvester

We are extremely pleased with the acceptance within our group of the open shop type operation.

Humble Oil

Outstanding features are low unit computing cost for machine in this price range. Excellent reliability.

The Martin Company Baltimore

Only two reels of magnetic tape are used. These are installed in magnetic tape units.

North American

Unique system advantages are computing and control simultaneous with magnetic tape and card operation. INTERCARD, a floating point interpretive system provides 500 seven-digit numbers/min input speed and 400/min. output speed. Off-line monitors for unattended night operation are used successfully.

Vitro Labs

Outstanding feature is that output proceeds while computation progresses. Programming may be done by the interpretive system or basic machine language.

Pomona College

Excellent small computer, simple to use.

Texas Western

Outstanding features are command structure is extremely flexible, two address command permits true minimum access coding, double length arithmetic registers permits programming of double-precision operations, and reduction in computation time by incorporating arbitrary precision multiplication and division in the design.

FUTURE PLANS

USA AMS

Intend to obtain a Field Artillery Digital Automatic Computer (FADAC) (rugged, lightweight computer for use in the field with artillery units).

USA C and G SC

Continuation of present projects with a study to be conducted for additional uses within the College.

USA Eng LAD

The present system is considered to be adequate for the present and foreseeable engineering needs of the District. Expansion of this system or acquisition of another system to accomplish data processing outside of the engineering field may occur in the future.

USA MS

Acquisition of tape preparation and verification system. Possible acquisition of auxiliary magnetic tape unit if efficiency and savings will result.

USA Snow Ice Perma

Future needs anticiapted are a medium size computer with floating point hardware to increase operating speeds.

USN ADC

Research and Development Program to tie system into external equipment for simulation applications.

USN HO Suitland

Plan to add another unit of same type.

USN MC Pt Mugu

Future plans call for tying the G-15 to the Simulation Facility analog computer for simulating Navy weapons systems components. The purpose will be to analyze the weapons systems capabilities. Equipment for conversion from digital information to analog and vice versa is on order from Bendix.

US B of R

Addition of CA-1 Card Coupler with IBM 026 Key Punch for minor accounting application. Addition of tape preparation unit.

Michigan SHD

A second Bendix G15-D Computer has just been proposed to management.

Bendix Eclipse-Pioneer

We are presently considering the acquisition of the Bendix G-20, General Purpose Digital Computer. This computer can perform arithmetic operations approximately 2500 times faster than the G-15A.

Dow Chemical

Possibly of leasing punched card facilities in the future.

Fellows

A separate data handling system for payroll and accounting may be acquired in the future.

Ford Instrument

Plans call for continued use of present equipment.

International Harvester

The following equipment may be added to this system at a later date: Alphanumeric Typewriter, Graph Plotter, Digital Differential Analyzer, and Magnetic Tape Unit.

Humble Oil

A Bendix G-20 System is proposed for installation during the first quarter of 1961. Components for this system are shown in the following table.

1	Central Computer
1	Card Reader, 500/min.
1	Printer, 600 lines/min.
5	Magnetic Tape Units
1	Coupler for IBM equipment
1	Auxiliary Memory
1	Buffer Control
1	Console
2	Auxiliary Magnetic Tapes

This machine will be shared with the Humble Division Petroleum Engineering Section of the Production Department and the Geologic Research Section of the Exploration Department. The proposed system will supplant IBM 704 time which is currently rented from service bureaus as well as some of the long problems done on our present system.

The purpose of the system with expanded capacity is primarily to provide means of carrying out predictions and optimization of reservoir performance. It is planned to retain the G-15A for a time after installation of the G-20.

North American

Replacement of G-15D facility with one (1) G-20 Computer with 16,392 word core storage, four (4) magnetic tapes, card input-output and high-speed printer, add digital-analog converter.

Vitro Labs

Additional equipment planned is an analog computer.

Pacific Union College

We are in process of developing a magnetic core storage buffer which will enable magnetic tape units to read information into and out of the computer at drum speed. We believe this will be unique in so far as a medium speed computer in the Bendix G-15 class is concerned.

Pomona College

System will be expanded when need arises.

Texas Western

A new alphanumeric programming system will soon be received. There are plans for transformer design production problems in the near future.

Univ of Del

For the life of the present machine we will keep abreast of increasing needs by more efficient input-output and debugging procedures and, if necessary, additional peripheral equipment.

INSTALLATIONS

U. S. Army Artillery and Missile School
Computer Branch
Fort Sill, Oklahoma

U. S. Army Command and General Staff College
Fort Leavenworth, Kansas

U. S. Army Engineer District, Little Rock
P. O. Box 867
Little Rock, Arkansas

U. S. Army Engineer District, Los Angeles
751 South Figueroa Street
Los Angeles 17, California

U. S. Army Map Service
6500 Brooks Lane
Washington 25, D. C.

Frankford Arsenal - ORDBA-6230
Philadelphia 37, Pennsylvania

U. S. Army Ordnance Mission
White Sands Missile Range, New Mexico

U. S. Army Snow, Ice, Permaforst Research Establishment
1215 Washington Avenue
Wilmette, Illinois

U. S. Naval Air Development Center
Aeronautical Computer Laboratory
Johnsville, Pennsylvania

Bureau of Weapons
Department of the Navy
Washington 25, D. C.

Charleston Naval Shipyard
Charleston, South Carolina

U. S. Naval Engineering Experiment Station
Applied Math Office, Code 502
Annapolis, Maryland

U. S. Navy Hydrographic Office
Geodetic Computing Unit
Suitland, Maryland

U. S. Navy Mine Defense Laboratory
Navigation Branch
Panama City, Florida

U. S. Naval Missile Center
Systems Department
Point Mugu, California

U. S. Naval Supersonic Laboratory, M. I. T.
560 Memorial Drive
Cambridge, Massachusetts

U. S. Bureau of Reclamation
Regional Office, Region 4
32 Exchange Place
Salt Lake City, Utah

Illinois Division of Highways
State Office Building, Room 703
Springfield, Illinois

Michigan State Highway Department
Computer Unit
S. T. Mason Building
Lansing, Michigan

AiResearch Manufacturing Company of Arizona
402 South 36th Street
Phoenix, Arizona

Bendix Aviation Corporation
Eclipse-Pioneer Division
Teterboro, New Jersey

Bendix Radio
A Division of Bendix Aviation Corporation
Department of Research and Development
Towson 4, Maryland

Bendix Systems Division
The Bendix Corporation
3300 Plymouth Road
Ann Arbor, Michigan

Dow Chemical Company
Engineering Department, Bldg. B-1201
Freeport, Texas

Ebasco Services Inc.
2 Rector Street
New York 6, New York

Fellows Gear Shaper Company
River Street
Springfield, Vermont

Ford Instrument Company
31-10 Thomson Avenue
Long Island City 1, New York

General Mills, Inc.
2003 E. Hennepin Avenue
Minneapolis 13, Minnesota

Hercules Powder Company
Applied Mathematics Division
Wilmongton 99, Delaware

International Harvester Company
Engineering Research
5225 So. Western Blvd.
Chicago 9, Illinois

Humble Oil and Refining Company
Humble Division
P. O. Box 2180
Houston 1, Texas

Lockwood, Kessler & Bartlett, Inc.
One Aerial Way
Syosset, New York

The Martin Company
Manufacturing, Engineering & Research Dept.
Baltimore 3, Maryland

North American Aviation, Inc.
Missile Division
12214 Lakewood Boulevard
Downey, California

The Ohio Oil Company
Refining Division
Robinson, Illinois

RCA Service Company
Data Processing, AFMTC, Bldg. 989
Patrick Air Force Base, Florida

Sun Oil Company
Reservoir Analytical Section
1096 Calder Avenue
Beaumont, Texas

Sun Oil Company
503 N. Central Expressway
Richardson, Texas

Vitro Laboratories
200 Pleasant Valley Way
West Orange, New Jersey

Pacific Union College
Data Processing Laboratory
Angwin, California

Pomona College
Physics Laboratory
Claremont, California

Texas Western College
Schellenger Research Laboratory
El Paso, Texas

University of Delaware
Computing Center, Evans Hall
Newark, Delaware

BENDIX G20

Bendix G 20 General Purpose Data Processing System

MANUFACTURER

Bendix Computer Division
Bendix Aviation Corporation

APPLICATIONS

The completely modular construction of the G-20 system permits the creation of general purpose commercial data processing, general purpose scientific computing, off-line, on-line, or real-time systems by appropriate selection and interconnection of modules.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	32 + 1 parity bit
Binary digits/instruction	32 + 1 parity bit
Instructions per word	1
Instructions decoded	63 for central processor
Arithmetic system	Floating point
Instruction type	One address
Number range	$\pm 10^{-57}$ to $\pm 10^{69}$

Instruction word format

Flags	Mode Code	Operation Code		Index	Base Address	
31 30	29 28	27	21	20 15	14	0

Automatic built-in subroutines include fixed point arithmetic and storage, 63 index register and associated operation codes, automatic repeatable commands (32 in number), can be repeated any desired number of times, interrupt request hardware, and clock interrupt (1 per sec.).

Automatic coding includes Symbolic Program and Assembly Routine, Algebraic Compiler, Executive Routine, Report Generator, Sort Routines, File Maintenance Routine, and Commercial Compiler.

Registers and B-boxes include 63 memory locations used as Index locations (Built-in Index Registers), interrupt and control registers, and a fixed point exponent register.

Photo by the Bendix Computer Division

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	27	13
Mult	70	56
Div	112	98

Construction (Arithmetic unit only)	
Transistors	5,000 approx.
Diodes	30,000 approx.
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Concurrent

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Magnetic Core	4,096 to 32,768	28,672 to 1,081,344	8.4

Magnetic Tape	
No. of units that can be connected	Any number Units
No. of char/linear inch of tape	550 Char/inch
Channels or tracks on the tape	10 Tracks/tape
Blank tape separating each record	0.75 Inches
Tape speed	110 or 220 Inches/sec
Transfer rate	60,000 Char/sec
Start time	4 Millisec
Stop time	4 Millisec
Average time for experienced operator to change reel of tape	30 Seconds
Physical properties of tape	
Width	1 Inch
Length of reel	3,600 Feet

INPUT

Media	Speed
Paper Tape	500 char/sec
Cards	650 cards/min
Control Console (type)	Manual
Magnetic Tape	60,000 char/sec

Characters are 8 bits.

OUTPUT

Media	Speed
Paper Tape	100 char/sec
Cards	250 cards/min
Printer	600 lines/min
Magnetic Tape	60,000 char/sec

Characters are 8 bits. Printer is up to 120 characters wide.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	240
Diodes	38,000
Transistors	8,900
Magnetic Cores	173,000 - 1,081,344

The entire system could range from a central processor and control console with typewriter to a large data system, with many magnetic tape and card units.

The above information considers the entire system as a central processor, control console, four magnetic tape units, a magnetic tape control unit, a card and printer coupler, a high speed printer and a control buffer.

CHECKING FEATURES

Checking features include parity check in central processor (to and from memory), parity check on all input-output equipment, and parity check, parity bit recorded and automatic read immediately after writing.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	3.5 KVA	0.9 pf
Volume, computer	67.5 cu ft	
Area, computer	12.7 sq ft	
Floor loading	24,000 lbs/sq ft	
	753 lbs concen max	
Weight, computer	2,000 lbs	

A plenum can be used for air intake from underneath.

No rear access is needed for Central Processor.

All accessory units - subfloor air cooling advisable, but air intake can be from the back as well as the underside.

Minimum rear access to accessories is 24 inches.

Air conditioner to maintain 65° - 80°F ambient temperature.

PRODUCTION RECORD

Time required for delivery Approx. 15 months

COST, PRICE AND RENTAL RATES

G-20 and Accessory Price List

		Purchase	Monthly Maint. for Purchased Equipment	Lease per Month
G-20	Processor, including 4,096 words of core memory	$ 290,000	$ 1,210	$ 6,500
MM-10	Auxiliary Core Memory of 4,096	55,000	230	1,650
MC-10	Auxiliary Core Memory of 4,096 words & Control Feature	110,000	460	3,300
CC-10	Control Console Station, including alphanumeric input-output monitor typewriter	10,000	45	300
TC-10	Magnetic Tape Control Unit - necessary for control of from one to four tape units	30,500	130	915
MT-10	High Speed Magnetic Tape Unit	28,500	120	855
LP-10	Line Printer (72 characters) (needs CP-10)	28,700	120	860
LP-11	Line Printer (120 characters) (needs CP-11)	68,300	285	2,050
CP-10	Adapter for Card and Tabulator Equipment (80 column)	22,500	95	675
CP-11	Adapter for Card and Tabulator Equipment (120 column)	27,500	115	825
CB-10	Buffer Control Station	50,000	210	1,500
PT-10	Paper Tape Input-Output Station, including a paper tape reader (500 characters per second) and a paper punch (100 characters per second)	17,500	75	525

The cost of maintenance for punched equipment on the G-20 Central Processor and all accessory equipment is given above, along with purchase price and lease rate. The minimum contract will be (1) one year.

PERSONNEL REQUIREMENTS

	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Supervisors	1	2	3
Analysts	2	4	5
Programmers	6	8	10
Coders	4	8	12
Clerks	0	1	1
Operators	1	2	3
In-Output Oper	0	0	1

Personnel required will vary from installation to installation due to type of application, i.e. third shift may be used unattended with one operator. Figures are for a minimum lease system.

ADDITIONAL FEATURES AND REMARKS

The addressing facilities allow the programmer to operate on the address, the contents of the address or the contents of the contents of the address with every command.

Prior to and after computation, information may be available with the decimal point in any prespecified digit position-for work in dollars and cents, etc.

Control buffers, which control input/output separate from the central processor, may be added to the systems.

INSTALLATIONS

Bendix Computer Division, Bendix Aviation Corporation, 5630 Arbor Vitae Avenue, Los Angeles 45, California
Bendix Aviation Corp., Research Laboratories Div., P.O. Box 5115, Detroit 35, Michigan

BIZMAC I

Radio Corporation of America BIZMAC System Model I

MANUFACTURER

Radio Corporation of America

Picture by Ordnance Tank-Automotive Command

APPLICATIONS

Demand History File - A file containing demand and issue data for approximately 100,000 items of supply. This process involves accumulating and recording for each item in the file one year's demand and issue activity.

Frequency of File Maintenance: Bi-Weekly

Availability Balance File - A magnetic tape file containing asset and level information both summarized and separated as to location for approximately 123,000 items. The processing of stock status information provides an up-to-date file of supply information for all items which are recognized as OTAC responsibility. This file also provides the capability of editing requisitions by machine and is also used for statistical analysis of inventory.

Frequency of File Maintenance: 3 Days

Financial Inventory Analysis - A process that provides for analysis of the asset position of each item in the Availability Balance File and provides management with necessary information from which to prepare required financial reports. Assets and levels are converted into dollar figures and assets are applied against levels in established priorities.

Frequency of File Maintenance: Quarterly

Vehicle Parts File - Maintenance of a file containing about 300,000 messages of repair parts, tools, equipment items, and special notes, arranged in end-item designation sequence.

Frequency of File Maintenance: Weekly

Type 3 Supply Manual - Maintenance of a file containing about 1,250,000 messages of a cross-reference between Federal Stock Numbers (FSN) and reference numbers, including repair-part identifying numbers and previously assigned stock numbers that were withdrawn. The record is maintained in FSN sequence for all Ordnance managed repair parts.

Frequency of File Maintenance: As required

Above applications are being made by the U. S. Army Ordnance Tank-Automotive Command.

COMPUTER - Picture by Radio Corporation of America

PROGRAMMING AND NUMERICAL SYSTEM

Arithmetic system	Fixed point
Instruction type	Three address

Data are organized in the RCA BIZMAC System in the following manner:

Seven bits (6 information + 1 parity) comprise one BIZMAC character (63 characters including ten decimal digits, 26 letters, control symbols, and miscellaneous symbols). A variable number of related characters preceded (on the left) by a control symbol comprises an item (corresponding to a word).

A group of related items enclosed by control symbols is a message (for handling as a unit on tape).

An instruction consists of eight BIZMAC characters interpreted as follows:

Operation	Variation	Addresses		
		A	B	C
B	B	BB	BB	BB

There are twenty-four basic operations which may be varied by the variation character to obtain approximately 140 distinct combinations.

The computer may perform decimal and binary arithmetic operations. Operands are completely variable in length. A 32-character operand limitation is necessary in decimal addition and subtraction where an end-around carry is possible and in multiplication where the multiplicand is also restricted in the same manner.

ARITHMETIC UNIT

In arithmetic operations, the three addresses are used to specify the High Speed Memory locations of the least significant characters of the operands and the result. Execution time for each of these instructions is variable depending on the number of significant characters in the operands. Control symbols as well as space symbols to the left of operands cause the operations to end. The following timing formulae are available:

ADDITION TIME is given by 120 + 40C microseconds, where C equals number of characters in longest operand. This is the formula for addition with positive operands. Formula time is increased when the zero suppression or automatic left justification option is desired or if there is an end-around-carry.

MULTIPLICATION TIME is given by 160 + 288N + 145MN microseconds, where M = No. of digits in multiplicand N = No. of digits in multiplier.

The constants 288 and 145 in the above formula are average times for reading out characters, and repetitive additions are determined by the magnitude of the digits in the multiplier.

Division is programmed, and the time varies with the type of division program used, as well as with the characters of the operands.

The timing formulae shown above include instruction-staticizing time as well as transfer-of-data time to and from the memory.

SORTER - Picture by Radio Corporation of America

Basic construction of the arithmetic unit is vacuum tube-diode. There are no programmed rapid access registers outside of the 4,096-character High Speed Memory. Basic pulse-repetition rate is 500 KC throughout the Computer. Arithmetic operations are primarily serial although pairs of characters (one from each operand) are read from memory in parallel.

Construction	Magnetic cores and vacuum tubes
Timing	Synchronous for the computer Asynchronous for tape operation
Operation	Sequential by character Concurrent by 7 bits forming the character.

STORAGE

Media	Digits	Microsec Access
Magnetic Core	4,096	20
Magnetic Drum	18,000	5,120
Magnetic Tape	Indefinite	5,000

Random access to any character in core storage.

Characters may be transferred between magnetic drum storage in blocks of 4 or 8 at 80 microseconds per block.

Words are variable in length. Intermediate storage is magnetic tape. Read/write 10,000 char/sec. 125 char/in density, 7 bit code.

INPUT

Media	Speed
Card Transcriber (Card to Magnetic Tape)	375 cards/min
Tapewriter and Verifier (Key to Paper Tape)	5,000 strokes/hour
Paper Tape Transcriber (Paper to Magnetic Tape)	200 char/sec

Inputs to all data processing equipment via magnetic tapes are at 10,000 characters/sec with blanks eliminated by variable word length. Direct paper tape input to the computer is at 400 characters/sec.

OUTPUT

Media	Speed
Electromechanical Printer	300/600 lines/min 120 char/line
Magnetic Tape Transcriber (Magnetic to Paper Tape)	20 char/sec
Trancoded (Magnetic Tape to Teletype Tape)	50 char/sec
Document Printer (Paper Tape to Typewriter)	10 char/sec
Transcribing Card Punch (Magnetic Tape to Card)	150 char/min
Interrogation Unit (Magnetic Tape to Typewriter)	4 min/inquiry (average)

ELECTROMECHANICAL PRINTER - Picture by Radio Corporation of America

With the exception of monitor print (via on-line typewriter) the output of all high-speed data processing equipment is magnetic tape: 10,000 characters per second with blanks eliminated by variable word length.

The document printer prints upper and lower case directly from magnetic tape.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	5,000
Tube types	12
Crystal diodes	14,500
Magnetic cores	28,700

The above figures are for the Computer only. System figures depend on exact equipment complement.

Government Sample
Ordnance Tank-Automotive Command
System has the following complement:

Tubes	30,000
Crystal diodes	70,000
Magnetic cores	35,000
Transistors	200
Separate cabinets	470

CHECKING FEATURES

Parity

The BIZMAC code is designed in such a fashion that each character of information contains a redundant parity bit for even parity checking. The various devices in the system contain hardware for extensive utilization of this feature. In the Computer, information circulating internally or transferred to and from tape is checked for parity.

Adder Comparison

The adder forms two sums (the second by using complements of the operands). These sums must be equal, or comparator alarms are registered.

Tape Checks

Input checks are provided to assure that the proper sequence of control symbols is sensed (marking the beginning and end of messages). The first character read in is checked to see that it is one of three permissible control symbols.

An output check is provided by an echo signal, which is used to determine that writing on tape has properly taken place.

Dual recording on magnetic tape is provided. Fourteen channel tape permits the duplicate storage of each bit.

Program Control

Checks are provided to insure that instructions are properly located, that drum switching is correctly completed, and that the flow of basic machine cycles is correct.

Instruction Characteristics

Facilities which are present for use in programs include a verify instruction for data comparison, and an overflow alarm usable with decimal arithmetic instructions.

Computer Stop-Rollback Switch

This device is used to reduce manual intervention when certain types of errors are detected: parity, adder comparison, programmed verify and overflow, control-symbol sequence incoming from tape. When the switch is in the rollback position a transfer of control will be made automatically to a specific

REMOTE PRINTER - Picture by Radio Corporation of America

drum line, permitting attempts to repeat the affected operation.

General

Only a partial listing of checking features is presented above. The RCA BIZMAC System makes extensive use of hardware checks to insure the proper operation of the system as a whole. Many of the checks are implicit in the design (e.g. no erase while reading) or explicit in special circuits (e.g. parity checking).

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Ordnance Tank-Automotive Command

Power, entire system	246 KW	274 KVA	0.9 pf
Power, air cond.	500 KW		
Volume, entire system	2,600 cu ft		
Area, entire system	20,000 sq ft		
Room size required	61 ft x 360 ft		
Weight, computer	26,500 lbs		
Floor loading	125 lbs/sq ft		
Capacity, air cond.	270 tons		
Volume, air cond.	1,200 cu ft		
Area, air cond.	100 sq ft		

False ceiling and pedestal floor in System Control Center. Accoustical walls necessary in high speed printer room. High temp. heads for sprinkler system. 270 ton air conditioning plant plus precipitrons.

COST, PRICE AND RENTAL RATES

$4.5 million acquisition cost.
(1) Computer, (3) File Maint. computers (fixed program), (1) Interrogation Unit, (182) tape stations, (1) System Control Unit, (1) Card Transcriber, (1) Paper Tape Transcriber, (2) high speed printers, (1) Transcribing Card Punch, (3) Document Printers, (10) Flexo-writers.

RCA Service Bureau Contract for Maint. $514,000/year

PERSONNEL REQUIREMENTS

	One 8-Hour Shift	Two 8-Hour Shifts
Supervisors	8	9
Analysts	7	0
Programmers	22	0
Clerks	4	3
Librarians	0	2
Operators	0	25
In-Output Oper	0	14
Tape Handlers	0	4

Operation tends toward modified "open" shop. Higher echelon positions of responsibility filled by upgrading. Personnel "pipe line" is filled at trainee level by necessity.

TYPEWRITER - Picture by Radio Corporation of America

Initially at manufacturer's plant in Camden, N.J.; later to be provided at site or plant as required. Programming and on-the-job operational training now conducted by Ordnance personnel at site.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Ordnance Tank-Automotive Command

Good time 98.29 Hours/Week (Average)

Operating Ratio (Good/Attempted to run time) 0.9928

Above figures based on period from Mar 60 to Jun 60

Date this system passed customer acceptance test Nov 55

Time is not available for rent to outside organizations.

Above calculations predicted on:

Total possible available system hours (minus actual machine downtime)

Example:

377.9	Total Production Hours - April 1960 Actual Avail Hours
Less 9.4	Total Unscheduled Maint.
Less 13.2	Total Hours Idle (All Causes)
Less 20.5	Total Hours Spoiled word (All Causes)
334.8	Total Hours Productive - Apr. 60 (Computer only)

ADDITIONAL FEATURES AND REMARKS

All equipment items in the RCA BIZMAC System are designed to accomodate actual data lengths.

All equipment items in the RCA BIZMAC System are designed to permit equipment integration, i. e. central operation of all equipment including interconnection of Tape Stations and operating devices. This means of integration permits parallel operation of equipment items on "tight" schedule basis.

A separate equipment item, the Sorter, is provided to rearrange information on magnetic tape. It is provided to sort, merge and extract said information with provision for variations of these basic operations.

A separate equipment item, the Interrogation Unit, is an optional part of the system. It is a search and print-out device which permits prompt access to any message stored on any Tape Station within the RCA BIZMAC System.

The BIZMAC Computer has definite operating advantages:

Random composition - read-in.
Random composition - write-out.
Full algebraic decimal add, subtract and multiply and binary add and subtract using variable length operands are possible.
Magnetic tape and drum memory storage of programs with automatic program input from drum memory.
Automatic rollback function to permit correction of transient errors.
Three address instruction code with operating variations provided per instruction.

TAPEWRITER & VERIFIER (Key to Paper Tape) - Picture by Radio Corporation of America

Addressable character extract.
Linear-time-dependent transfer of data.
Automatic zero suppression.
Specific instruction provision for handling subroutines.
Ability to write on tape while computing or reading (Simultaneous Write Instruction).
High speed paper tape input of 400 characters per second.
Fifteen addressable universal tape trunks, each can be used either as an input or output trunk.
Ability to read into High Speed Memory in compressed data form. (Linear Read).

Ordnance Tank-Automotive Command
Outstanding features include variable word length, absolute count control, and an interrogation unit.

Unique system advantages are that the interrogation unit permits rush interrogations at no loss of computer availability. It also permits data quality control check which minimizes re-run time. Electronic sorters preclude use of computer for non-essential processing. One hundred-eighty two tape stations permits maximum machine loading thru pre-scheduling.

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage are those internal procedures that are in

TRANCODER (Magnetic Tape to Teletype Tape) - Picture by Radio Corporation of America

accordance with Department of the Army and Command directives.

INSTALLATIONS

Ordnance Tank-Automotive Command
Detroit 9, Michigan

FUTURE PLANS

Plans are being formalized to supplement existing system with the addition of one (1) RCA 501 System consisting of (1) Computer - 65K memory, eighteen (18) Tape Stations, one (1) card transcriber, one (1) transcribing card punch, one (1) high speed printer, one (1) tape selecting unit and one (1) tape switching unit. Part of the above system will be Government owned and the remainder will be leased from RCA.

When the capacity of the new system has absorbed a major portion of the mark I process, it is planned that one (1) operating shift of the mark I will be phased out.

Task groups have been recently organized to study new applications for the other Directorates of this Command.

PRODUCTION RECORD

Produced	3
Operating	3

Above includes all early BIZMAC models.

Interrogation Unit (Magnatic Tape to Typewriter)

Photo by Radio Corporation of America

Document Printer (Paper Tape to Typewriter)

Photo by Radio Corporation of America

Card Transcriber (Card to Magnetic Tape) Photo by Radio Corporation of America

Magnetic Tape Transcriber (Magnetic to Paper Tape) Photo by Radio Corporation of America

BIZMAC II

BIZMAC II

MANUFACTURER

Radio Corporation of America

APPLICATIONS

Located at the EDP Center, Electronic Data Processing Division, RCA, Camden, New Jersey, the system is used for engineering desing, automated design of wiring for electronic equipment, accounting, statistical analysis, medical research, market research - automated logic, and management controls and clerical automation.

PROGRAMMING AND NUMERICAL SYSTEM

Arithmetic system	Fixed point
Instruction type	Three address

Data are organized in the BIZMAC II System in the following manner:

Seven bits (6 information + 1 parity) comprise one BIZMAC character (63 characters including ten decimal digits, 26 letters, control symbols, and miscellaneous symbols). A variable number of related characters preceded (on the left) by a control symbol comprises an item (corresponding to a word).

A group of related items enclosed by control symbols is a message (for handling as a unit on tape).

Photo by Radio Corporation of America

An instruction consists of eight BIZMAC characters interpreted as follows:

Operation	Variation	Addresses		
		A	B	C
B	B	BB	BB	BB

There are twenty-four basic operations which may be varied by the variation character to obtain approximately 140 distinct combinations.

The computer may perform decimal and binary arithmetic operations. Operands are completely variable in length. A 32-character operand limitation is necessary in decimal addition and subtraction where an end-around carry is possible and in multiplication where the multiplicand is also restricted in the same manner.

ARITHMETIC UNIT

In arithmetic operations, the three addresses are used to specify the high speed memory locations of the least significant characters of the operands and the result. Execution time for each of these instructions is variable depending on the number of significant characters in the operands. Control symbols as well as space symbols to the left of operands cause the operations to end. The following timing formulae are available:

ADDITION TIME is given by 120 + 40C microseconds, where C equals number of characters in longest operand. This is the formula for addition with positive operands. Formula time is increased when the zero suppression or automatic left justification option is desired or if there is an end-around-carry.

MULTIPLICATION TIME is given by 160 + 288N + 145MN microseconds, where M = No. of digits in multiplicand N = No. of digits in multiplier.

The constants 288 and 145 in the above formula are average times for reading out characters, and repetitive additions are determined by the magnitude of the digits in the multiplier.

Division is programmed, and the time varies with the type of division program used, as well as with the characters of the operands.

The timing formulae shown above include instruction-staticizing time as well as transfer-of-data time to and from the memory.

Basic construction of the arithmetic unit is vacuum tube-diode. There are no programmed rapid access registers outside of the 8,192-character high speed memory. Basic pulse-repetition rate is 500 KC throughout the computer. Arithmetic operations are primarily serial although pairs of characters (one from each operand) are read from memory in parallel.

Construction	Magnetic cores and vacuum tubes
Timing	Synchronous for the computer Asynchronous for tape operation
Operation	Sequential by character Concurrent by 7 bits forming the character

STORAGE

Media	No. of Alpha Char	Access Microsec
Magnetic Core	8,192	20/char
Magnetic Drum	32,736	5,120
Magnetic Tape	Indefinite	5,000

INPUT

Media	Speed
Card Transcriber	400 char/min
Tapewriter & Verifier	Operator limited
Paper Tape	200 char/sec

OUTPUT

Media	Speed
Electro-mechanical Printer (off-line)	600 lines/min
Document Printer	9 char/sec
Transcribing Card Punch	150 cards/min
Interrogation Unit	4 min/avg inquiry

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	5,000
Tube types	12
Crystal diodes	14,500
Magnetic cores	28,700

The above figures are for the computer only. System figures depend on exact equipment complement.

CHECKING FEATURES

Parity

The BIZMAC code is designed in such a fashion that each character of information contains a redundant parity bit for even parity checking. The various devices in the system contain hardware for extensive utilization of this feature. In the computer, information circulating internally or transferred to and from tape is checked for parity.

Adder Comparison

The adder forms two sums (the second by using complements of the operands). These sums must be equal, or comparator alarms are registered.

Tape Checks

Input checks are provided to assure that the proper sequence of control symbols is sensed (marking the beginning and end of messages). The first character read in is checked to see that it is one of three permissible control symbols.

An output check is provided by an echo signal, which is used to determine that writing on tape has properly taken place.

Dual recording on magnetic tape is provided. Fourteen channel tape permits the duplicate storage of each bit.

Program Control

Checks are provided to insure that instructions are properly located, that drum switching is correctly completed, and that the flow of basic machine cycles is correct.

Instruction Characteristics

Facilities which are present for use in programs include a verify instruction for data comparison, and an overflow alarm usable with decimal arithmetic instructions.

Computer Stop-Rollback Switch

This device is used to reduce manual intervention when certain types of errors are detected: parity, adder comparison, programmed verify and overflow, control-symbol sequence incoming from tape. When the switch is in the rollback position a transfer of control will be made automatically to a specific drum line, permitting attempts to repeat the affected operation.

General

Only a partial listing of checking features is presented above. The RCA Bizmac System makes extensive use of hardware checks to insure the proper operation of the system as a whole. Many of the checks are implicit in the design (e.g. no erase while reading) or explicit in special circuits (e.g. parity checking).