G-15 TECHNICAL BULLETIN • EQUIPMENT SERIES

BENDIX G-15
GENERAL PURPOSE
DIGITAL COMPUTER SYSTEM

THE BENDIX G-15 COMPUTER

The Bendix G-15 is a powerful, internally programmed, digital computer of medium speed. The basic unit provides a complete, general purpose computing system in a single cabinet. However, the system is expandable by means of selected accessories. The computer is versatile in operation, compact in size, and low in cost—a combination obtained by the use of both serial logic and of time-sharing techniques in the internal design.

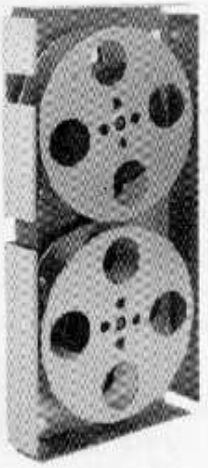
Extensive Storage Capacity

A magnetic drum provides internal memory storage. A built-in, searchable, photo-electric reader for punched tape provides external storage for the basic computer. Magnetic tape storage is optional. In each of the three, data and commands may be stored interchangeably.

The external storage facilities can be used as an extension of the magnetic drum memory. Information can be read into one of the channels on the drum, either from the photo-electric reader or from a magnetic tape unit, while internal computation is progressing.

The high-speed, photo-electric reader reads punched tape from a magazine that snaps onto the front of the computer. Tape in the magazine can be moved under computer control, in either the forward or reverse direction, simultaneously with internal computation.

BENDIX G-15 COMPUTER



PUNCHED TAPE MAGAZINE SHOWING REELS

Great Programming Ability

The basic command structure has been made very flexible in order to meet a wide variety of programming needs. This flexibility provides power for the experienced programmer and has enabled the development of an extremely simple, programming and operating system for the novice. Programming systems are available for either fixed point or floating point decimal input and output.

Double-length arithmetic registers are included to permit the programming of double-precision operations with the same ease as single-precision ones.

A single command may operate on a single word or on a selected group of words.

A conditional transfer of control may be based on the existence of non-zero information, on the sign of a number, or on the overflow of an arithmetic register.

Breakpoints which halt computation may be added to, or removed from, any portion of the program, at will. This feature simplifies the check-out of new programs since the programmer need not guess ahead of time which portions of his program will require "debugging."

High Practical Computing Speed

The G-15 is faster in practical computation than any other magnetic drum computer at its price level.

Two addresses are specified in the basic machine command; one is the location of the operand, and the other is the location of the next command to be executed. This type of two-address command permits true minimum access coding; that is, non-productive computer time, which is spent in waiting for a specific drum location to be in an operative position, may be eliminated.

Computation time is reduced by incorporating arbitrary-precision multiplication and division in the design; either operation may be terminated as soon as the number of digits required for the desired accuracy is obtained.

Commands may operate directly on information stored in any drum channel. No time is lost in switching between channels, since the switching operation is completely electronic.

Rapid-access information storage is provided by four short recirculating channels on the drum. Each short channel has a capacity of four words.

Superior Input-Output System

An input or output operation for as many as 108 words may be initiated by a single command. The operation, which may be simultaneous with internal computation, will proceed without intervention and terminate itself on completion.

Various input-output devices are available. Typewriter, tape punch, and searchable photoelectric reader for punched tape are included in the basic price; magnetic tape units and punched card equipment are available as optional accessories. Other accessories simplify the programming of differential equations, provide compatibility between the computer and external, data-processing equipment and prepare tape for machine tool control.

Two or more computers can communicate with each other when operated simultaneously. The computers can receive information from, and send information to, each other during computation.

ACCESSORY EQUIPMENT

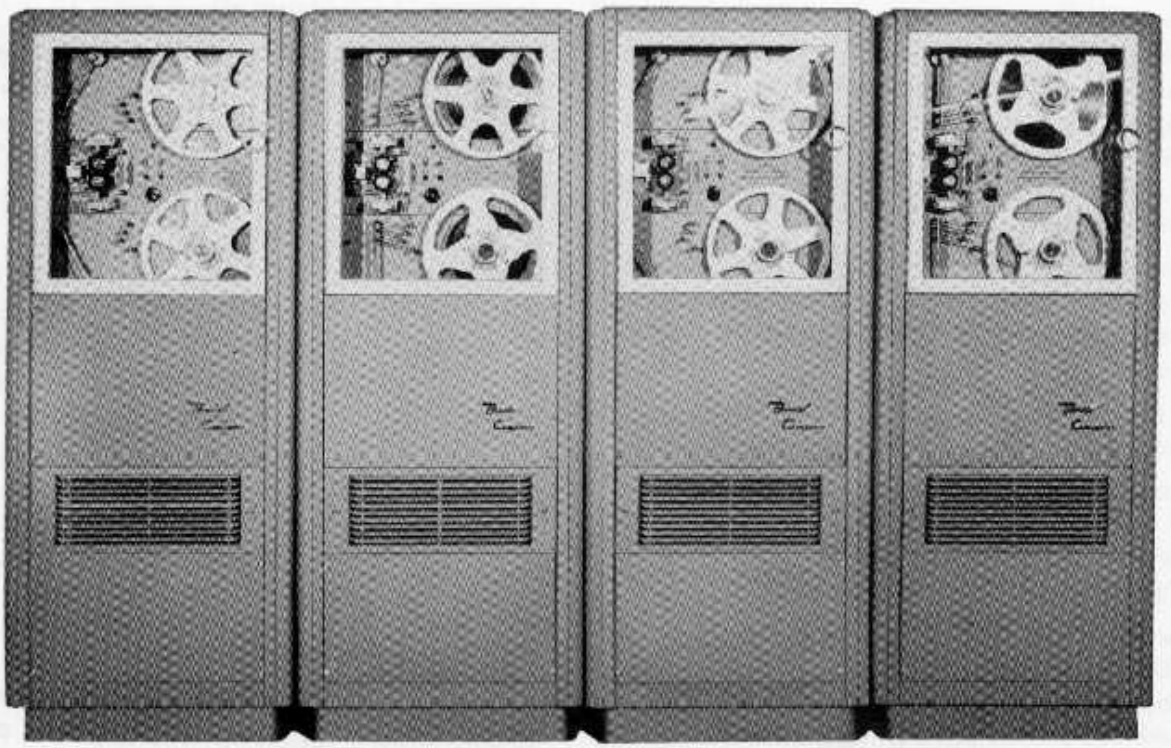
MAGNETIC TAPE UNIT MTA-2

MTA-2 Magnetic Tape units provide inexpensive, fast and compact auxiliary storage. One to four MTA-2 units may be connected to the computer; facilities are included for the unique addressing of each tape unit. One MTA-2 may store 300,000 words on standard half-inch magnetic tape.

Tape may be searched either for blocks of up to 108 words or for file sections consisting of any arbitrary number of blocks.

Information may be written on tape or read from tape under computer control at a rate of 430 characters per second. (A character consists of four binary digits. The four binary digits may represent a decimal digit, if desired.) Tape may be searched in both the forward and reverse directions, under computer control, at a rate of 2500 characters per second.

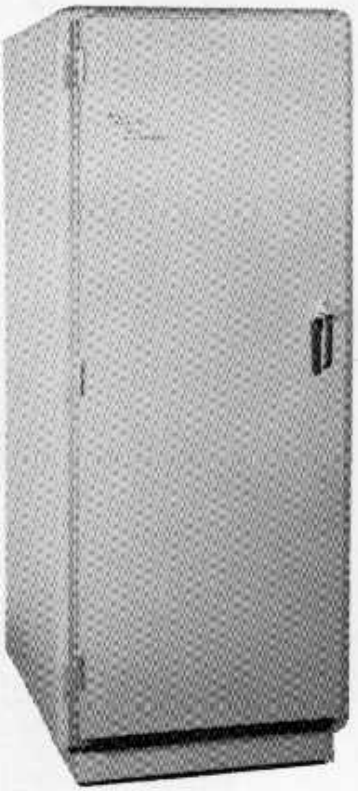
Each unit is the size of a standard filing cabinet (60 by 24 by 22 inches) and weighs 175 lbs. Power consumption is .64 kva.



FOUR MTA-2 MAGNETIC TAPE UNITS

DIGITAL DIFFERENTIAL ANALYZER DA-1

Accessory DA-1 provides the computer with facilities for the simple programming of the solution of differential equations. The combination of a general purpose computer with a digital differential analyzer makes a new and powerful tool for solving engineering and automatic control problems.



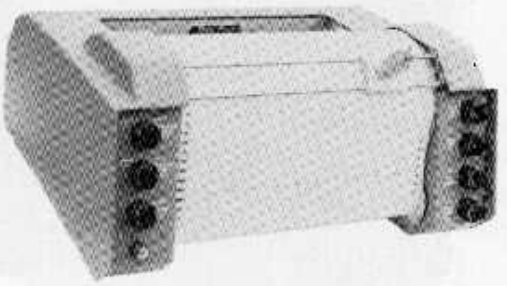
DA-1 DIGITAL DIFFERENTIAL ANALYZER

DA-1 programming is similar to that which is used for an analog differential analyzer but much greater accuracy is attained. Problems solvable with the DA-1 are those which can be expressed in the form of differential equations. These include the solutions of linear and non-linear differential equations, linear and non-linear simultaneous equations, solutions for roots of transcendental equations, and the simulation of real systems.

The DA-1 provides the unusually large number of 108 integrators and 108 constant multipliers; hence, it may be used to obtain numerical solutions of complex problems involving high-order, differential equations or sets of simultaneous equations. Facilities are provided for the input of empirical functions. The set of 108 integrators is processed 34 times per second. Seven decimal digit precision is available. Output may be tabulated or plotted graphically by G-15 equipment. The accessory is the size of a standard filing cabinet and weighs 300 lbs. Power consumption is one kva.

GRAPH PLOTTER PA-3

Accessory PA-3 is an incremental plotter that provides graphical output directly from the computer or from Accessory DA-1. The unit plots the relationships between two output increments on a standard, sprocketed roll of paper, 1 foot by 100 feet.



PA-3 GRAPH PLOTTER

A retractable pen holder is available, as an optional feature, that permits plotting to begin at any point on the paper and eliminates retrace lines.

The unit makes continuous or broken line markings, under manual or program control, at speeds up to 200 increments per second on either one or both coordinates. Accuracy is within .005 of an inch. The PA-3 fits on a desk top and weighs 35 lbs.

PUNCHED CARD COUPLER CA-2

Accessory CA-2 increases the versatility and rapidity of input-output operation for the Bendix G-15 Computer. Standard 80-column cards, punched in any commonly used numeric or alphanumeric code, are processed rapidly and numeric or alphanumeric printed copy is tabulated at high speed.

Three IBM units, one for input, one for output, and a third for either input or output, may be simultaneously connected to the CA-2. Cards may be read or punched in standard code; alphanumeric and numeric characters may be mixed. Special characters, indicated by multiple holes in card columns, may be read or punched.

Information can be tabulated, punched on cards, or read from cards automatically under control of the computer program. An input or output operation via the CA-2 may be simultaneous with internal computation and with any input-output operation that does not make use of the CA-2.

CA-2 CARD COUPLER
WITH TYPICAL PUNCHED CARD EQUIPMENT

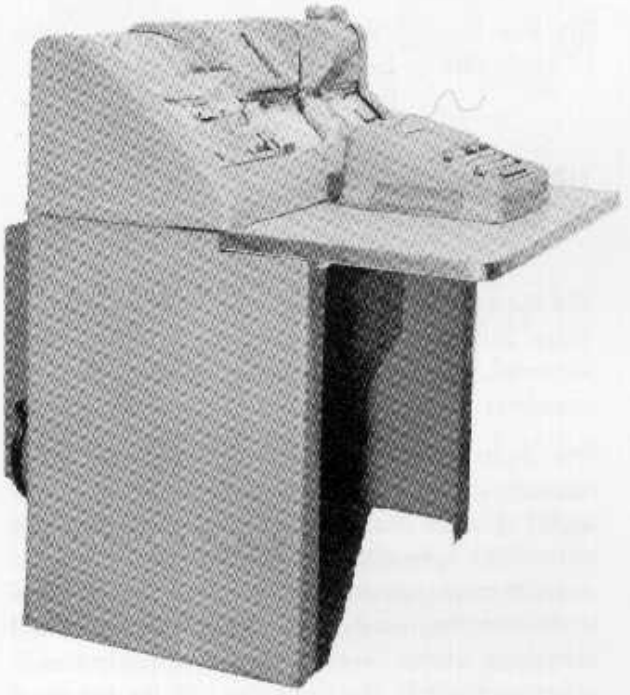
Information may be read or punched at the rate of 100 cards per minute by summary punches, such as the IBM 514 or IBM 523. Output information may be tabulated at the rate of 100 lines per minute by the IBM 402.

The CA-2 is 60 inches high, 29 inches wide and 22 inches deep.

PUNCHED CARD COUPLER CA-1

Accessory CA-1 is designed for use with an IBM Model 026 Card Reader-Punch. One or two Model 026 Reader-Punch units can be connected to the coupler. When one 026 unit is connected, it is used for both reading and punching; when two are connected, one is used for reading and one for punching.

Cards are read or punched under computer control. A program card, inserted into the IBM-026, selects the columns to be read or punched in the cards being processed.



CA-1 CARD COUPLER
MOUNTED ON 026 PUNCH-READER

Cards are read at a rate of 17 columns per second and are punched at a rate of 11 columns per second. Columns are skipped at a rate of 80 columns per second.

PUNCHED TAPE READER PR-1

Accessory PR-1 is a photo-electric, paper tape reader which supplements the built-in photo-reader in the G-15. The computer can control up to three PR-1 units; information from any one of the units can be read in any order desired.

PR-1 PUNCHED TAPE READER

Tape-reading capabilities of the PR-1 are the same as the standard reader on the computer; that is, 250 characters per second reading rate, bi-directional searching, and simultaneous computation with reading or searching.

The PR-1 is magazine-loaded; each magazine holds 2500 words.

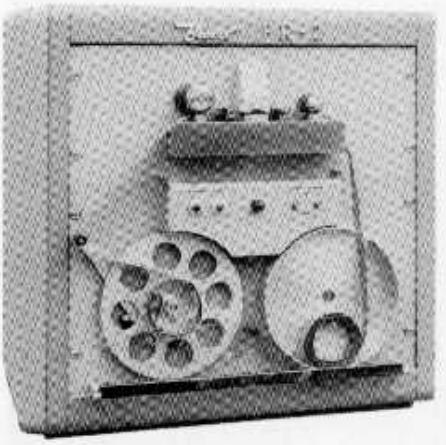
The PR-1 is 11 inches high, 10 inches wide, 15 inches deep and weighs 40 lbs.

PUNCHED TAPE READER PR-2

Accessory PR-2 is an additional photo-electric reader that permits any external numeric code, punched on five, six, seven, or eight channel tape, to be read into the G-15 Computer.

The tape being read may contain control characters in the external code as well as positive and negative numerical values. A control character may signify the end of a numerical value or that tape reading is to immediately halt.

Movement of tape is unidirectional at a rate of 430 characters per second. Tape motion halts immediately after any specified character. When tape motion is re-initiated, reading begins with information punched immediately after the specified "stop" character.

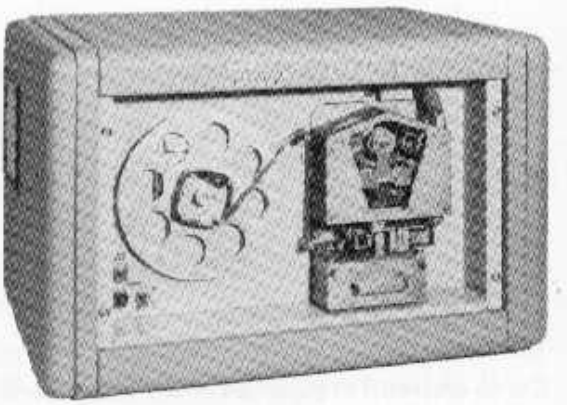


PR-2 PUNCHED TAPE READER

The PR-2 is 22 inches high, 24 inches wide and 19 inches deep.

TAPE PUNCH PTP-1

Accessory PTP-1 is a high speed, paper tape punch unit for the G-15 Computer. The PTP-1 punches 5-channel tape at a rate of 60 characters per second under computer control. Tape punched by this unit may be read by the computer's built-in photo-electric reader or by any of the auxiliary photo-electric readers.



PTP-1 TAPE PUNCH

A tape take-up device is provided which holds approximately 500 feet of tape.

The PTP-1 is 15 inches high, 24 inches wide, 17 inches deep and weighs 110 lbs.

UNIVERSAL CODE ACCESSORY AN-1

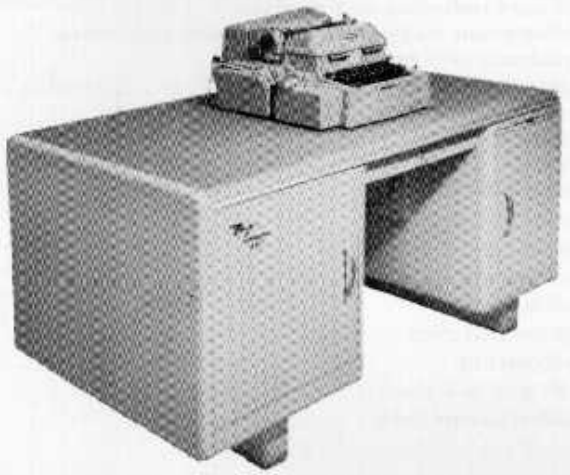
The Model AN-1 Universal Code Accessory provides compatibility between the computer and external, data-processing equipment and also prepares tape for machine tool control.

For data-processing equipment, the AN-1 accepts alphanumeric or numeric input in any code of eight bits or less per character and enters the information directly into the computer's memory. A special conversion routine translates the input language into the internal language of the G-15. After the information is processed within the computer, results are read out to external, data-handling equipment in any numeric or alphanumeric code.

The HSR-8 reader and HSP-8 punch are provided with the AN-1.

The Model HSR-8 mechanical reader permits paper tape with eight or fewer channels to be read into the AN-1 at a rate of 110 characters per second.

The Model HSP-8 punch permits paper tape with eight or fewer channels to be punched out of the AN-1 at a rate of 110 characters per second.



AN-1 UNIVERSAL CODE ACCESSORY WITH 35-4 FLEXOWRITER

The AN-1 enables the G-15 to punch and read tapes which are used with Bendix Three-dimensional Machine Tool Control Units. The information from an engineering specification sheet or process card is typed on a standard Flexowriter, and a six-channel tape is prepared in standard Flexowriter code. The Flexowriter tape is then read into the AN-1 via the tape reader. The AN-1 transmits the information to the G-15. The computer, by means of a special program, makes the necessary computations and causes the AN-1 to punch a seven-channel control tape. The control tape may then be inserted in the machine tool control unit, which will direct the machine tool so that the original engineering specifications are fulfilled.

The AN-1 can also be connected to the user's present input-output equipment. Input and output speed may then be as high as 200 alphanumeric characters per second. The rate will vary depending on the type of input-output equipment used.

A modified Model 35-4 Flexowriter may be used in conjunction with the AN-1. The Flexowriter permits keyboard or paper tape input and typed or punched tape output for six-level alphanumeric information. Tape is read or punched at a rate of 10 characters per second. The Flexowriter also provides facilities for the independent preparation, duplication and punching of six-channel tapes for use with the HSR-8.

SPECIAL INPUT-OUTPUT REGISTERS

Facilities are provided in the computer for the direct connection of external registers which can be designed to meet special input-output requirements.

Such specially designed registers facilitate use of the G-15 Computer, without modifications, as a directly-coupled, information-processing unit in an existing system.

COMPUTER INTERCONNECTION

Computers can be connected to each other by means of special cables. If five or fewer computers are connected to each other, each unit would be able to receive information from and send information to any other unit. MTA-2 magnetic tape accessories may take the place of one to four of these computers.

APPLICATIONS

The G-15 Computer is being used by large and small organizations to help solve a wide range of problems. Some of the present applications are:

Aviation Industry

- Airborne computer design
- Analysis of landing gear systems
- Auto-pilot design
- Flight pattern scheduling for jet aircraft
- Flight test data reduction and analysis
- Missile component study through computer simulation
- Missile guidance and trajectory analysis
- Missile impact prediction
- Multiple airborne target tracking
- Radar antenna design
- Stress analysis
- Wind tunnel data reduction

Business Data Processing

- Actuarial calculations
- Inventory control
- Labor distribution
- Mortgage amortization
- Payroll processing
- Sales audit and unit control
- Standard cost comparison

Civil Engineering

- Highway construction and design
- Photogrammetry
- Sewer design based on rain run-off calculations
- Truss analysis
- Structural analysis and design
- Surveying
- Traffic analysis

Crystallography

- Atomic form factors
- Computation of X-ray scattering parameters
- Crystal structure factors
- Lengths and angles between inter-atomic vectors
- Two-dimensional Fourier synthesis

Geodetics and Navigation

- Cartography
- Coordinate conversion
- Inertial navigation studies
- Navigation calculations for carrier air traffic control
- Shipboard navigational fixes in real time
- Weather computations

Hydrology

- Backwater analysis
- Correlation of factors of stream flow and reservoir storage in a hydroelectric system
- Dam design
- Power generation
- Reservoir design for maximum power output
- Spillway flood routing

Industrial Research	Air traffic control study Distribution of radio-active materials on a surface Heat transfer studies Information retrieval Lamp research Radar research Study of optimum designs for electromechanical devices Vibration and motion studies Cam design
Machine Tool Industry	Design of gear cutters and shaving tools Numerical control of machine tools
Mathematical Analysis	Analysis of variance Complex polynomials Eigen-values and Eigen-vectors Fourier analysis Generation of tables of specialized functions Matrix calculations Least square curve fitting Multiple regression analysis Probability analysis Simultaneous linear and non-linear differential equations Simultaneous linear and non-linear algebraic equations Statistical analysis for quality control Sum of squares and correlation coefficients
Nuclear Research	Design of nuclear power plant Design of gas-cooled power reactor Nuclear reactor simulation Nuclear and thermonuclear energy applications in weapons systems
Optical Industry	Optical lens design Ray tracing
Petroleum Industry	Catalytic cracking Crude oil reservoir studies Distillation equipment design Gas network analysis Harmonic analysis of ocean waves for off-shore drilling Interpretation of seismic data Oil production analysis Petroleum exploration and refining Pipeline design for gas transmission
Textile Industry	Denier of fiber computation from resonant frequency Elasticity studies Strain gauge tests of synthetic fibers and plastic materials Stress-strain and pulse-propagation data for fibers
Universities	Classroom instruction Executive training Laboratory experimentation Statistical analysis for animal industry

PROGRAMMING SYSTEMS

The design of the Bendix G-15 Computer permits efficient use of a variety of programming systems. In these systems much of the detailed work that would otherwise be involved in programming is done by the computer itself. Both "interpretive" and "compiling" systems are available.

An interpretive system is one in which a program is written in simple form and stored in the memory of the computer in that form. During computation the computer examines the simple commands one at a time. The computer then executes a series of basic machine language commands for each stored simple command. Intercom 1000 is an interpretive system.

A compiling system is one in which a program, written in simple form, is transformed by the computer into a new program made up of basic machine commands which the computer records on paper tape or magnetic tape. The program on tape may then be re-entered in the computer for execution whenever desired. Algo is a compiling system.

INTERCOM 1000

Intercom 1000 is a very easy to use programming system in which the decimal points in numbers are automatically handled.

A single Intercom command causes execution of a number of internal operations in the computer. Since the programmer need have no knowledge of the varied internal operations performed by each Intercom command, and since numbers exist in floating point form internally, the time and skill required for programming is greatly reduced.

Intercom 1000 has facilities for computer control, input, output, program preparation and check-out. Single-precision or double-precision operation is available; the same command list is used in either case. Data may be written with five or fewer significant digits in the single-precision system; data may be written with twelve or fewer significant digits in the double-precision system. Positive or negative decimal numbers may be handled. Input and output may be in conventional notation in which the decimal point can occur in any position in each number; or input and output can be in floating point notation in which the multiplier of the decimal fraction may range in value from 10^{-87} to 10^{87}.

There are 1200 words of internal memory in single-precision operation and 1000 words in double-precision operation. Additional data and command storage is provided by punched tape or magnetic tape. The use of subroutines is facilitated by special commands.

Nine index registers, addressable within each command code, are available in the system. Each index register provides automatic means for successively modifying the address portion of commands within selected limits.

The command list includes all arithmetic operations, transfers of control based on a variety of conditions, commands for index register control, and commands to aid in program check-out. There are commands for punched tape, punched card, magnetic tape and typewriter input-output.

TYPICAL COMMANDS IN INTERCOM 1000

Clear and add
Add
Clear and subtract
Subtract
Multiply
Divide
Store
Clear and add absolute value
Transfer control, unconditionally
Transfer control if accumulator positive or zero
Transfer control if accumulator negative
Transfer control if accumulator zero
Mark place and transfer control
Return to marked place
Perform subroutine
Read paper tape
Punch paper tape
Permit type-in
Print and tab
Print and return carriage

ALGO

Algo is a compiling system that follows the principles set forth in the international algorithmic language, Algol. The Algo system permits the programmer to state a problem in algebraic form. The compiler automatically translates the algebraic statements into a machine program for the G-15. The computer then executes the program and obtains a solution to the problem. No special knowledge of computers or programming is required to prepare an Algo program. Anyone with a background in high school algebra can learn the Algo language quickly.

Algo may handle data of up to 14 decimal digits. The range of values is from 10^{-14} to $10^{14} - 1$. Input and output data may be in fixed point notation with the decimal point appearing in any position. Input and output data can also be in floating point notation.

The Algo programming system includes facilities for computer control, input, output, and error detection and correction.

STANDARD PROGRAMMING

The standard programming system provides fixed decimal point input-output of seven digits per number, if single-precision, or of fourteen digits per number, if double-precision. Data and commands are written in the form of decimal numbers. Numerous facilities are provided which aid in the preparation and checking out of a program.

A two-address command structure is used in which one of the addresses is the location of the operand and the other address is the location of the next command to be executed. Each standard command corresponds to a single basic machine command.

The standard command list consists of fifty basic commands which are sufficient to program any problem. However, the code for a basic command may be altered and its function modified. The estimated number of 1300 different commands which are possible by this means permit an increase in the efficiency and speed of computation.

The basic commands include:
All arithmetic operations; shift and normalize commands, with automatic tally for floating-point operations; commands for the extraction and re-assembly of a group of digits in a word or group of words; information transfer operations; unconditional transfers of control including commands which simplify the incorporation of subroutines in programs; conditional transfers of control; and input-output commands for typewriter, magnetic tape, punched tape and punched cards.

A partial list of standard commands, excluding input-output commands and commands for accessory equipment, is shown in the table. Any operation in the command list may be specified to be single or double-precision. A double length product or quotient may be obtained from either single-length or double-length factors. The terms AR, MQ, ID and PN refer to arithmetic registers. Register AR is the accumulator for single-precision operation and holds one word. Register PN is the accumulator for double-precision operation. Registers MQ, ID and PN hold two words each.

STANDARD COMMANDS

Arithmetic Operations

Clear and add to AR
Clear and add absolute value to AR
Clear and subtract from AR
Add to AR
Add absolute value to AR
Subtract from AR
Store sum or difference from AR
Clear multiplication and division registers
Load multiplicand, denominator or number to be shifted right
Load multiplier or number to be shifted left or normalized
Load numerator
Multiply
Divide
Store product
Store quotient
Normalize MQ
Shift MQ left and ID right under control of command
Shift MQ left and ID right under control of AR
Clear and add to PN (double-precision)
Add to PN (double-precision)
Add absolute value to PN (double-precision)
Subtract from PN (double-precision)
Store sum or difference from PN (double-precision)

Information Transfer

Transfer word between addresses

Conditional Transfer of Control

Test for zero
Test sign of AR
Test for overflow
Test for "Ready" state of regular input-output

Command Channel Selection

Select command line and mark
Select command line and return
Take next command from AR

Extract Operations

Transfer "one" bits of word in Line 21 that correspond to "one" bits of same-numbered word in Line 20
Transfer "one" bits of word in Line 21 that correspond to "zero" bits of same-numbered word in Line 20

Special Commands

Halt
Ring bell

CUSTOMER SERVICES

MACHINE MAINTENANCE

Maintenance service is provided by the Bendix Computer Division for all leased computers.

Maintenance service can be provided, if desired by the customer, for purchased equipment. The minimum one-year contract includes all parts, preventive maintenance, and emergency service as required. The basic service charge normally includes transportation of the service engineer to the installation from the nearest Bendix Computer Service Center.

Emergency service is also provided on a "per call" basis.

Present Bendix Computer Service Center locations include: Albany, New York; Albuquerque; Baltimore; Boston; Buffalo; Cape Canaveral; Chicago; Cincinnati; Cleveland; Dallas; Dayton; Denver; Detroit; El Paso; Hartford, Connecticut; Houston; Jacksonville, Florida; Kansas City, Missouri; Lansing, Michigan; Little Rock; Los Angeles; Milwaukee; Minneapolis; Nashville: New York City; Philadelphia: Phoenix; Pittsburgh; Rochester, New York; Salt Lake City; San Francisco; South Bend; Springfield, Illinois; Trenton; Tulsa; Washington, D.C. and Wichita. Other service centers are located in the states of Alabama, Delaware, Iowa, Nebraska, North Carolina, Oklahoma, Virginia and Wyoming. Additional service centers are continually being established.

PERSONNEL TRAINING

Courses in programming and operation of the G-15 Computer are scheduled at frequent intervals in Los Angeles, Washington and Chicago. Computer maintenance courses are held in Los Angeles. All courses are free of charge at the established training locations.

Course	*Duration*
Intercom 1000 System Programming and Operation	**4 hours**
General Computer Programming and Operation	**3 weeks**
DA-1 Digital Differential Analyzer Programming and Operation	**1 week**
Computer Maintenance	**4 weeks**

PROGRAMMING SUPPORT

A programming staff to aid users is maintained in each regional office, as well as in Los Angeles. An extensive library of programs and subroutines is available for many divergent fields of application. This library is constantly being expanded.

The exchange of problems and routines between users is facilitated by an active G-15 users' exchange organization. The group is directed by a steering committee elected from the membership. Subcommittees which meet at frequent intervals have been organized for specific fields of application. Each subcommittee has compiled a library of programs for the use of its members.

SUMMARY OF SPECIFICATIONS

GENERAL INFORMATION

Number Length

Single-precision—seven decimal digits plus sign during input-output, twenty-nine binary digits internally.

Double-precision—fourteen decimal digits plus sign during input-output, fifty-eight binary digits internally.

Internal Specifications

Instruction specifies address of operand and address of next instruction.

Tubes and germanium diodes for logical circuitry mounted on plug-in etched circuit packages. 180 tube packages, 300 diode packages.

Magnetic drum for internal memory with separate "read" and "write" amplifiers for each channel. Operations synchronized by 107 kc signal from drum.

Cooling by internal forced air.

External Specifications

Power requirements are 3.8 kva, 115 volts ±10% at 45 amp.

Dimensions are 32" deep by 27" wide by 61" high. Weight is 965 lbs. Ambient temperature should be 85°F, maximum.

DATA AND COMMAND STORAGE

Internal Storage on Magnetic Drum

2160 words in twenty channels of 108 words each. Average access time, 14.5 milliseconds.

16 words of fast-access storage in four channels of 4 words each. Average access time of 0.54 milliseconds.

Eight words in registers consisting of 1 one-word command register, 1 one-word arithmetic register, and 3 two-word arithmetic registers for double-precision operations.

External Storage

Searchable paper tape, 2500 words per magazine.

Magnetic tape (optional), one to four units with 300,000 words per tape unit reel.

SPEED OF OPERATION

Arithmetic Speed

The basic computation times listed below are in milliseconds. In each case, the time required for the computer to read the command prior to its execution is included; the figures are based on the use of G-15 minimum access coding facilities. The time range listed for multiplication and division represents the range between single decimal digit precision and maximum precision.

	Single-Precision	*Double-Precision*
Addition or Subtraction	0.54	0.81
Multiplication or Division	2.43 to 16.7	2.43 to 33.1

Input-Output Speed

A 108-word buffer channel is provided on the magnetic drum so that input-output may proceed simultaneously with computation.

Input Speed

Punched tape		
Standard photo-reader	250	char/sec.
PR-2 photo-reader	430	char/sec.
HSR-8 reader for AN-1	110	char/sec.
Magnetic tape	430	char/sec.
Punched cards		
via CA-2	100	cards/min.
via CA-1	17	char/sec.

Output Speed

Typewriter	10	char/sec.
Punched tape		
Standard tape punch	17	char/sec.
PTP-1 tape punch	60	char/sec.
HSP-8 punch for AN-1	110	char/sec.
Magnetic tape	430	char/sec.
Punched cards		
via CA-2	100	cards/min.
via CA-1	11	char/sec.
Line printer		
via CA-2	100	lines/min.
Graph plotter		
PA-3 plotter	200	incr/sec.