GE-235 SYSTEM MANUAL

GENERAL ELECTRIC

COMPUTER DEPARTMENT

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In the construction of the equipment described, General Electric reserves the right to modify the design for reasons of improved performance and operational flexibility.

CONTENTS

The GE-235 is the fastest, most versatile member of the GE-200 Series of information processing systems (GE-215, 225, and 235). Like the other members of this family, the GE-235 is complemented by a full range of powerful programming tools. Together, the equipment and programming tools provide an integrated system adaptable to a wide variety of business, scientific, and engineering applications.

The basic design philosophy of the GE-235 system is the same as that of the GE-215 and 225, which have proved themselves fast, accurate, reliable, and economical in widely divergent fields. This design similarity makes the GE-235 upward compatible with the GE-215 and 225 in respect to logic, programming, and coding. As a result, most programs and applications originally designed for the other members of the family can immediately be processed on a GE-235 having the same system configuration. Only in the relatively few programs containing timing loops, minor changes may be necessary.

GE-235 INFORMATION PROCESSING SYSTEM

The basic system comprises a central processor with a six-microsecond core memory, card or perforated tape input and output, electric typewriter input and output, and an operator's control console. The system configuration can readily be expanded to fit increasing information processing needs. Equipment available includes:

Magnetic core memory -- 4096-, 8192-, or 16,384-word capacity

Card readers -- 400 or 1000 cards per minute

Card punch -- 100 or 300 cards per minute

Perforated tape reader -- 250 or 1000 characters per second

Perforated tape punch -- 110 characters per second

Magnetic tape handlers -- read and write 15,000 characters per second (at 200 bits per inch) or 15,000/41,600 characters per second (at 200/555.5 bits per inch)

Mass random access data storage (MRADS) -- 18.8 million alphanumeric characters or up to 34.4 million numeric digits per unit

High-speed printers -- 900 alphanumeric lines per minute, on line, or 900 alphanumeric lines per minute, on/off line

Document handler -- reads and sorts 1200 documents per minute, on or off line

Data communication controllers

Floating point arithmetic capability (through the Auxiliary Arithmetic Unit)

An outstanding feature is that up to ten input-output devices may be operated concurrently within the system, allowing great flexibility in system configuration. Some typical system configurations for various applications are shown on the following pages.

Programming aids available for the GE-235 include:

GECOM -- the general compiler, an all purpose, problem-oriented language program that may be used with:

COBOL-type statements (specific, simplified English language statements)
ALGOL-type statements (algebraic expressions)
TABSOL (structured decision tables)
GECOM Report Writer (for programming business reports)

FORTRAN -- a scientific compiler

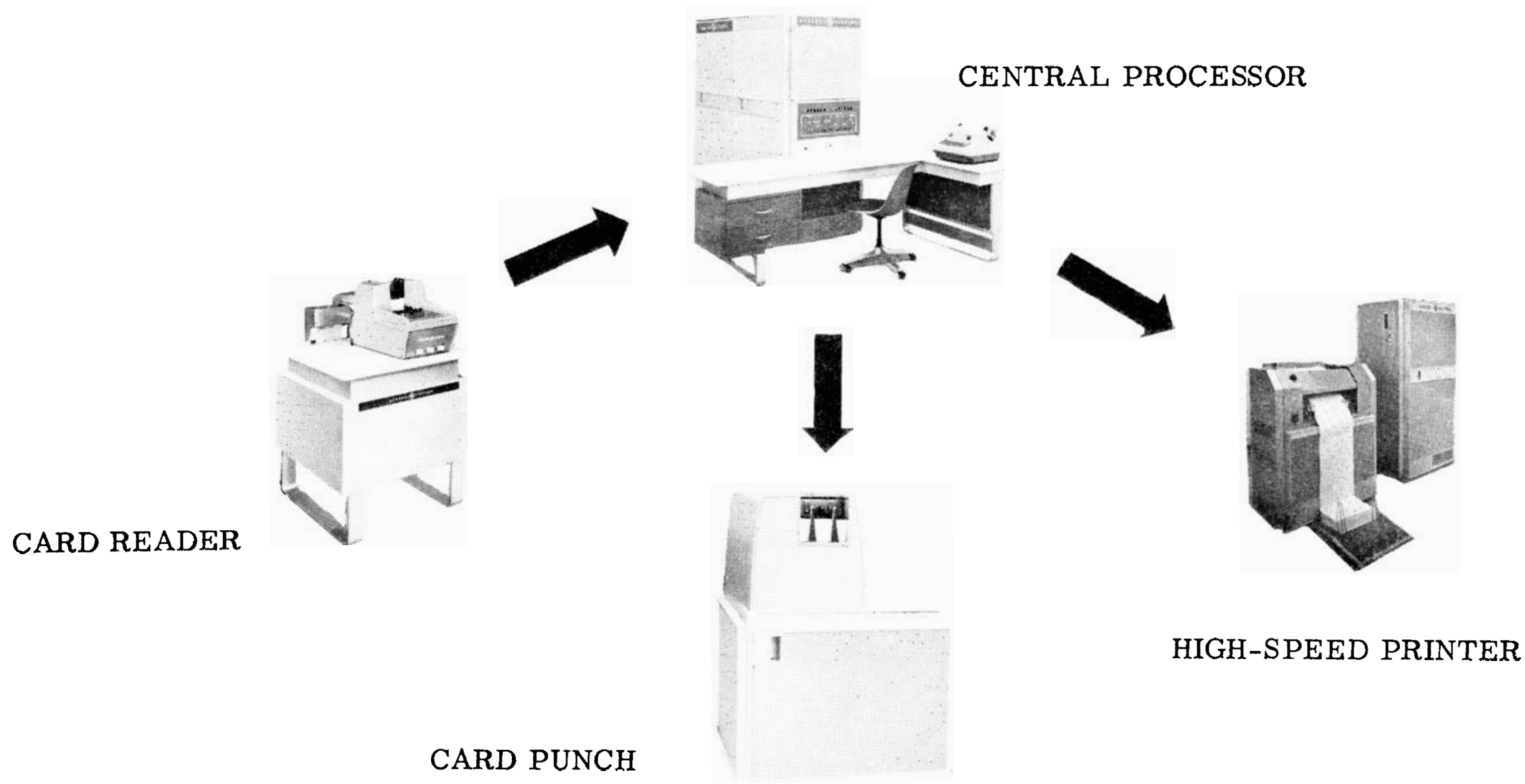
ZOOM -- a macroassembly system

WIZ -- a highly competent, one-pass algebraic compiler

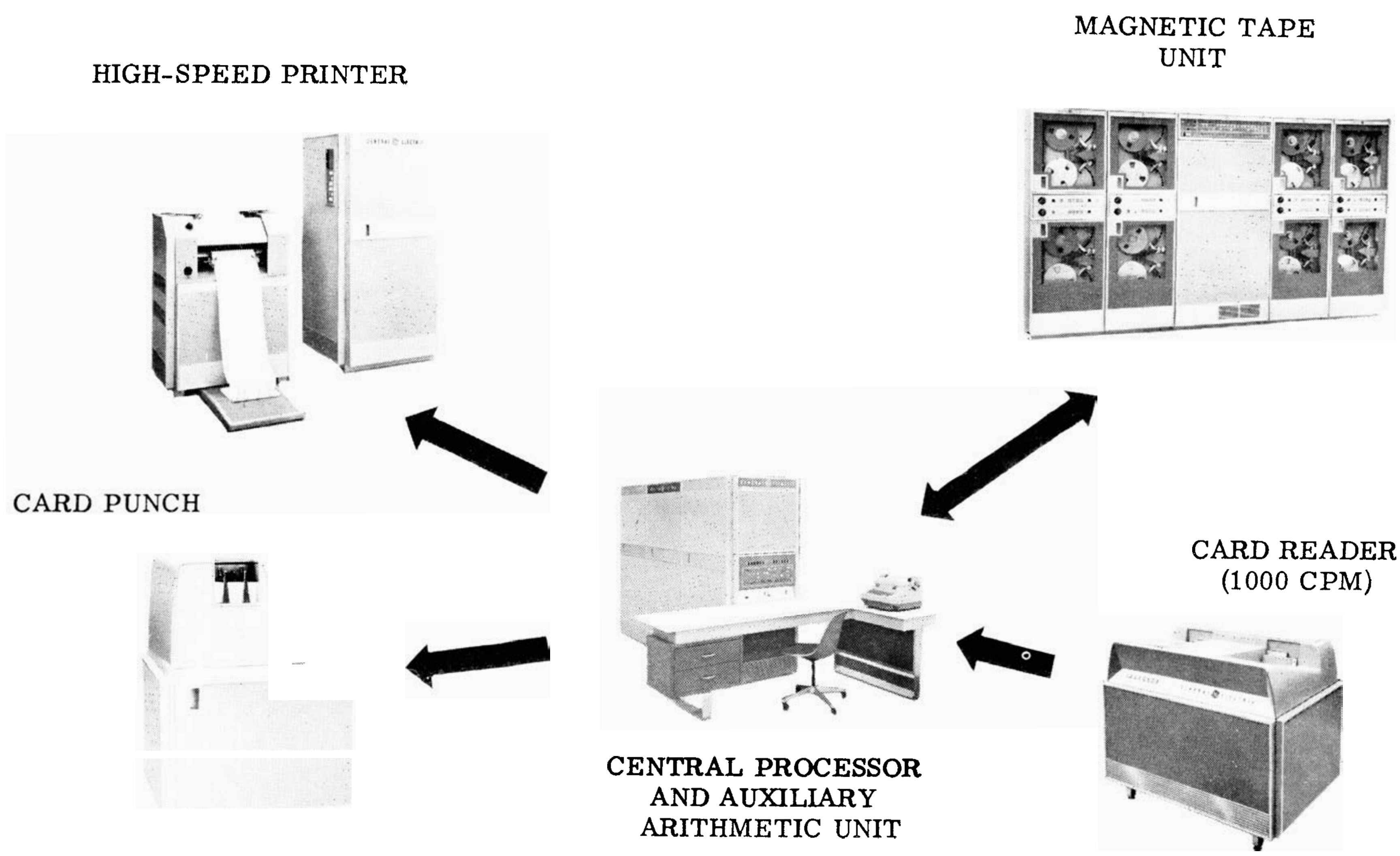
GAP -- a fast, compact, machine-oriented assembler

Standard report generators, sort/merge routines, BRIDGE (an operating system), GE-235/CPM (a major network analysis technique), and other specialized programs and routines are also available.

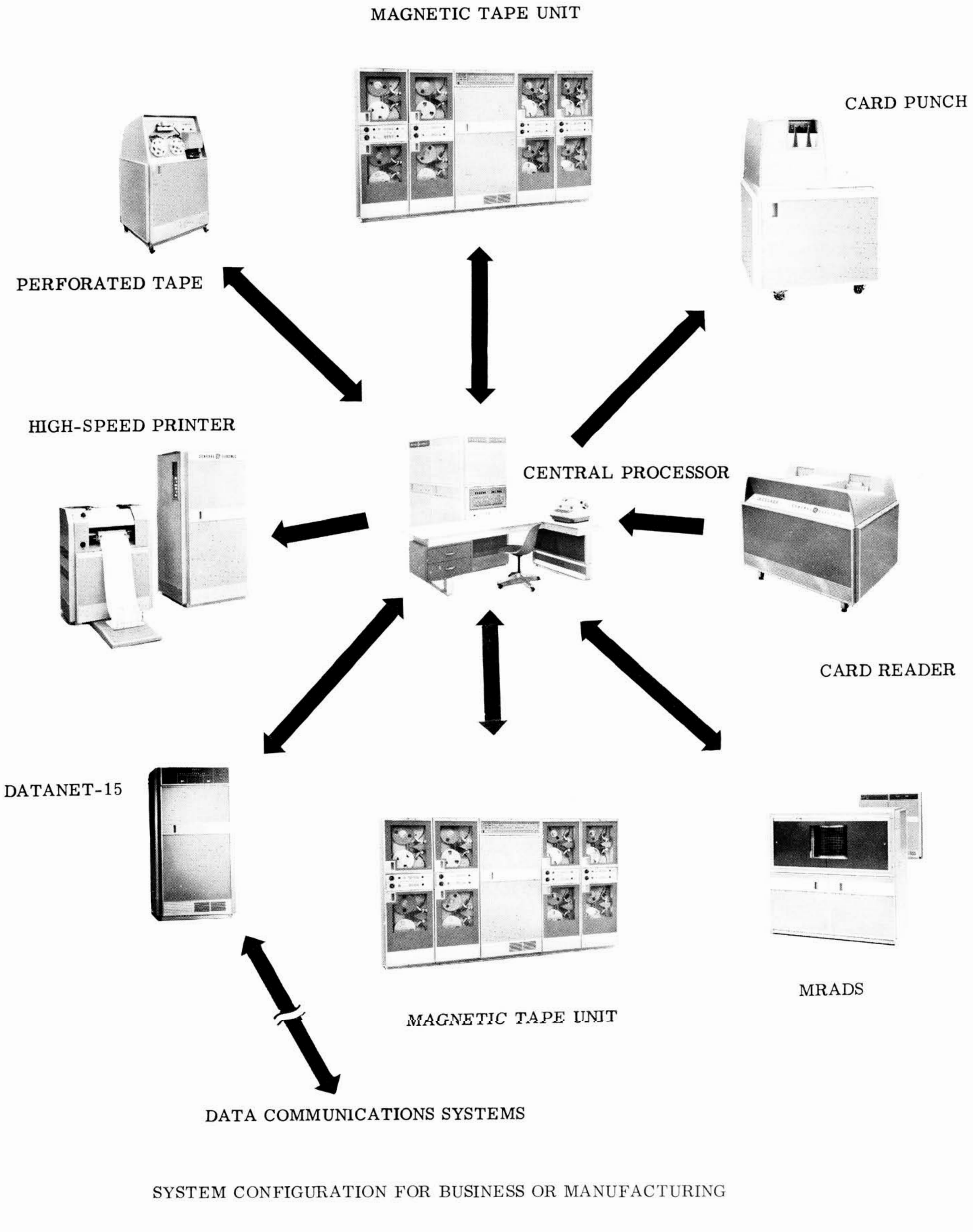
Thus, the GE-235 provides all the tools for effective management decision-making, for fast and economical solution of data processing and scientific problems, and for potential growth in desired areas. The characteristics and capabilities of this new member of the GE-200 Series are fully described in this manual. However, detailed information for operating and programming the system is in separate manuals on these subjects.



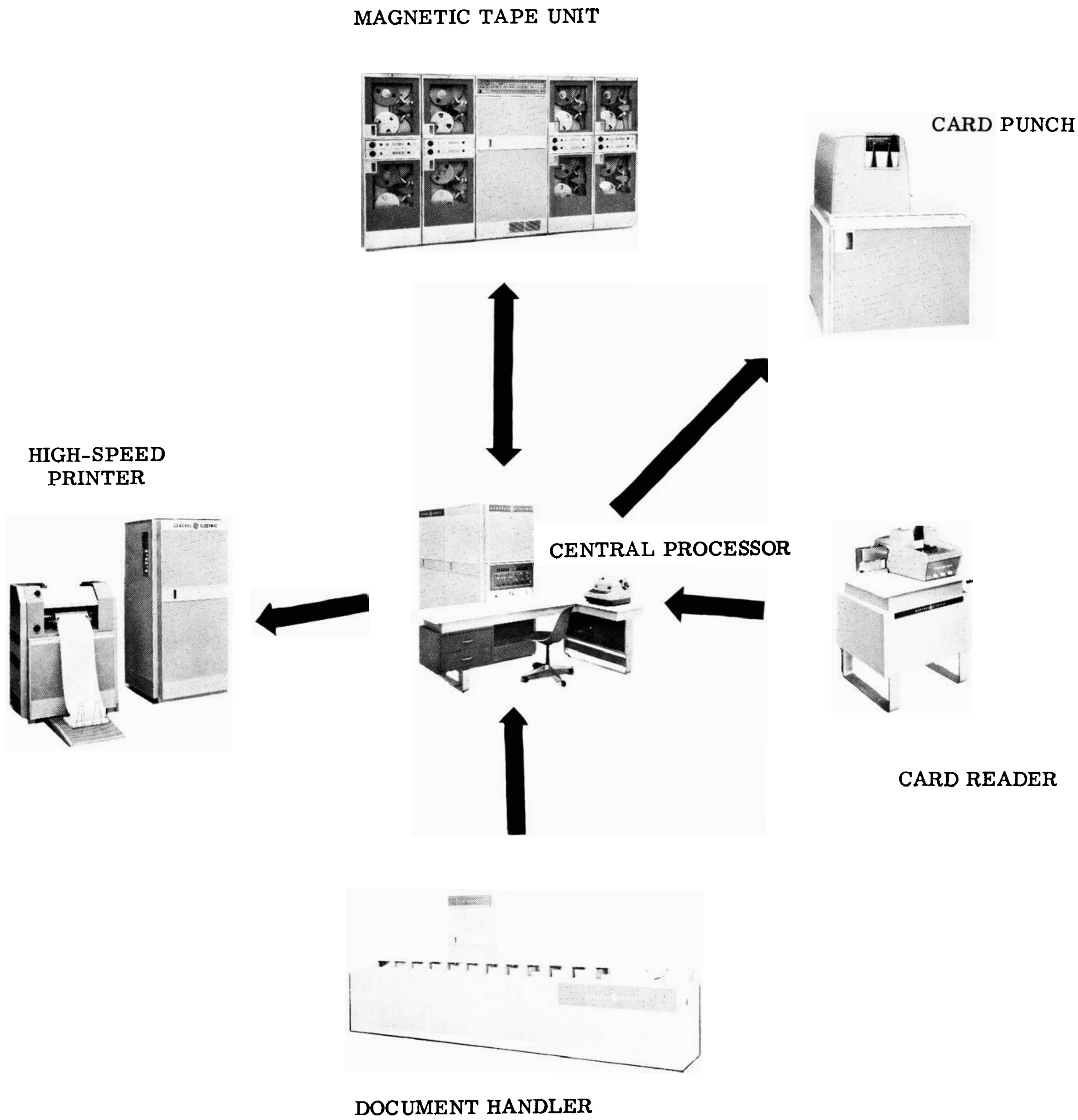
SYSTEM CONFIGURATION FOR ENGINEERING CALCULATIONS OR REPORT GENERATION



SYSTEM CONFIGURATION FOR SCIENTIFIC CALCULATIONS OR DATA RETRIEVAL AND REDUCTION



SYSTEM CONFIGURATION FOR BUSINESS OR MANUFACTURING



SYSTEM CONFIGURATION FOR BANKING

PROGRAMMING AIDS

The General Electric Computer Department has developed a large library of programming aids to help the programmer communicate with the GE-235 and simplify the task of producing useful results from the computer. This section describes some of the available programming tools: compilers, generators and special programs designed to enhance the use of the GE-235 information processing system.

GECOM, THE GENERAL COMPILER

The General Compiler (GECOM) System introduces a fresh, versatile approach to computer communication. This exclusive General Electric product makes available in one package both proved and newly developed programming techniques. GECOM accepts many languages, so problem statements may be written in familiar terminology. The source languages available to the General Compiler are broad and comprehensive.

GECOM will process English language sentences (COBOL-type statements), algebraic expressions (ALGOL-type statements), structured decision tables (TABSOL), and a language for report generation. The user may select only that portion of the system applicable to his needs, using any combination of the language features for any specific program run. Because the machine coding is derived directly from the logic of the problem statement, program check-out on the GE-235 may be done at the logic level.

Because GECOM problems are written in familiar languages, they can be more easily read and understood. In addition, program format provides a high degree of standardization. The selected approach allows the user to accommodate the more important common coding languages and still incorporate later changes conveniently. Several distinct advantages over manual programming methods can be realized.

GECOM automatically produces a documented record of the program it produces. A permanent record of the program, in its original source language form and with a detailed listing of its transformation to machine instructions, is available for reference, revision, or augmentation.

Because plans call for implementing GECOM on the General Electric family of general-purpose computers, programming conversion costs are reduced as installations outgrow their present computer equipment.

Using familiar language sharply reduces personnel training time and expense. Manual coding is eliminated and debugging cut to a minimum. Thus, a machine program may be produced quickly and efficiently.

COBOL came into being as a result of a conference on Data Systems Languages sponsored by the U. S. Department of Defense. Computer manufacturers and users developed the language called COBOL (COmmon Business Oriented Language) to achieve standardization of data processing languages. COBOL reduces programming effort and achieves a more effective utilization of computers. The language first available with the General Compiler is based primarily on COBOL, which satisfies the needs of the broadest spectrum of data processing applications. COBOL is so close to English syntax that it can easily be read and understood by management, systems, and accounting personnel. As a result, close coordination between management and computer application is both practical and efficient.

COBOL is well suited to creating and processing information contained in data files. In contrast, ALGOL provides an excellent means for expressing the mathematics and logic associated with scientific applications.

<u>ALGOL</u> was developed by an international group prompted by a growing interest in a standardized notation for numerical methods for computers.

ALGOL (<u>ALGO</u>rithmic <u>L</u>anguage) has proved to be far superior to any of its predecessors and has enjoyed the first widespread acceptance and respect accorded a computer language. ALGOL notations are gaining acceptance internationally in numerical methods, text-books and university classes.

TABSOL, the language of decision making, resulted from a need for a language that could solve an unwieldy number of sequential decisions, without involving extensive data file processing or profound mathematics.

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GENERAL COMPILER SENTENCE FORM

PROGRAM: SAMPLE DECISION TABLE
PROGRAMMER: COMPUTER: DATE: PAGE:

```
SEQUENCE
NUMBER
     5  PROCEDURE DIVISION.
    10      OPEN INPUT MASTER~FILE.
    15  GET~RECORD. READ MASTER~FILE RECORD IF END FILE GO TO END~RUN.
    20      IF FEMALE GO TO GET~RECORD.
    25      EXPERIENCE = 61 - YR~EMPLOYED + PREV~EXP.

    30  TABLE EXAMPLE. 3 CONDITIONS 2 ACTIONS 5 ROWS.

    35   LEVEL EQ  EXPERIENCE       TITLE                        I  GO TO
    40      6          EQ 2         PROGRAMMER                   1  TYPE~OUT
    45      7          EQ 3         PROGRAMMER OR ANALYST        2     "
    50      8          GR 3         ANALYST                      3     "
    55      9          GR 4         ANALYST OR SR. ANALYST       4     "
    60      10         GR 4         SR. ANALYST                  5     "

    65      GO TO GET~RECORD.
    70  TYPE~OUT. WRITE DEPARTMENT NAME TITLE LEVEL EXPERIENCE ON TYPEWRITER.
    75      TOTAL(I) = TOTAL (I) + 1.
    80      GO TO GET~RECORD.
    85  END~RUN. CLOSE MASTER~FILE.
    90      WRITE TOTAL(1) TOTAL(2) TOTAL(3) TOTAL(4) TOTAL(5) ON TYPEWRITER.
    95      STOP "END RUN".
```

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SAMPLE TABSOL TABLE

TABSOL

LEVEL	EXPERIENCE		1	GO-TO
6	EQ 2	PROGRAMMER	1	TYPE-OUT
7	EQ 3	PROGRAMMER OR ANALYST	2	TYPE-OUT
8	GR 3	ANALYST	3	TYPE-OUT
9	GR 4	ANALYST OR SR-ANALYST	4	TYPE-OUT

TABSOL depicts, by means of tables, the relationships of logical decisions that are written in terms of the conditions to be satisifed and the subsequent action to be taken. The TABSOL structure provides a readable, understandable table of decisions.

TABSOL encompasses both scientific and business applications. GECOM accepts COBOL and ALGOL-type statements within the framework of the table, thus providing an even more efficient method for stating the logic of complex information systems.

The GECOM Report Writer is an extension to the General Compiler that simplifies the programming of business reports. Readily understandable program documentation and ease of preparation of new and revised report programs are realized by use of this tool.

In brief, the Report Writer performs any or all of the following functions:

- Prints report headings once at the beginning of the report
- Prints report footings once at the end of the report
- Maintains page control by line count and or skip to a new page at specified line printings
- Maintains line spacing on the page
- Prints page headings at the top of each report page
- Prints page footings at the bottom of each report page
- Numbers pages
- Issues detail or body lines of the report
- Accumulates detail field values conditionally or unconditionally to one or more levels of total
- Counts detail lines and/or detail conditions to one or more levels of total

- Detects control breaks at one or more levels so as to:

  a. Control the tabulation procedure
  b. Issue logical control totals
  c. Issue logical control headings

- Edits data fields for reporting (for example, comma, decimal point, and dollar-sign insertion and zero suppression)

The COBOL-61 to GECOM Translator converts programs described in COBOL-61 language into language acceptable to GECOM. The source language of the basic compiler is based in part on COBOL-60. The translator enables GECOM to provide for additional functions defined in COBOL-61 specifications.

FORTRAN

FORTRAN II Compiler

Using this compiler with the GE-235, a source program written in the language of FORTRAN II, a scientific compiler, will produce an assembled program ready for use.

FORTRAN II Compiler With Card Input-Output

This compiler will compile a FORTRAN II source program on a GE-235 system with a minimum input-output configuration. The full FORTRAN language is not implemented in this compiler (magnetic tape operations, for example, are omitted).

ZOOM

Simplicity and flexibility of coding are principal features of the macroassembler called ZOOM (in some respects a compiler). The simplicity of ZOOM coding is illustrated by the fact that the programmer writes algebraic expressions with such ordinary symbols as the plus, minus, and equal signs. Since they are easily read, the expressions are easily and quickly checked for errors.

ZOOM translates these algebraic expressions into near optimum GAP coding. To the programmer who has a working knowledge of GAP, ZOOM allows for more condensed and readable symbolic programs and produces near optimum object programs. Input is punched cards with combinations of GAP coding and ZOOM statements; output can be punched cards, magnetic tape, or printer listings.

WIZ

Engineers and other users of the GE-235 who are not primarily programmers will find the WIZ System a simple, easy-to-use algebraic compiler. The compiler translates source programs written in the simple WIZ language, using ordinary mathematical symbols, into GE-235 object programs ready to run. WIZ produces GE-235 instructions on cards at a rate of 500 to 700 instructions per minute. WIZ makes it easy for the user to perform either simple or complex calculations and print the results in edited form.

WIZ works with both floating point and fixed point numbers and handles typical algebraic and trigonometric problems quickly and easily. Modification I permits use of paper tape as well as punched cards. Use of the optional AAU with the WIZ System significantly decreases the run time of the object program.

GAP, THE GENERAL ASSEMBLY PROGRAM

The General Assembly Program allows the programmer to write instructions for the GE-235 computer in symbolic notation rather than in the absolute code of the computer. Mnemonic codes for each instruction are carefully chosen to provide significance to the user. Memory addresses may be assigned by using decimal notation or by using symbolic notation chosen for maximum convenience to the particular program or programmer. To extend the use of the General Assembly Program the programmer can call on various subroutines (described below) as required by the program. The General Assembly Program also provides facility for assembling of programs in either absolute or relocatable form.

A wide range of assembler (pseudo) operations are available as follows:

ALF The ALF is used to enter an alphanumeric constant in the program.

BSS The BSS is used to reserve a block of memory storage.

DDC This is used to enter a double-word decimal constant in the object program.

DEC This is used to enter a single-word decimal constant in the object program.

EJT This operation causes the printer to slew the GAP listing paper to the top of the following page.

END The END (End of Program) indicates the end of the program to be assembled.

EQO Performs the same function as the EQU operation but the operand is assumed to be an octal number.

EQU Used to over-rule the normal memory assignment performed by the assembly program.

FDC This is used to enter a floating point decimal constant in the object program. If no binary scale is specified, determines the binary scale and yields a normalized floating point number.

LOC This operation performs the same function as the ORG operation but the contents are assumed to be in octal form.

LST This pseudo-operation may be used to start the listing again after it has been suppressed by the NLS.

MAL This pseudo-operation can be used to specify from 1 to 9 words of alphanumeric constants on one card.

NAL This pseudo-instruction causes any A/N constant or group of constants to be assembled in the 2's complement form.

NAM Permits a program name to be printed at the top of each page of the GAP listing.

NLS Suppresses listing of the object program during assembly.

OCT The OCT converts up to seven octal digits into a binary equivalent.

ORG ORG (Origin) is used to indicate the location of the first instruction of the program.

PAL This pseudo-operation can be used to specify from 1 to 9 words of alphanumeric constants on one card. The last word generated will have the sign set to terminate a print line.

PLD The pseudo-operation PLD will cause the assembly program to punch loader cards. When the PLD pseudo-operation is encountered, all cards from that point to the end of the assembly will be punched in loader format.

REM The REM programmer's remarks immediately following are not processed by the assembly but they do appear on the final program listing.

SBR This pseudo-operation is used to call a specified subroutine master tape during assembly.

SEQ Checks the sequence number of each card against the sequence number of the previous card.

TCD Generates an instruction that transfers control to the location specified in the operand field, at execution time; however, does not indicate end of assembly.

ZXX The ZXX pseudo-operation is used to set the operation bits of the assembled instruction to any desired configuration. The operand can be decimal or symbolic, and indexing is optional. In use, a Z is placed in column 8 with the two octal digits (XX) desired as an operation code in columns 9 and 10.

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225 GENERAL ASSEMBLY PROGRAM CODING SHEET

PROGRAMMER | PROGRAM: SAMPLE GAP CODING | DATE | PAGE OF

	Symbol (1–6)	Opr (8–10)	Operand (12–19)	X (20)	REMARKS (31–75)	Sequence (76–80)
1						
2						
3	INPUT	SPB	READ	3	CALL FOR NEXT INPUT RECORD	
4		LDA	RCODE			
5		BZE			IF RECORD CODE IS ZERO,	
6		BRU	INPUT		GO TO READ NEXT RECORD.	
7		LDA	TOTAL			
8		ADD	SALES			
9		STA	TOTAL		ACCUMULATE SALES TOTAL	
10		DLD	ACCT#			
11		DSU	SPEC#			
12		BNZ			IF ACCOUNT # IS NOT SPECIAL,	
13		BRU	NORMAL		GO TO NORMAL PROCESSING.	
14						
15						
16						
17						
18	TOTAL	DEC	0		SALES TOTAL STORAGE	
19	SPEC#	ALF	ABC		SPECIAL ACCOUNT # CONSTANT	
20		ALF	001			
21						
22						
23	NORMAL				START OF NORMAL PROCESSING	
24						
25						

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SAMPLE GAP CODING

SUBROUTINES, SERVICE ROUTINES AND BRIDGE II

Subroutines

Subroutines are designed to handle, manipulate, move, or sort information within the computer memory. Some of the important routines accomplish the following:

- Conversion of data from one radix to another (octal, binary, BCD)
- Word replacement
- Internal memory sort

To solve problems in scientific areas, mathematical routines are available to calculate complex functions and mathematical procedures such as:

- Sine-cosine, square root, arctangent, exponential, and logarithm
- Matrix transposition, inversion
- Scalar multiplication
- Linear simultaneous equations
- Multiple regression
- Roots of a polynomial
- Least squares polynomial fit
- Linear programming

Service Routines

The main functions of service routines are to assist in debugging programs and in simplifying operating procedures. These routines have been prepared in symbolic and/or object program form.

Service routines to perform tasks such as the following are available:

- Reset memory
- Dump memory to cards, magnetic tape, paper tape, or printer
- Load programs into memory
- Trace programs
- Compare, correct, and print out contents of tape
- Correct cards

- Scan memory
- Convert, analyze, and relativize card decks
- Reproduce cards or print out contents

Bridge II

Bridge II is a tape maintenance and run sequencing program. Upon the use of simple instructions by the programmer, Bridge II provides such functions as:

- Run collection and sequencing from cards or tape
- Tape correction of binary or symbolic programs
- Dating of magnetic tape, using either date created or current date
- Blocking of tape records
- Provision of run-to-run linkage
- Provision of altering run sequencing
- Combining of runs with subroutine or relocatable sections
- Provision for loading priority programs for use with API

The functions of Bridge II are directed by control cards that establish the run sequence for run execution. For installations that have a steady work load, use of Bridge II reduces over-all time.

SIMULATORS AND GENERATORS

Forward Sort/Merge Generator

The Forward Sort and Merge Generator produces tailored card or tape programs to efficiently sort and merge GE-235 data files. The sorts and merges are tailored at generation time according to descriptive parameters written by the user. Extensive options that allow for use of GAP coding enable users to attain complete flexibility in data format and selection and to utilize input/output media other than tape.

IBM-650 Simulator

The IBM-650 Simulator accepts IBM-650 System programs and data as input, selects and executes the required routines to simulate the IBM-650 computer commands, and produces the same results and outputs as the IBM-650 computer. An existing IBM-650 program need not be written in GE-235 language in order to run on the GE-235 computer.

Potential users of the GE-235 who have the IBM-650 computer can make a smooth transition to the GE system through the use of simulators provided by General Electric.

The simulator program achieves the following objectives without loss of accuracy or flexibility:

- Simulates the basic IBM-650 System, with 2000 words of drum memory, one 533 card reader, and punch with alphabetic device. An extended version provides the capability of core storage, index registers, floating point, and magnetic tapes. The simulator program runs on the GE-235, with at least 8192 words of memory, card reader and card punch, and typewriter.
- Control cards preceding the IBM-650 program deck define the IBM-650 plugboard wiring and console switch settings.
- Can be modified to include other IBM-650 configurations or features with a minimum of programming effort. Documentation is detailed and complete so that features peculiar to certain applications may be readily incorporated.

LGP-30 Simulator

The LGP-30 Simulator executes the Royal McBee LGP-30 system instructions in the GE-235 and produces essentially the same results and outputs as that computer.

SPECIALIZED PROGRAMS

Special needs of computer users are filled by specialized programs such as the text searching system and the GE-235/CPM program. Other programs are tailored to needs of a specific industry or user.

The Text Searching System

The Text Searching System permits retrieval of information from texts. The System consists of three principal programs. One converts texts (written in a natural or artificial language) into a form suitable for searching. A second program compiles programs to search the texts for requested symbol occurrences. The third program executes the compiled programs to search converted texts and announce the search results.

GE-235/CPM

The GE-235/CPM program adapts a major network analysis technique to the GE-235. Complex projects (such as new product introduction, large construction projects, and assembly-line planning) consisting of as many as 2100 activities and 1000 events can be analyzed by the GE-235 in minutes. Alternate schedules with optimum time and cost data, or other major project parameters, are produced as a printed output. The GE-235/CPM program can be used with GE systems having at least an 8K memory, 4 magnetic tape handlers, a card reader, and a printer.

BankPac

A series of generalized programs, called BankPac, have been tailored to the needs of commercial banks. General Electric prepares broad programs to do such jobs as updating and maintaining files, issuing reports, making customer statements, and the handling of many other normal banking functions. The user can readily add desired detailed programs. BankPac program will cover demand deposit accounting, installment loans, savings accounts, transit items, and personal trusts.

Electric Utility Routines

Groups of Electric Utility Routines were tailored to needs of individual utility companies. These programs are designed to compute load flow, optimal loading, load duration, gas flow and pressure, and short circuit conditions.

SYSTEM CONTROL OF INPUT-OUTPUT PERIPHERAL DEVICES

In a GE-235 system up to ten input-output (I/O) devices of various types may operate simultaneously with the central processor and with each other. This truly active configuration is extremely flexible and efficient; it is capable of a maximum throughput of 55, 000 20-bit words per second, plus card reading, card punching and printing. The throughput may be doubled to 110, 000 words per second, plus card reading, card punching and printing, by the addition of optional dual access I/O controller selector channels.

This performance is the result of two significant design concepts:

- Each I/O device controls itself and executes its own I/O commands.
- All I/O devices (with exception of perforated tape reader/punch and typewriter) and the central processor have access to memory on a time-sharing basis.

INDEPENDENT-CONTROL OF I/O DEVICES

The individual operation of each I/O device is determined by the controller through which it is attached to the system. The controller receives the commands appropriate to it (such commands as to start, stop, edit data, and rewind tape are typical) from the central processor and executes these commands without further instruction. Thus, having given a command to a controller, the central processor is free to continue with the succeeding item in the program.

TIME-SHARING OF MEMORY ACCESS BY I/O DEVICES

Orderly and efficient time-sharing of memory access among the central processor and I/O devices of the GE-235 is ensured by:

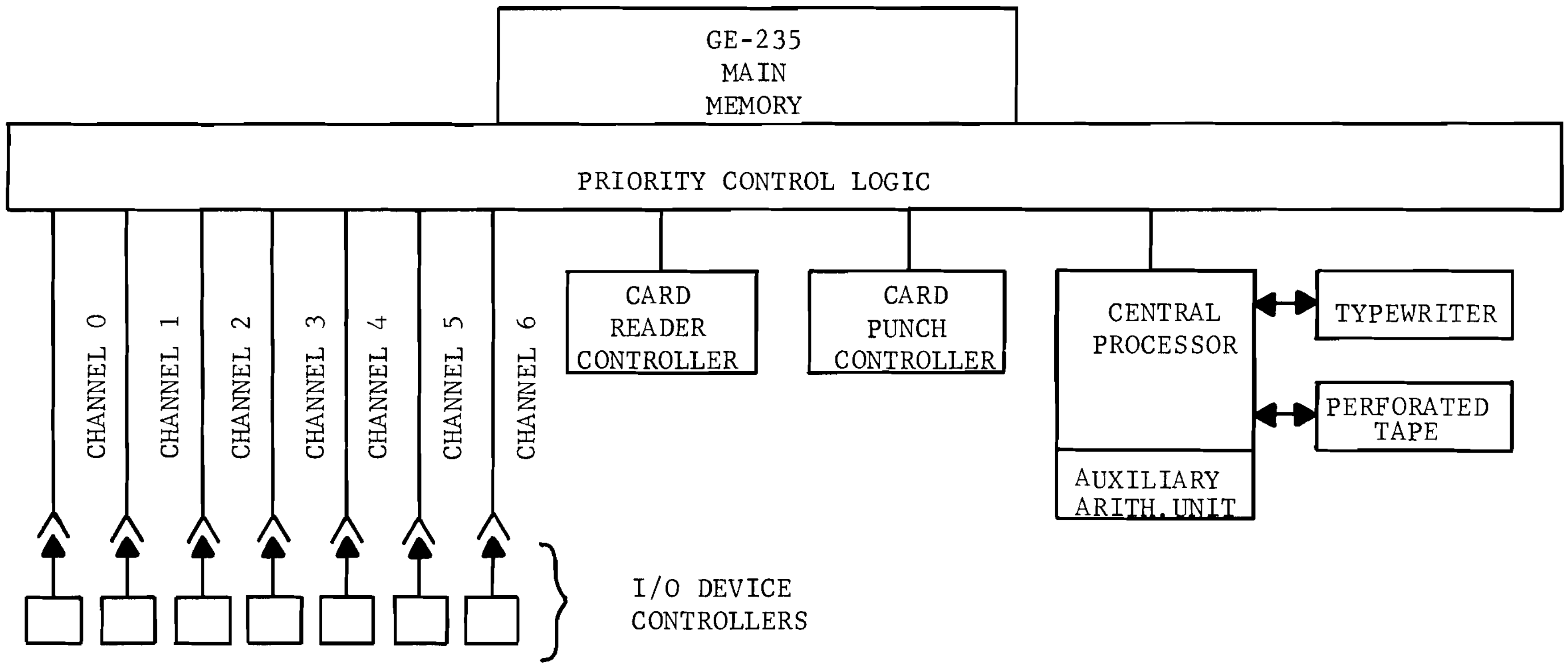
- Allowing only one system element to have access to memory at one time.
- Allowing each element access to memory on a priority schedule when it needs it and causing it to relinquish access when it does not.

These conditions are satisfied in the GE-235 by the built-in priority control logic. The success of this feature, in fact, accounts for the high efficiency and capacity of the system and the simultaneity of operation of its various elements.

Priority Control and Time-Sharing

The GE-235 priority control feature is shown schematically in the accompanying block diagram. For the numbered channels shown on the diagram, descending priority is from left to right (from 0 to 6). The channel assigned to a particular I/O device depends upon its information transfer rate - that is, its memory access requirements.

For example, a high-speed printer has a lower priority requirement than a magnetic tape unit, since a tape controller cannot wait as long for access as a printer controller can without causing timing errors. If the printer had the higher priority, it could possibly monopolize access to memory at the expense of the tape unit without increasing its effective printing speed. Thus, the most efficient operation follows from assigning the highest-priority channel to the I/O device with the highest access speed.



A recommended assignment of priorities is:

0 MRADS Controller
1 Magnetic Tape Controller or MRADS Controller
2 Magnetic Tape Controller
3 Magnetic Tape Controller
4 Document Handler Adapter
5 Datanet Controller, Document Handler Adapter or High-Speed Printer Controller
6 High-Speed Printer Controller

Examples of Time-Sharing

Three examples of GE-235 equipment configurations are shown below, with the relative amounts of time consumed in each case by I/O activity and internal computation.

- Example A

	Percent of Total Time
Read cards at 400 cards per minute	.3
Read magnetic tape at 15,000 characters per second (500-character record)	2.1
Print at 900 lines per minute (edited)	.7
Total	3.1

Percent of total time left for computing: 96.9*

- Example B

Read cards at 400 cards per minute	.3
Mass random access data storage (read and write cycle at 200 milliseconds)	.4
Print at 900 lines per minute (edited)	.7
Total	1.4

Percent of total time left for computing: 98.6*

- Example C

High-speed card reading at 850 cards per minute	.7
Read magnetic tape at 41,600 characters per second (500-character record)	4.2
Write magnetic tape at 41,600 characters per second (500-character record)	4.2
Print at 900 lines per minute (edited)	.7
Total	9.8

Percent of total time left for computing: 90.2*

* Since execution of many instructions does not require access to memory, actual computing time may range upward from the amount shown.

Overall Effect of Time-Sharing

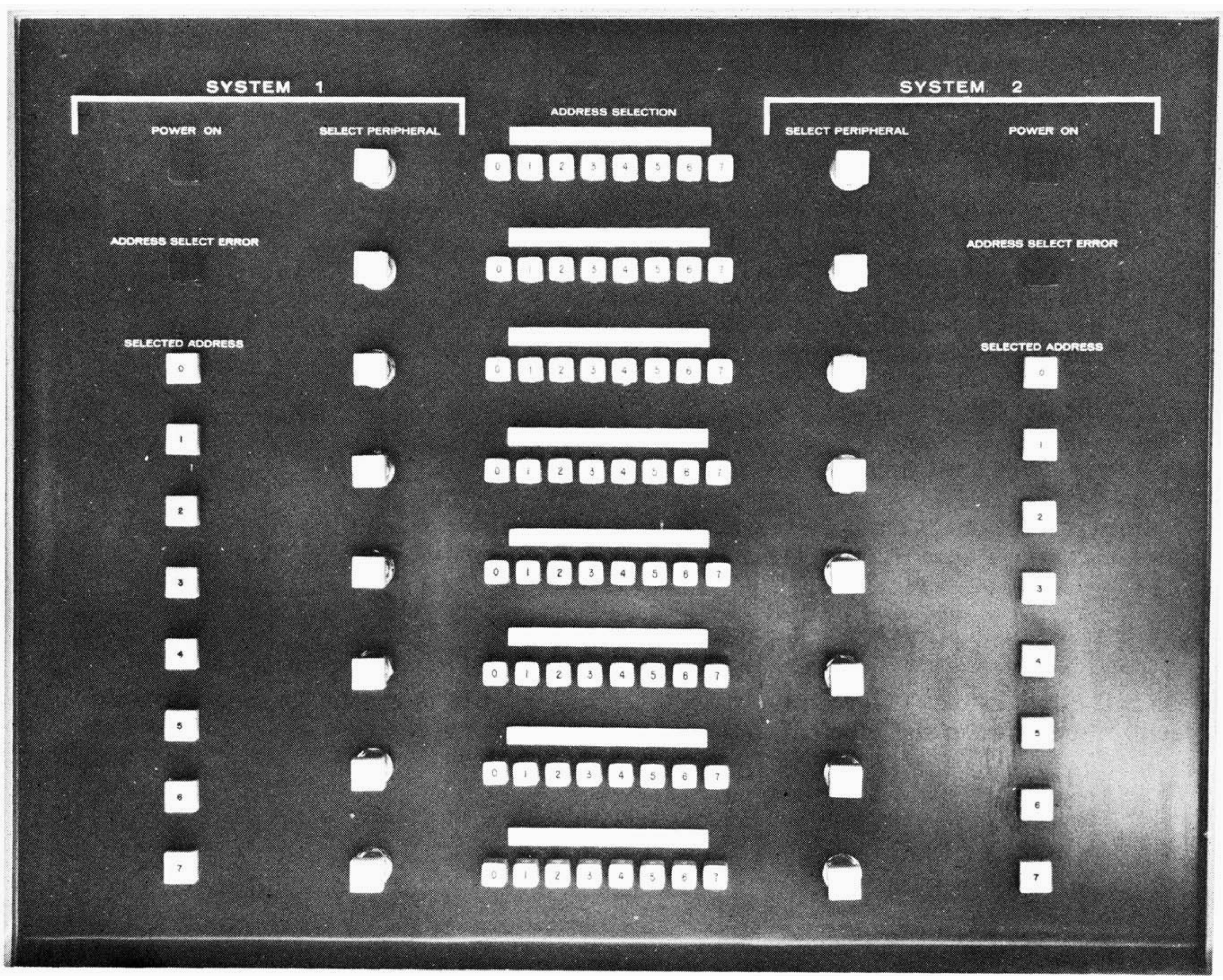
The overall effect of the GE-235 time-sharing arrangement is to create the most efficient balance between I/O operations and internal computation, regardless of the type of application.

PERIPHERAL SWITCH CONTROL UNIT

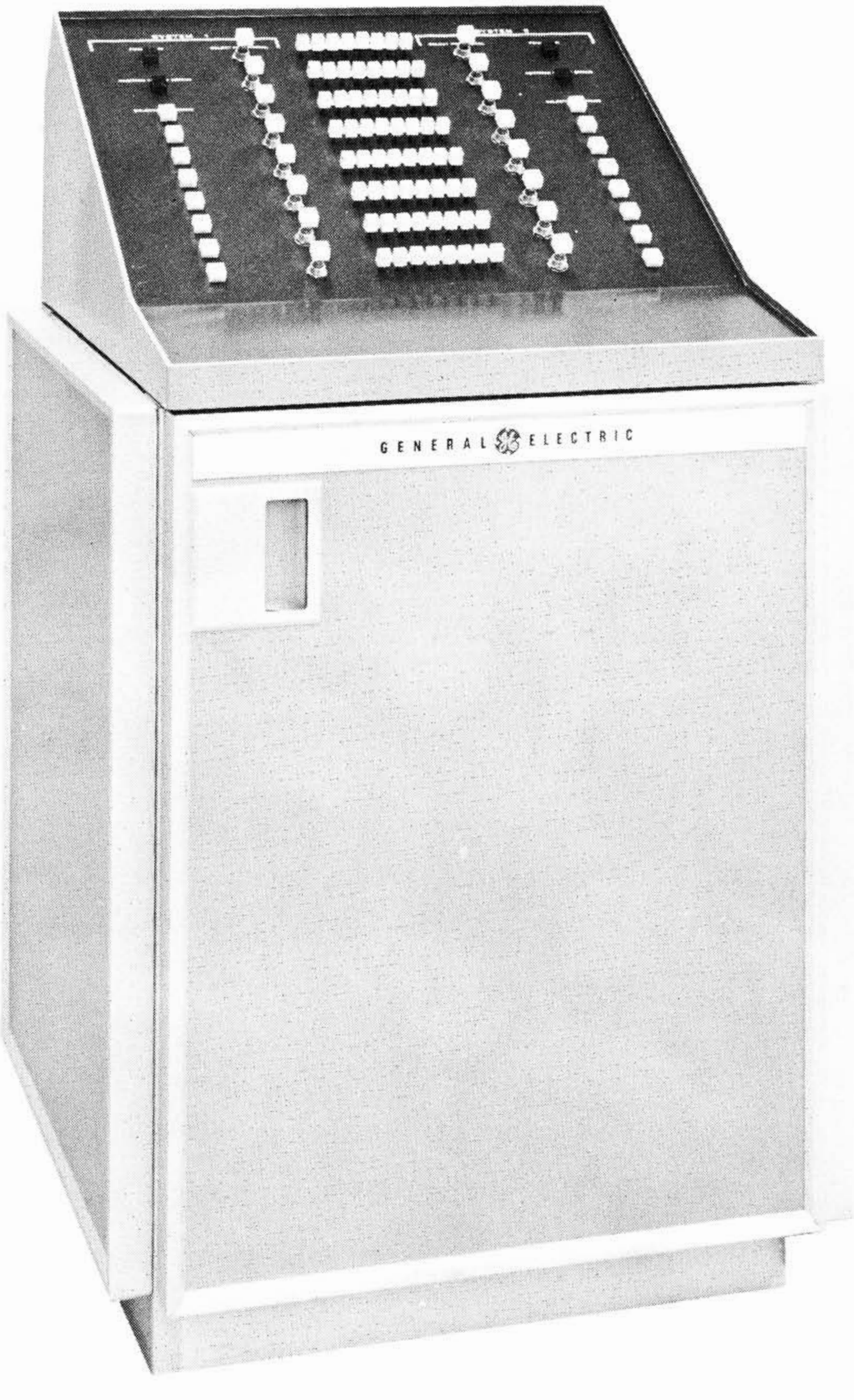
The Peripheral Switch Control Unit is an optional feature that makes possible the switching of as many as seven I/O device controllers between two GE-200 Series systems. Any I/O device normally connected to one of the numbered priority control channels may be switched by this unit. This switching capability permits optimum utilization of all peripheral equipment for multiple system operation.

The heart of the unit is the switch control console (see the accompanying illustration). The console is connected to each I/O device to be switched and to the two central processors. The console performs two functions: 1) assigns each controller to the desired central processor and 2) assigns the selected priority to each I/O device.

Two lighted pushbuttons are associated with each I/O device--one on the left of the panel (SYSTEM 1 - SELECT PERIPHERAL) and one on the right (SYSTEM 2 - SELECT PERIPHERAL). Separating each pair of SELECT buttons is a row of ADDRESS SELECTION buttons for determining the priority level of the associated I/O device. Additional circuitry actuates one of the ADDRESS SELECT ERROR indicators if more than one controller is switched to the same priority level on one system. A vertical column of eight numbered panel indicators marked SELECTED ADDRESS also appears on each side of the panel. **These indicators show which priority levels are in use** on each system.



I/O DEVICE SWITCH CONTROL UNIT CONSOLE PANEL



I/O DEVICE SWITCH CONTROL UNIT CONSOLE

CENTRAL PROCESSOR

Central Processor

- transistorized, single address, general purpose digital computer.
- accepts and processes information from punched cards, magnetic tape, perforated tape, magnetic ink character recognition equipment, mass random access data storage, data communications systems and other peripheral equipment.
- provides output to magnetic tape, punched cards, perforated tape, high speed printer, mass random access data storage, data communications systems and other output media.

Control Console

- provides for complete operator control and communication with the system.
- displays contents of the significant registers and provides control signals to the operator for the effective monitoring of system operations.

Console Typewriter

- accepts instructions from the operator.
- prints instructions to the operator.
- monitors system operations.
- prints direct output from the central processor.

MAGNETIC CORE MEMORY

The memory portion of the Central Processor is the immediate-access storage element for the GE-235 system. Both the data to be processed and the controlling instructions are held in memory and are called for by the control unit as required.

The memory is composed of magnetic cores .050 inch in diameter; each core is capable of storing one unit of information, referred to as a bit. The basic unit of memory storage is the "word" -- each word consisting of 20 bits plus a parity check bit. Each word has its own unique address.

The size of the basic memory is 4096 words. The memory design allows for an expansion to an 8192-word memory or to a 16,384-word memory without the necessity of expensive retrofits. The 16,384-word memory is divided into two groups of 8192 words each, referred to as the upper bank and the lower bank.

Minimum instruction word access and execution time is 6 microseconds. A data word transfer to or from memory, including the instruction word time, is accomplished in 12 microseconds; a double word transfer is made in 18 microseconds. The transfer of words to and from memory are made in one-word parallel form; that is, the word bits are transferred simultaneously.

Internal checking is accomplished by generating and storing a parity bit when a word is transferred to memory, and by recomputing and verifying that parity bit when the word is read from memory. The effect of a parity error may be controlled to meet the needs of the application by console STOP/RUN switch operation.

WORD FORMATS

The GE-235 can process data in either binary or alphanumeric form. This feature permits both modes of operation to take advantage of the particular characteristics of a given application.

Alphanumeric (BCD) Words

When cards punched in Hollerith code are used as computer input, the information contained in each of the 80 columns is automatically converted into a six-bit binary-coded-decimal (BCD) character. Thus, 3 alphanumeric characters occupy 18 of the 20 bit positions of an alphanumeric data word. Double length word operations permit the automatic handling of six alphanumeric characters with a single instruction. These convenient word sizes eliminate the need for elaborate partial word facility. Information must be in the BCD format prior to printing or typing.

The word below illustrates how 3 random characters are represented in a six-bit (BCD) format within one word:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	0	0	1	0	0	0	1	0	1	1	0	1	1	0	0	0	0	0	1
				A						.						1			

The table below illustrates the range of alphanumeric characters which can be represented within any six bit positions within any word of storage:

Alphanumeric Character

Zone Bits	Numeric Bits													
	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1011	1100	1101	1110
00	0	1	2	3	4	5	6	7	8	9	#	@	_	=
01	+	A	B	C	D	E	F	G	H	I	.			
10	-	J	K	L	M	N	O	P	Q	R	$	*		
11	Space	/	S	T	U	V	W	X	Y	Z	,	%	[	]

GE-235 Alphanumeric Characters

Binary Words

A binary data word consists of 19 bits plus the sign bit. For example, the decimal number +49 is represented in binary form as:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1

0 = + $\quad 2^5 + 2^4 + 2^0 = 32 + 16 + 1 = +49$

Negative binary numbers are expressed in 2's complement form. For example, the decimal number -10 is represented in binary form as:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	= -10

1 = - (minus)

A 20-bit word can accommodate a range of decimal values from -524,288 to +524,287, sometimes referred to as 5-1/2 decimal digits. Double length word operations permit the efficient processing of decimal values between +274,877,906,943 and -274,877,906,944. The advantages associated with representing numeric data in the true binary format are:

Memory storage efficiency.

An effective increase in the rate with which numeric data can be transferred to and from magnetic tape.

Increased speed of arithmetic and data handling operations.

Binary and BCD information may be intermixed in memory so as to provide the most efficient mode of representing each field in each application. Subroutines are provided to convert numeric data from BCD to binary, or vice-versa.

Decimal Arithmetic

An optional Decimal Arithmetic feature of the GE-235 provides a decimal add and subtract capability without requiring BCD to binary conversion. These arithmetic operations can be performed on single decimal words of 3 digits or on double length decimal words of 6 digits. Automatic carry is provided for larger fields. The examples below illustrate how the decimal numbers +368 and +15896 would appear in memory.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	1	0	0	0
				3						6						8			

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	Word One
				0						1						5				

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	Word Two
				8						9						6				

Floating Point Arithmetic

The GE-235 Auxiliary Arithmetic Unit can be used to advantage in scientific and engineering applications where numerous floating point or double precision arithmetic calculations are required. The logic of the AAU performs double precision fixed point and floating point arithmetic more efficiently than is possible when using mathematical subroutines. However, subroutines may be preferable when floating point arithmetic is done on a limited basis.

Three modes of calculation may be performed by the Auxiliary Arithmetic Unit: unnormalized floating point, normalized floating point, and fixed point double precision operations. Addition, subtraction, multiplication, and division may be done under any of the three modes of operation. All arithmetic is performed in binary mode.

During floating point calculations, the data to be operated upon by the internal logic of the AAU comes from the main memory of the Central Processor. A floating point number occupies two words of memory storage and assumes the following format:

Word One

Bits 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Se	Exponent	Mantissa

Word Two

Bits 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Sm	Mantissa

Se = Sign of Exponent (0 = plus; 1 = minus)
Sm= Sign of Mantissa (0 = plus; 1 = minus)

The binary point is assumed to be placed before the mantissa. This format produces a binary number with a 30-bit mantissa and a binary exponent range of -256 to +255. This is approximately equal to a decimal format of a 9-digit mantissa and a decimal exponent range of -76 to +76. The use of two words allows one of the sign positions to be applied to the exponent which, in turn, allows the use of the full range of the exponent.

The word format for fixed point double precision words in memory is as follows:

Word One

Bits 0 1 ←——→ 19

S	

S = Sign of Word One is the Sign of Fixed Point Double Word

Word Two

Bits 0 1 ←——→ 19

S	

S = Sign of Word Two

Instruction Words

With the exception of certain peripheral equipment operations, a GE-235 instruction is a single-address word consisting of 20 bits. Except for branching operations, instructions are executed sequentially; the reading of the next instruction from memory occurs after the execution of the current instruction.

The basic format of the instruction word is:

Bits 0 – 4	5	6	7 – 19
DO THIS	X	X	WITH DATA LOCATED HERE

OR

Bits 0 – 4	5	6	7 – 19
Operation Code	X	X	Operand Address

Bits 0 through 4 designate the operation to be performed, bits 5 and 6 indicate whether the instruction is to be automatically modified (indexed), and bits 7 through 19 indicate the operand address.

Because the five bit positions allowed in the instruction word for the operation code can define only 32 operations, additional bit positions are required to define the more than 300 instructions in the repertoire of the GE-235. This is achieved by using bit positions in the operand address field for instructions that require only a limited portion of that field.

REGISTERS

With the exception of shift instructions, all information transfers between Central Processor registers, between the registers and memory, and between the registers and the adder occur in parallel. That is, all 20 bits comprising words in transit or being operated upon arithmetically are transferred at the same time.

A Register

The A register is a 20-bit register that serves as the accumulator for the Central Processor. It performs this function by holding:

The augend during addition.

The sum after addition.

The minuend during subtraction.

The result after subtraction.

The most significant half of the product after multiplication.

The most significant half of the dividend before division.

The quotient after division.

The most significant half of a double word after the execution of all double length instructions.

The word to be shifted during various shift instructions.

The word transferred to or from memory or another register or to be modified in some way during the execution of various data transfer instructions.

The word on which tests are performed during the execution of branch instructions.

Q Register

The Q register is a 20-bit register which holds the multiplier during multiplication and the remainder after division and acts with the A register to form a 38-bit (plus a sign bit) accumulator during the execution of double word operations. When double word instructions are used, the least significant half of the double word is automatically transferred into the Q register through the A register. Briefly, the functions of the Q register are:

Holds the multiplier during multiplication.

Holds the least significant half of the product after multiplication.

Holds the least significant half of the dividend before division.

Holds the remainder after division.

Holds the least significant half of a double word after the execution of all double length instructions.

Shifts in conjunction with the N and A registers in special shift instructions.

N Register

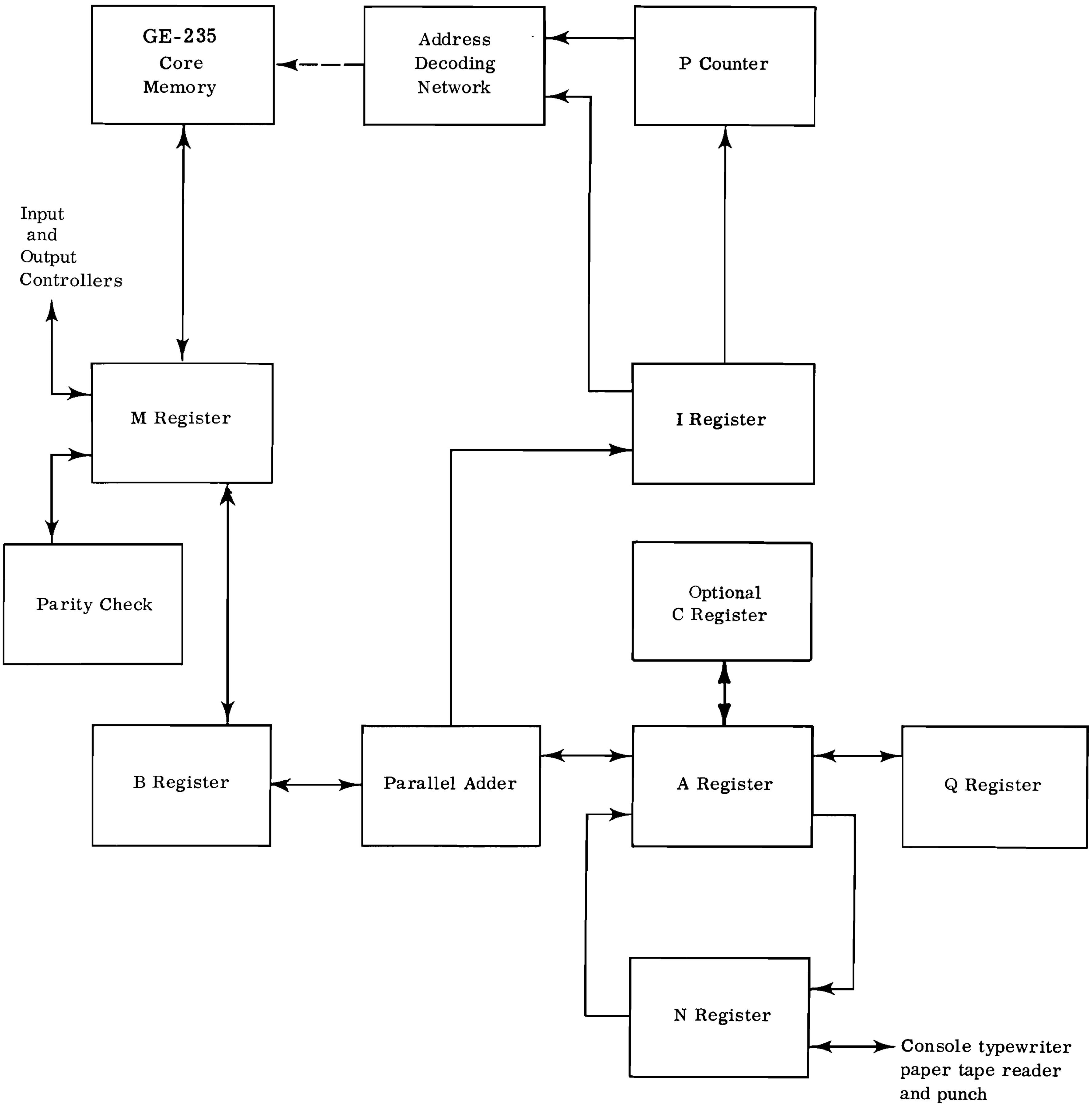
The N register is a 6-bit register which is used as a single character (BCD) buffer between the computer and the typewriter and the perforated paper tape reader and punch. Information is transferred directly between the N register and the A register.

I Register

The I register is the instruction register. It contains the 20 bits of an instruction word during execution of a computer command. While instructions are being processed, bits 0 through 4 indicate the operation to be performed and bits 5 and 6 control the indexing of instructions when specified by the program. During the execution of instructions involving reading an operand from memory (and after appropriate indexing has taken place), bits 5 through 19 contain the memory location of the operand.

Index Words

Index words are locations in memory (0000, 0001, 0002, 0003) reserved for use as counters or for the automatic modification of instructions in the I register when specified by the program. Unlike GE-235 registers, the index words are integral parts of memory and not separate physical storage devices. An optional feature adds 31 index groups of 4 locations each, giving a total of 128 index words.



GE-235 REGISTER RELATIONSHIPS - BLOCK DIAGRAM

P Counter

The P counter is a 15-bit sequence control counter that contains the memory address of the next instruction to be executed. The contents of the P counter are incremented by one after the current instruction has been selected from memory and placed in the I register, so that the P counter normally indicates the address of the next instruction in sequence. The contents of the P counter can be set from the I register during the execution of branching instructions specified by the program.

M Register

The M register is a 21-bit register that acts as an input-output buffer between the magnetic core memory and the Central Processor or peripheral equipment. When a word enters the M register from the Central Processor or punched card equipment for recording in memory, a parity bit is computed and 21 bits are stored in memory. Peripheral controllers that are connected through the numbered priority control channels generate a parity bit which is checked in the M register prior to the storage of the 21-bit word in memory. When a word is read from memory into the M register, parity is again computed and the new parity bit is compared with the one already existing to ensure accuracy of data transfers.

Adder

The adder of the Central Processor is a high-speed, parallel, binary adder network that executes the calculations specified by the instruction code in the I register during arithmetic operations.

Real Time Clock

The Clock, or C register, is a 19-bit register (there is no sign bit). While power is applied to the Central Processor, the C register is automatically incremented by a binary one every sixth of a second. When the count reaches 518,400, the decimal equivalent of 24 hours in sixths of a second, the C register is automatically reset on the next increment to all zeros and starts counting again.

The real time clock is loaded from the A register, and its contents can be read by transferring them to the A register. The clock can be set or read either by program or by manually inserted instructions.

AUXILIARY ARITHMETIC UNIT

The addition of the GE-235 Auxiliary Arithmetic Unit (AAU) extends the arithmetic capability of the GE-235 system. This device, with built-in logic, facilitates floating point and double precision arithmetic through its increased capacity and the speed with which it computes. The Auxiliary Arithmetic Unit contains two 40-bit registers, AX and QX, which correspond functionally to the A and Q registers in the Central Processor. Eighty bits permit the unit to add, subtract, multiply and divide extremely large numbers represented in either fixed or floating point format. At the option of the programmer, the unit functions in three modes: normalized floating point, unnormalized floating point, and fixed point computations. Underflow and overflow conditions are checked by means of programmed interrogation.

The Auxiliary Arithmetic Unit is not a peripheral device; it is an extension of the basic arithmetic unit of the Central Processor. All peripheral operations may occur concurrently with the use of this device.

When data in the two-word floating point format enters the Auxiliary Arithmetic Unit, it is converted into one 40-bit word and stored in the AX register. (Number designations for bits in the AAU start with number 1 rather than 0 as used in memory.) The word exists in the 40-bit AX register as:

Bits 1	2 — 9	10 — 20	21	22 — 40
Se	Exponent	Mantissa	Sm	Mantissa

Se = Sign of Exponent
Sm = Sign of Mantissa

The QX register is an extension of the AX register. It also consists of an eight bit exponent with sign and a thirty bit mantissa with sign. The value of the exponent of the QX register is the value of the AX register minus 30.

When data in the fixed point double precision format enters the Auxiliary Arithmetic Unit, the two words from memory (Y and Y + 1) are converted into one 40-bit word and stored in the AX register. The word exists in the 40-bit AX register as:

Bits 1	2 — 20	21	22 — 40
S	Y	S	Y+1

S = Sign

An instruction for the Auxiliary Arithmetic Unit is contained in one 20-bit word identical to the format of Central Processor instructions.

ADDRESS MODIFICATION (INDEXING)

The GE-235 is capable of automatic address modification under program control. This is achieved through the use of the special index words in memory locations 0001, 0002, and 0003. Memory location 0000 is not used for address modification, but it can operate as a counter.

Thirty-one additional index word groups are available as an optional feature. Each group contains four index words; the first word may be used as a counter, the other three words may be used either as counters or for automatic address modification. The total of 32 index word groups (groups are numbered 0 - 31), if included in the system, occupy memory locations 0000 through 0127. Any of these locations may be used for normal storage if not required for address modification in a program. Thus, the GE-235 features a total of 96 index words for the address modification of instructions and a total of 128 index words which may be used as counters and incremented and tested by special index word instructions.

Bit positions 5 and 6 of an instruction word designate the index word to be used in modifying the operand address portion of the instruction. Binary configurations select index words as follows: 01 = location 0001, 10 = location 0002, and 11 = location 0003. Bits 00 in positions 5 and 6 indicate that no modification is to be performed. If the additional 31 index word groups are available, an instruction is provided to allow the selection of any one of the 32 groups at any point in the program.

If an instruction in the I register calls for automatic address modification, an extra word time (6 microseconds) is required to accomplish the operation.

The sequence of events in an automatic address modification is:

The instruction to be executed is read into the I register.

Bits 5 through 19 of the designated index word and bits 7 through 19 of the I register are added together and the result replaces bits 5 through 19 of the I register. Bits 0 through 4 of the I register are unchanged.

The modified instruction in the I register is executed.

The original instruction in memory is not changed.

INSTRUCTION REPERTOIRE

The descriptions on the following pages are those of instructions which may be completely executed by the Central Processor without assistance from any of the other system units. Descriptions associated with peripheral units may be obtained elsewhere in the manual following the description of each peripheral device. Instructions in this section have been grouped under the following headings:

Data Transfer
Arithmetic
Shift
Branch
Address Modification
Auxiliary Arithmetic Unit
Real Time Clock

Each description gives the mnemonic operation code for the instruction and an indication of whether a memory location (Y) or a constant (K) is required in the operand address portion. Some instructions do not require an operand, so for these no entry will be found under the Operand Address column. The letter X under the Index column indicates that the instruction can be indexed. Execution times are given in microseconds. The execution times include the fetching of the instruction and data.

In all instructions which involve the bringing of a word from memory, the word in memory remains unchanged. For most instructions involving the transfer of information from registers, the condition of the register after execution is unchanged.

FOR THE PURPOSES OF THIS MANUAL, THE DESCRIPTION OF EACH INSTRUCTION IS NECESSARILY ABBREVIATED. COMPLETE EXPLANATIONS WITH EXAMPLES MAY BE FOUND IN THE GE-235 PROGRAMMING REFERENCE MANUAL.

Data Transfer

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
LDA	Y	X	12	LOAD A register with the contents of Y.
DLD	Y	X	18	DOUBLE LENGTH LOAD registers A and Q with the contents of Y and Y+1.
STA	Y	X	12	STORE A register contents into memory location Y.
DST	Y	X	18	DOUBLE LENGTH STORE contents of registers A and Q into Y and Y+1.
MOV	Y		24+12N	MOVE a block of N words starting at memory location Y into another area of memory. Register A contains starting address of new area; register Q contains number of words to be moved (in 2's complement form). This instruction is an optional feature.
STO	Y	X	18	STORE OPERAND ADDRESS field of register A in the operand address field of Y.
ORY	Y	X	18	OR A INTO Y by placing a 1 bit in Y wherever register A has a 1 bit in the corresponding position.
EXT	Y	X	18	EXTRACT into A by placing a 0 bit in register A wherever Y has a 1 bit in the corresponding position.
LAQ			18	LOAD A FROM Q by transferring the contents of register Q into A.
LQA			18	LOAD Q FROM A by transferring the contents of register A into Q.
MAQ			18	MOVE A TO Q and replace the contents of A with zeros.
XAQ			18	EXCHANGE A AND Q by interchanging the contents of registers A and Q.
LDZ			18	LOAD ZERO into all bit positions of register A.
LDO			18	LOAD ONE bit into 19th bit position of register A and set the other bit positions to 0.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
LMO			18	LOAD MINUS ONE into register A by setting all bit positions to 1.
CPL			18	COMPLEMENT register A by replacing each 1 bit with 0 and each 0 bit with 1.
NEG			18	NEGATE A by replacing the contents of register A with the 2's complement.
CHS			12	CHANGE SIGN of register A by replacing 1 bit in sign position with 0 and a 0 bit in sign position with 1.
NOP			18	NO OPERATION; next instruction is executed.

Arithmetic

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
ADD	Y	X	12	ADD the contents of Y and register A algebraically; sum in A.
DAD	Y	X	18	DOUBLE LENGTH ADD the contents of Y and Y+1 and registers A and Q algebraically; sum in A and Q.
ADO			18	ADD ONE (plus one) algebraically to the contents of register A.
SUB	Y	X	18	SUBTRACT the contents of Y algebraically from the contents of register A.
DSU	Y	X	30	DOUBLE LENGTH SUBTRACT the contents of Y and Y+1 algebraically from the contents of registers A and Q; result in A and Q.
SBO			18	SUBTRACT ONE algebraically from the contents of register A.
MPY	Y	X	54-138	MULTIPLY the contents of Y algebraically by the contents of register Q, placing the product in registers A and Q.
DVD	Y	X	156-174	DIVIDE the contents of registers A and Q algebraically by the contents of Y, placing the quotient in A and the remainder in Q.

OPTIONAL DECIMAL ARITHMETIC

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SET	BINMODE		12	SET BINARY MODE, permitting arithmetic instructions to operate in the binary mode as detailed above. (When power is turned on, the computer will be set automatically in the binary mode.)
SET	DECMODE		12	SET DECIMAL MODE, permitting arithmetic instructions to operate in the decimal mode as detailed below.
ADD	Y	X	12	DECIMAL ADD the contents of Y and register A algebraically; sum in A.
DAD	Y	X	18	DOUBLE DECIMAL ADD the contents of Y and Y+1 and registers A and Q algebraically; sum in A and Q.
ADO			18	ADD ONE DECIMAL (plus one) algebraically to the contents of register A.
SUB	Y	X	18	DECIMAL SUBTRACT the contents of Y algebraically from the contents of register A.
DSU	Y	X	30	DOUBLE DECIMAL SUBTRACT the contents of Y and Y+1 algebraically from the contents of registers A and Q; result in A and Q.
SBO			18	SUBTRACT ONE DECIMAL algebraically from the contents of register A.

Shift

The shift instructions shift the contents of register A to the right or left serially either alone or with the contents of the N and/or Q registers. Twelve microseconds are required for a shift of two bit positions or less; six additional microseconds are required for each additional 3-bit shift or fraction thereof.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SRA	K	X	12+	SHIFT RIGHT A. The contents of register A are shifted right K places.
SRD	K	X	12+	SHIFT RIGHT DOUBLE. The contents of registers A and Q together are shifted right K places, with bits shifting out of A into Q.
SLA	K	X	12+	SHIFT LEFT A. The contents of register A are shifted left K places.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SLD	K	X	12+	SHIFT LEFT DOUBLE. The contents of registers A and Q together are shifted left K places, with bits shifting out of Q into A.
SCA	K	X	12+	SHIFT CIRCULAR A. The contents of register A are shifted K places to the right in a circular fashion.
SCD	K	X	12+	SHIFT CIRCULAR DOUBLE. The contents of registers A and Q together are shifted K places to the right in a circular fashion, with bits shifting out of A into Q and out of Q into A.
SAN	K	X	12+	SHIFT A AND N RIGHT. The contents of registers A and N together are shifted K places to the right, with bits shifting out of A into N.
SNA	K	X	12+	SHIFT N AND A RIGHT. The contents of registers N and A together are shifted K places to the right, with bits shifting out of N into A.
ANQ	K	X	12+	SHIFT A INTO N AND Q. The contents of register A are shifted K places to the right into both registers N and Q.
NAQ	K	X	12+	SHIFT N, A, AND Q RIGHT. The contents of registers N, A, and Q together are shifted K places to the right.
NOR	K	X	18+	NORMALIZE. The contents of register A are normalized by shifting left and eliminating leading zeros up to K places.
DNO	K	X	18+	DOUBLE LENGTH NORMALIZE. The contents of registers A and Q are normalized by a double shift left and the elimination of leading zeros in register A up to K places.

Branch

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BRU	Y	X	6	BRANCH UNCONDITIONALLY. Control is transferred to the instruction at memory location Y.
SPB	Y	X	12	STORE P AND BRANCH. The location of this SPB instruction replaces the contents of index word X and control is then transferred to the instruction at memory location Y.

The following branch instructions test to determine whether a particular internal condition is true or false. If the condition tested is true, the computer executes the next **sequential** instruction; if false, the second sequential instruction is executed.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BPL			12	BRANCH ON PLUS. Register A tested for plus sign.
BMI			12	BRANCH ON MINUS. Register A tested for minus sign.
BZE			12	BRANCH ON ZERO. Register A tested for all zeros.
BNZ			12	BRANCH ON NON-ZERO. Register A tested for not all zeros.
BOV			12	BRANCH ON OVERFLOW. Overflow indicator tested for ON.
BNO			12	BRANCH ON NO OVERFLOW. Overflow indicator tested for OFF.
BOD			12	BRANCH ON ODD. Register A tested for odd value.
BEV			12	BRANCH ON EVEN. Register A tested for even value.
BPE			12	BRANCH ON PARITY ERROR. Parity error indicator tested for ON.
BPC			12	BRANCH ON PARITY CORRECT. Parity error indicator tested for OFF.
CAB (Optional feature)	Y	X	12-24	COMPARE AND BRANCH. Register A compared algebraically with contents of Y. If contents of Y are greater, the next instruction is executed; if contents of Y and A are equal, the second sequential instruction is executed; if contents of Y are less, the third sequential instruction is executed.
DCB (Optional feature)	Y	X	12-24	DOUBLE COMPARE AND BRANCH. Registers A and Q together are compared algebraically with contents of Y and Y+1. Branching occurs in an analogous manner to the CAB instruction above.

Address Modification

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
INX	K	X	18	INCREMENT X. The constant K is added absolutely to the contents of index word X, and the result replaces the contents of X.
BXH	K	X	18	BRANCH IF X IS HIGH OR EQUAL. Contents of index word X are tested for an equal to or greater than K condition. Branching follows the normal sequence of branch instructions.
BXL	K	X	18	BRANCH IF X IS LOW. Contents of index word X are tested for a less than K condition. Branching follows the normal sequence of branch instructions.
LDX	Y	X	18	LOAD X. The contents of Y are placed in index word X.
STX	Y	X	18	STORE X. The contents of index word X are stored in Y.
SXG	Y		12	INDEX GROUP SELECT. If additional index word groups are available, this instruction selects one of the 32 possible groups. Y (00 - 31) specifies the particular group.

Auxiliary Arithmetic Instructions

AAU instructions for floating point operations assume that the operands to be acted upon are already in floating point format. The operands are put in floating point format by means of a subroutine furnished for this purpose.

Before giving an arithmetic instruction to the AAU it is necessary to set the mode of operation by one of the following SET instructions:

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SET	UFLPOINT		6	This instruction sets the format for unnormalized floating point operations.
SET	NFLPOINT		6	This instruction sets the format for normalized floating point operations.
SET	FIXPOINT		6	This instruction sets the format for double word fixed point operations.

The mnemonics for the following AAU instructions consist of the normal three alphabetics plus the tag A in GAP coding sheet column 20. For example, LAQ A moves the contents of the QX register to the AX register in the AAU while LAQ without the A tag moves the contents of Q to A in the central processor.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
LAQ	A		6	LOAD AX FROM QX. The contents of register QX are moved into AX. QX is unchanged.
MAQ	A		6	MOVE AX TO QX. The contents of register AX are moved into QX. AX is cleared to zeros.
LQA	A		6	LOAD QX FROM AX. The contents of register AX are moved into QX. AX is unchanged.
XAQ	A		6	EXCHANGE AX AND QX. The contents of registers AX and QX are interchanged.

The memory address (Y) designated in an AAU instruction, as it appears in the I register after address modification, must be greater than 0015.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
FLD	Y	X	18	LOAD AAU. Contents of Y and Y+1 are loaded into register AX.
FST	Y	X	18	STORE AAU. Contents of register AX are stored into Y and Y+1.
FAD	Y	X	24-36	NORMALIZED FLOATING POINT ADD. The floating point number in Y and Y+1 is added algebraically to the floating point number in register AX. The result is in AX in normalized form.
			24-30	UNNORMALIZED FLOATING POINT ADD. Same as normalized floating point add except the result is placed in registers AX and QX and may or may not be in normalized form.
			24	DOUBLE WORD FIXED POINT ADD. The contents of Y and Y+1 are algebraically added to the contents of register AX and the result is placed in AX as a 38 bit fixed point number.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
FSU	Y	X	30-36	NORMALIZED FLOATING POINT SUBTRACT. The floating point number in Y and Y+1 is subtracted algebraically from the floating point number in register AX. The result is placed in AX in normalized form.
			30-36	UNNORMALIZED FLOATING POINT SUBTRACT. Same as normalized floating point subtract except the result is placed in registers AX and QX and may or may not be in normalized form.
			24	DOUBLE WORD FIXED POINT SUBTRACT. The contents of Y and Y+1 are algebraically subtracted from the contents of register AX and the result is placed in AX as a 38 bit fixed point number.
FMP	Y	X	36-78	NORMALIZED FLOATING POINT MULTIPLY. The floating point number in Y and Y+1 is algebraically multiplied by the floating point number in register QX. The 60-bit product of the two mantissas is normalized. The most significant half of the normalized product is stored with its exponent in AX; the least significant half is stored in QX (the exponent 30 less than the floating point exponent in AX).
			36-66	UNNORMALIZED FLOATING POINT MULTIPLY. Same as normalized floating point multiply except the result is placed in registers AX and QX and may or may not be in normalized form.
			36-90	DOUBLE WORD FIXED POINT MULTIPLY. The contents of Y and Y+1 are algebraically multiplied by the contents of register QX, giving a 76-bit product and 4 identical sign bits. The most significant half of the product is stored with 2 sign bits in AX, and the least significant half is stored with 2 sign bits in QX.
FDV	Y	X	72-78	NORMALIZED FLOATING POINT DIVIDE. The floating point number in registers AX and QX is algebraically divided by the floating point number in Y and Y+1. The normalized quotient is stored in AX, and the remainder, which may or may not be normalized, is stored in QX.
			72-78	UNNORMALIZED FLOATING POINT DIVIDE. Same as normalized floating point divide except the quotient that is stored in AX may or may not be in normalized form.
			96-102	DOUBLE WORD FIXED POINT DIVIDE. The contents of registers AX and QX are divided by the contents of Y and Y+1. The quotient is stored in AX and the remainder in QX.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BAR	XXX	7	12	BRANCH ON AAU INTERROGATED CONDITIONS. The BAR instruction interrogates the AAU for specific conditions. The condition tested is indicated by a mnemonic placed in the operand address field and indicated by XXX in the format given here. If the condition tested is true, the computer executes the next sequential instruction. If false, the second sequential instruction is executed. BAR instructions require a 7 in GAP coding sheet column 20.
BAR	BPL	7	12	BRANCH ON AAU PLUS. Register AX is tested for a plus sign.
BAR	BMI	7	12	BRANCH ON AAU MINUS. Register AX is tested for a minus sign.
BAR	BZE	7	12	BRANCH ON AAU ZERO. Register AX is tested for all zeros.
BAR	BNZ	7	12	BRANCH ON AAU NOT ZERO. Register AX is tested for not all zeros.
BAR	BOV	7	12	BRANCH ON AAU OVERFLOW. AAU is tested for overflow indicator ON.
BAR	BNO	7	12	BRANCH ON AAU NO OVERFLOW. AAU is tested for overflow indicator OFF.
BAR	BUF	7	12	BRANCH ON AAU UNDERFLOW. AAU is tested for underflow indicator ON.
BAR	BNU	7	12	BRANCH ON AAU NO UNDERFLOW. AAU is tested for underflow indicator OFF.
BAR	BER	7	12	BRANCH ON AAU ERROR. The error indicator is tested for ON.
BAR	BNE	7	12	BRANCH ON AAU NO ERROR. The error indicator is tested for OFF.
BAR	BOO	7	12	BRANCH ON OVERFLOW HOLD ON. AAU is tested for overflow indicator ON.
BAR	BON	7	12	BRANCH ON OVERFLOW HOLD NOT ON. AAU is tested for overflow indicator OFF.
BAR	BUO	7	12	BRANCH ON UNDERFLOW HOLD ON. AAU is tested for underflow hold indicator ON.
BAR	BUN	7	12	BRANCH ON UNDERFLOW HOLD NOT ON. AAU is tested for underflow hold indicator OFF.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
ROV			6	RESET OVERFLOW HOLD. The overflow hold indicator is turned off.
RUN			6	RESET UNDERFLOW HOLD. The underflow hold indicator is turned off.
RIN			6	RESET INDICATORS. The underflow hold and overflow hold indicators are turned off.

Real Time Clock Instructions

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
LAC			18	The contents of register A are replaced by the contents of register C and the sign of register A is set to zero.
LCA			18	Bit positions 1 through 19 of register A are placed in register C.

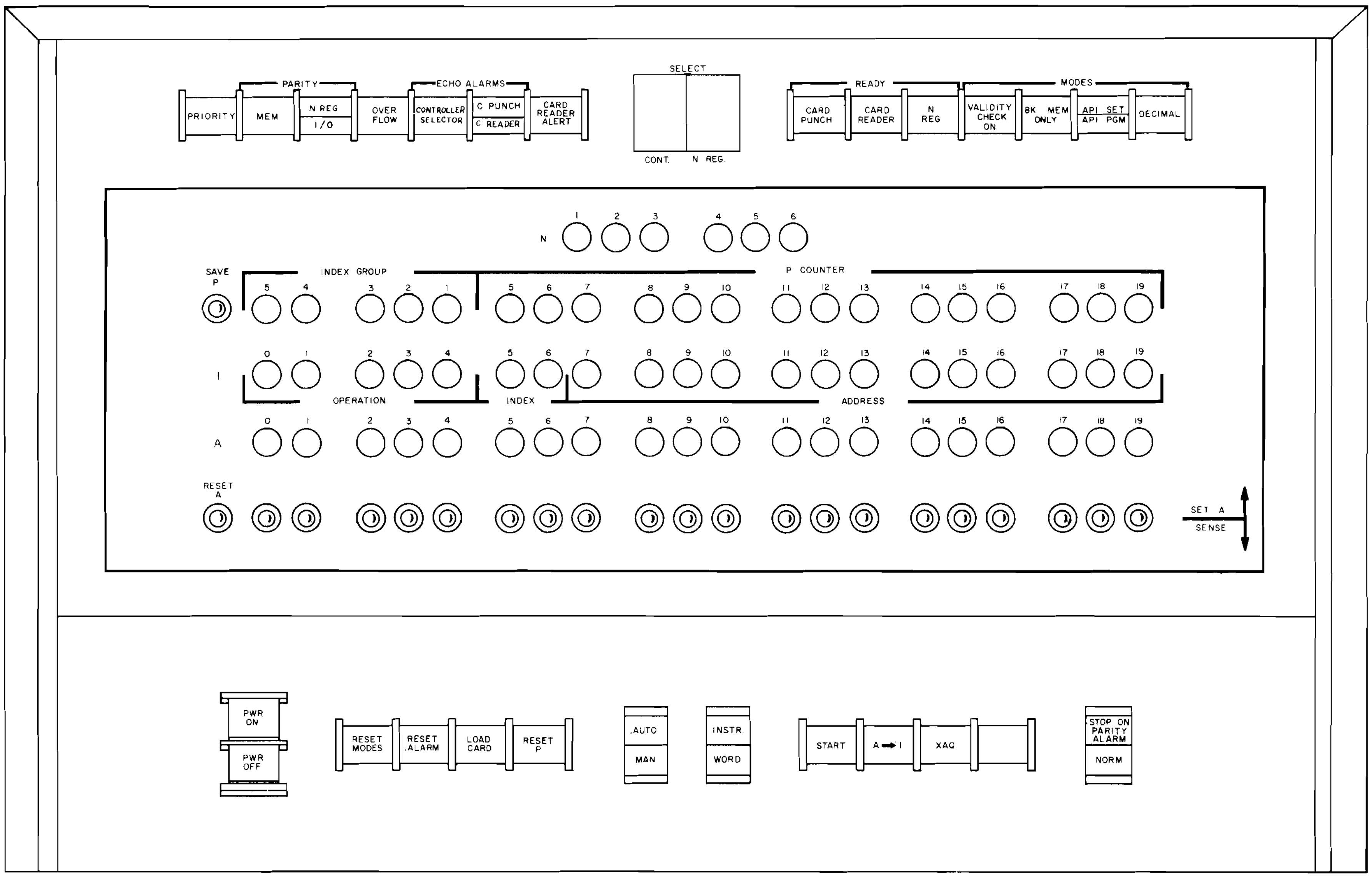
CONTROL CONSOLE

The GE-235 Control Console provides the operator with the controls and indicators necessary for direct manual and visual communication with the Central Processor. Basic alarm conditions are clearly displayed to facilitate accurate operator corrective action. The detailed contents of arithmetic, instruction and program counter registers are displayed. Changes or deletions of instructions or data can be made through convenient toggle switches.

Automatic and manual control modes allow complete operator control of programs. In the automatic mode, the computer executes instructions in the normal sequential manner. In the manual mode, the computer executes instructions in a step-by-step procedure, going from one instruction to the next under operator control.

The lower third of the console consists of the Control Panel which contains operating switches that control Central Processor power, operating mode selection, alarm and register resetting, initial program loading, and starting and stopping of computer operation.

The upper two-thirds of the Control Console is occupied by the Indicator Panel and Register Control Switches. The Indicator Panel consists of display lights for the contents of the A, N and I registers and the P counter and for the location of the current selected index word group. Toggle switches are provided to allow for the manual entry of information into the A register. In addition, various alarm and ready status indicators that are essential for proper control are provided, as well as an indicator showing the controller that is actively accessed at any given time. For Central Processors equipped with the optional AAU, additional AAU switches and indicators appear above the standard indicator panel.



CONTROL CONSOLE

INPUT/OUTPUT TYPEWRITER

The GE-235 Input/Output Typewriter can transmit input data to the Central Processor from the keyboard while simultaneously printing the data. Communication with the Central Processor during both input and output operations is through the N register. All input and output operations are programmed single-character (BCD) operations. Output is at the rate of 15 characters per second.

The typewriter keyboard has 44 data keys, a space bar and standard functional control keys. Typewriter characters include:

ALPHABETICS A THROUGH Z
NUMERIC DIGITS 0 THROUGH 9
SPECIAL CHARACTERS AS FOLLOWS:

&	-	/	#	@	:	>
?	.	⌑	<	!	$	*
]	;	△	,	%		

Functions that can be programmed are:

Space
Carriage Return
Tabulation
Print Red
Print Black
Ignore
Index

Console And Typewriter Instructions

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
RCS			12	READ CONTROL SWITCHES. Each of the 20 console control switches for register A are examined. If a switch is down (ON), a 1 bit is placed in the corresponding position of A.
TON			12	TYPEWRITER ON. The typewriter is logically connected to the N register.
TYP			12	TYPE. If the typewriter is ON, one BCD character in the N register is typed.
KON			12	KEYBOARD ON. The typewriter input keyboard is activated. Striking of a key will load the corresponding BCD character into the N register.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
OFF			12	OFF. All N register peripherals are logically disconnected from the N register, and the power supply for the perforated paper tape punch is turned off.
BNN			12	BRANCH ON N REGISTER NOT READY. The N register is tested for the not-ready condition. Branching follows the normal branch instruction sequence.
BNR			12	BRANCH ON N REGISTER READY. The N register is tested for the ready condition. Branching follows the normal branch instruction sequence.

AUTOMATIC PROGRAM INTERRUPT

Automatic Program Interrupt (API) is an optional feature designed to control the simultaneous operation of two or more unrelated programs. When the API is set by programmed instruction, the peripherals needed to process an additional program are allowed to interrupt the main program.

Information can be sent to, or taken from, a peripheral. Then, while the peripheral is operating on this information, control can be returned to the main program until the peripheral becomes "ready" to send or receive more information. The programmer can prevent the main program from being interrupted through execution of a Priority Break instruction.

The API monitors the card reader, card punch, and the controllers connected through the numbered priority control channels (magnetic tape, printer, document handler, mass random access data storage, and Datanet-15). An external off/on switch on the peripheral controller must be in the ON position before that controller can interrupt the program through the API. This switch effectively inhibits interruptions from main program peripherals. The input/output typewriter and other N register input/output devices cannot interrupt the program through the API.

Automatic-Program Interrupt Instructions

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SET	PST		12	SET PRIORITY START. The Central Processor enters the API mode, where it will remain until a SET PBK instruction is executed.
SET	PBK		12	SET PRIORITY BREAK. The Central Processor leaves the API mode and will not return until a SET PST instruction is executed.

GE-235 PUNCHED CARD EQUIPMENT

The GE-235 information processing system features two types of card readers and two types of card punch units with which to process tabulating cards.

CARD READERS

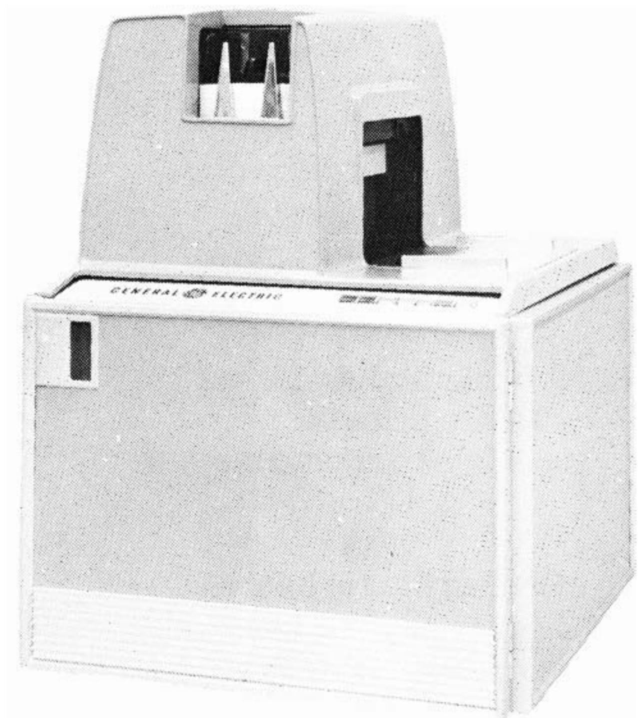
400 CARD PER MINUTE UNIT

1000 CARD PER MINUTE UNIT

- Punched cards may be read in decimal (Hollerith), 10-row binary, and 12-row binary modes.
- Card readers can operate simultaneously with central processor computation and other input/output operations.
- Cards are read serially, column by column, by photocells, providing reliable and accurate card reading in either continuous or demand type operations.
- Intermixed Hollerith and 12-row binary coded cards can be read by detecting a 7-9 punch in column one of binary cards.

CARD PUNCHES

There are two card punches available: 100 card per minute and 300 card per minute.



100 CARD PER MINUTE PUNCH

- Cards are punched in decimal (Hollerith), 10-row binary, or 12-row binary modes.
- Punching may occur simultaneously with central processor computation and operation of other peripheral units.
- Cards are punched in parallel, row by row, with all 80 columns of each row being punched simultaneously.
- Input and output bins each have a capacity of 800 cards.
- Extensive error monitoring systems assure high accuracy of data transfer to cards.

MEDIA FORMAT

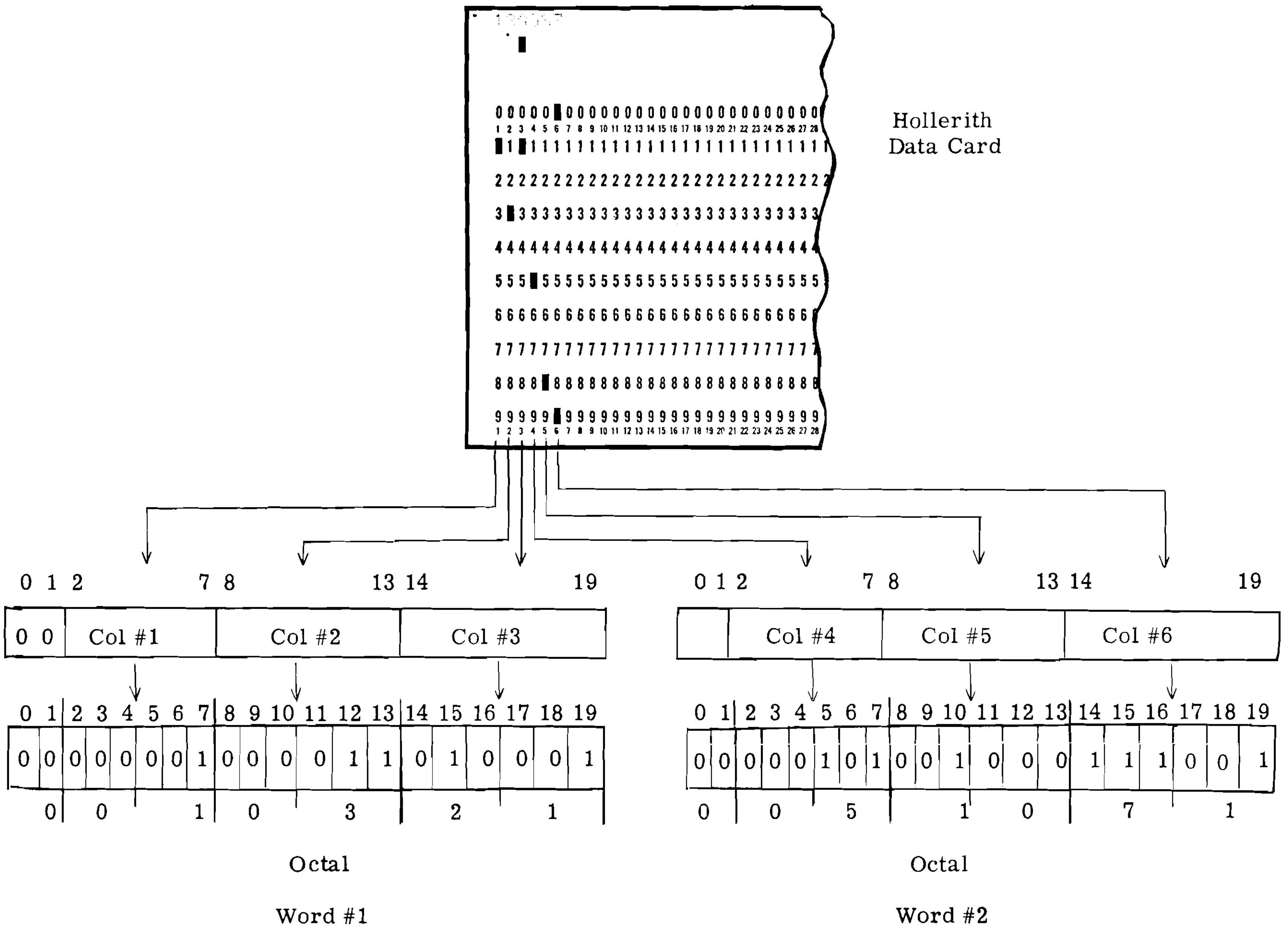
Cards may be punched and read in either Decimal or Binary Modes.

Decimal (Hollerith) Mode

The characters used are the decimal numbers 0 to 9, the 26 letters of the alphabet, and 28 special characters which include punctuation marks, and a space or blank. See the Representation of GE-235 Characters on page 15 of the appendix for the complete list.

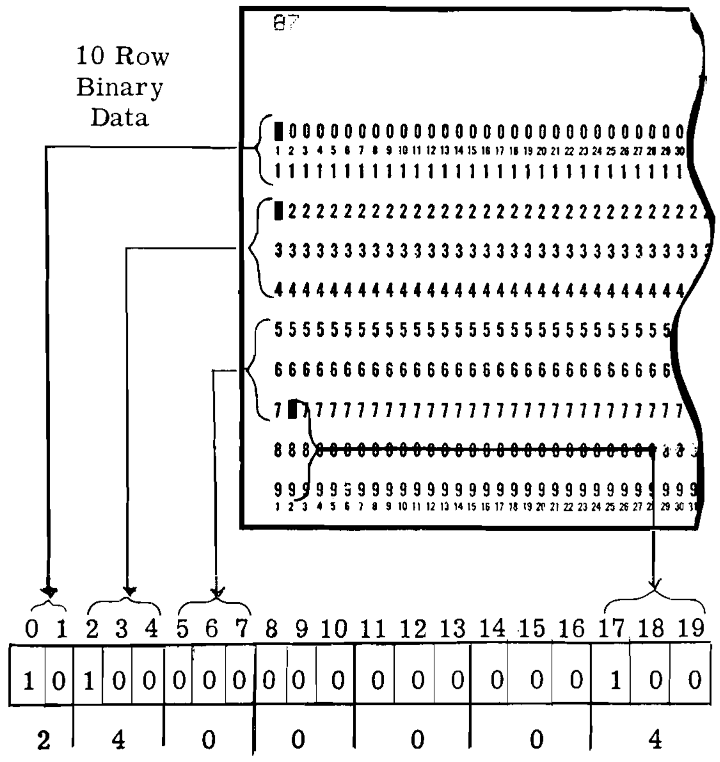
Characters are automatically converted to Binary Coded Decimal mode of 6 bits.

One GE-235 word is made up of 3 characters.

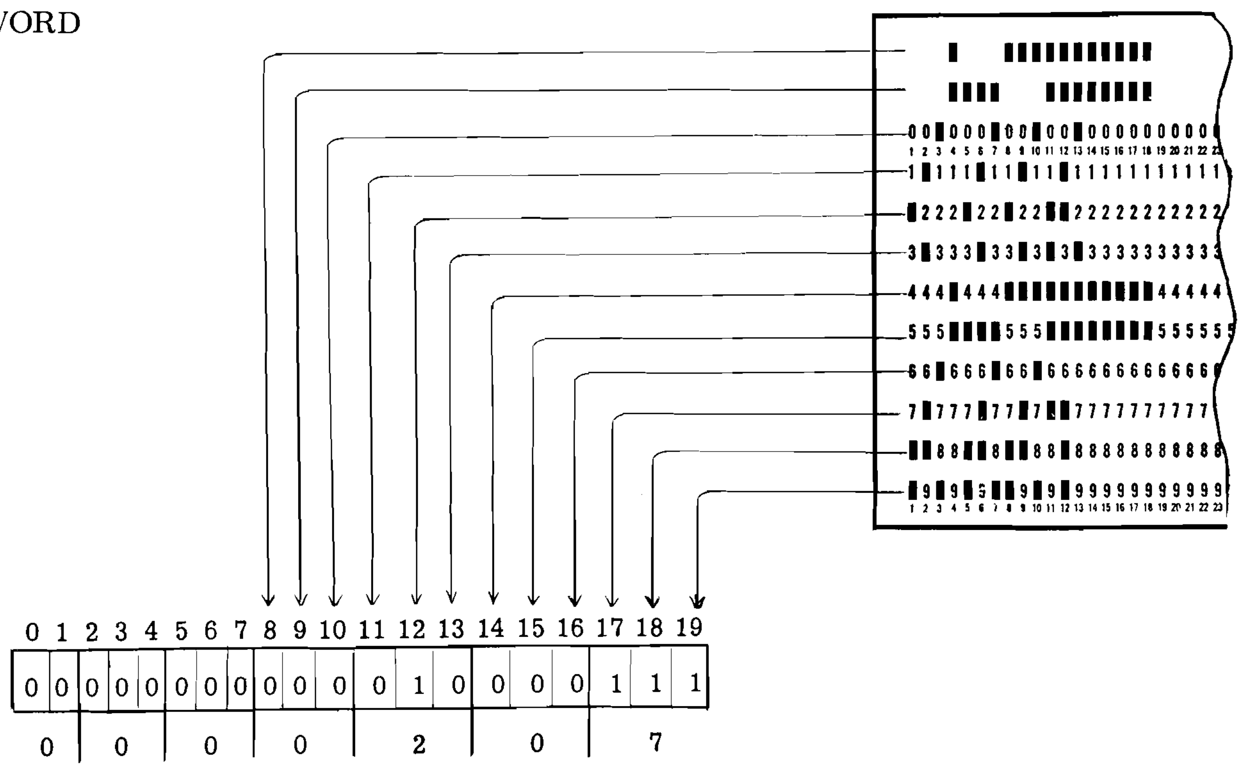


10 and 12 Row Binary Mode

Each hole punched in a column represents 1 bit of the GE-235 word in memory of the Central Processor Unit.



GE-235 MEMORY WORD



GE-235 MEMORY WORD

10-row Binary mode is used primarily for program instruction words.

12-row Binary mode uses the blank space at the top of the card for rows 12 and 11 and in this manner provides complete compatibility with other computing systems.

CHECKING FEATURES

GE-235 Card Readers

Errors in feeding and reading are detected by the timing and checking features of the respective GE-235 Card Readers. Indicators on the control panels are illuminated at the time of any of the following errors, depending on the model:

CHECKING FEATURE	MODEL 400 CPM	1000 CPM
Card Timing - Checked for slippage and proper synchronization to insure that each card column is read at the proper time.	Yes	Yes
Optical Checks - Light source and all photocells are checked for proper operation after each card is read.	Yes	Yes
Card Feed Error - Occurs if a card is called for but card fails to read.	Yes	Yes
Card Read Error - Occurs if any of the above checks fail.	Yes	Yes
Stacker Full--Input Hopper Full - Occurs each time a card is read.	No	Yes
End of File - A program check is made for end of file.	No	Yes
Card Jam - Transport mechanism is continuously monitored for possible card jams or changes in operating speed.	No	Yes
Invalid Characters - When reading cards in the Decimal Mode, each column is checked for character validity.	Yes	Yes

GE-235 Card Punches

In the GE-235 card punches, error checking circuitry and the punching mechanism monitor for the following errors:

Any column was erroneously left blank.
Any column was double punched with numeric characters.
If input hopper is empty, card punching stops.
If there is a misfeed, card punching stops.
If there is a card punch alarm, card punching stops.

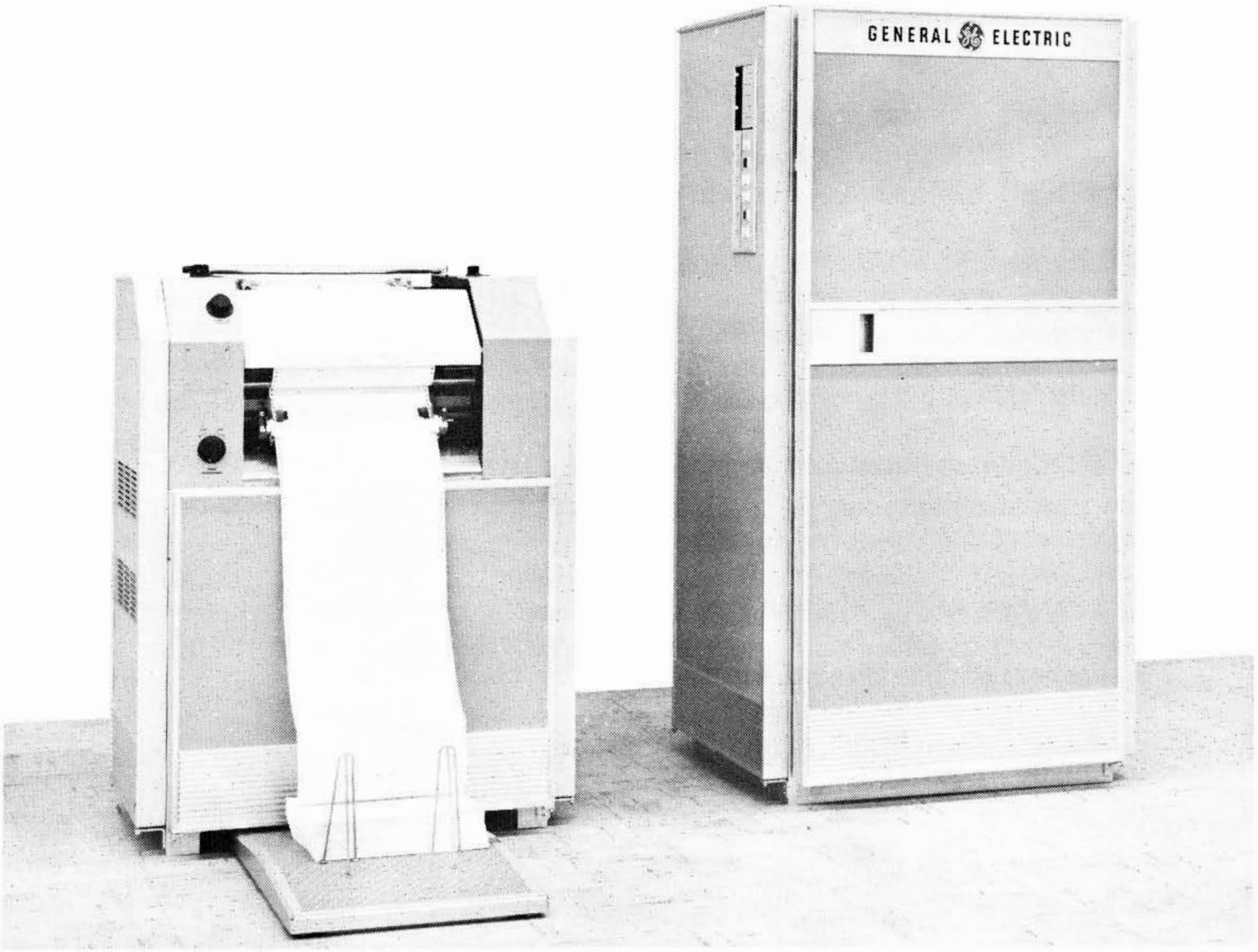
CARD READER INSTRUCTIONS

Mnemonic Oper. Code	Index Word	Operand Address	Time Microsec.	Description
BCN			12	BRANCH ON CARD READER NOT READY. Reader is not ready to read cards.
BCR			12	BRANCH ON CARD READER READY. Reader is ready to read cards.
RCB	X	Y	12	READ CARDS BINARY. Initiates continuous reading of 10-row Binary Mode cards.
RCD	X	Y	12	READ CARDS DECIMAL. Initiates continuous reading in Decimal (Hollerith) Mode.
RCF	X	Y	12	READ CARD FULL. Reads one card in 12-row Binary Mode.
RCM	X	Y	12	READ CARD MIXED. Initiates a one card read in Decimal Mode and senses for a 7-9 punch in column 1. If found, reading of card is changed to 12-row Binary Mode.
HCR			12	HALT CARD READER. Halts the continuous feeding of cards.

CARD PUNCH INSTRUCTIONS

Mnemonic Oper. Code	Index Word	Operand Address	Time Microsec.	Description
BPN			12	BRANCH ON CARD PUNCH NOT READY. Punch is not ready to punch cards.
BPR			12	BRANCH ON CARD PUNCH READY. Punch is ready to punch cards.
WCB		Y	12	WRITE CARD BINARY. Card is punched in a 10-row Binary Mode.
WCD		Y	12	WRITE CARD DECIMAL. Card is punched in Decimal Mode.
WCF		Y	12	WRITE CARD FULL. Card is punched in 12-row Binary Mode.

GE-235 HIGH-SPEED PRINTER



GE-235 HIGH SPEED PRINTER AND CONTROLLER

- An on-line, buffered type printer.
- Prints 900 lines per minute.
- Prints 120 alphanumeric characters per line.
- Prints in Open Gothic style, spaced 10 characters per inch horizontally, and 6 lines per inch vertically.
- Provides automatic editing of format.

- Skipping lines (or paper slew) is accomplished at 25 inches per second under program control by:

    Vertical Format tape; or,

    Vertical Line Count.

- Paper width may vary from 3-1/2 to 19 inches.
- Paper may be up to 22 inches in length per page in fan folded, continuous form type.
- Makes up to 5 copies.
- Total of 50 characters are provided on the printer:

    Numbers 0 through 9;

    26 letters of the alphabet;

    14 special characters, plus a space or blank:

+	Plus Sign	=	Equal
.	Period	,	Comma
-	Minus	[	Left bracket
$	Dollar Sign	]	Right bracket
*	Asterisk	#	Number sign
%	Percent sign	@	"At" sign
_	Underscore		Space or blank
/	Slash		

- FORTRAN and other special characters are available as options.

FORMATS

Data to be printed on the GE-235 High-Speed Printer is transferred from memory to the printer controller. Three methods for arranging horizontal line format for printing are available; these methods may be used in any combination.

1. Initial setup on the data to conform exactly to the print line desired;

2. Rearrangement of the data in memory by programmed insertion or deletion of characters;

3. Automatic editing performed by logic in the printer controller, based on a combination of related data and format words transferred to the printer controller. Editing includes zero suppression, deletion of data, insertion of constants and spaces, and dollar amount field editing. Many program steps and the inherent mechanical limitations of wired plugboards are eliminated because of the powerful automatic editing capability.

Slewing can be accomplished by program or switch control. The programmer can cause slewing of any number of lines up to 63 by specifying the number of lines to be skipped. Paper can be slewed to the top of a page by either program or manually pressing the Slew Top Page switch on the printer control panel. Special vertical formats can be printed by specifying slews to any one of eight channels of a perforated tape loop (vertical format tape) contained in the printer mechanism.

Editing of Data with Automatic Format Control

When a line is to be printed under format control, format words are stored in the Central Processor memory in a block of words organized the same as the print line data. The format control data consists of:

Any printable character
Control characters

The Printer Controller, in assembling a formatted line, reads in from memory one data word and one format word. The first format character is considered initially. If it is a printable character, it is printed. If it is a control character, it is treated as described below.

Five characters are available for controlling the format of the printed line. These characters, their octal representations, and their functions are:

IGNORE (OCTAL: 35). On Ignore, the next data character is immediately considered.

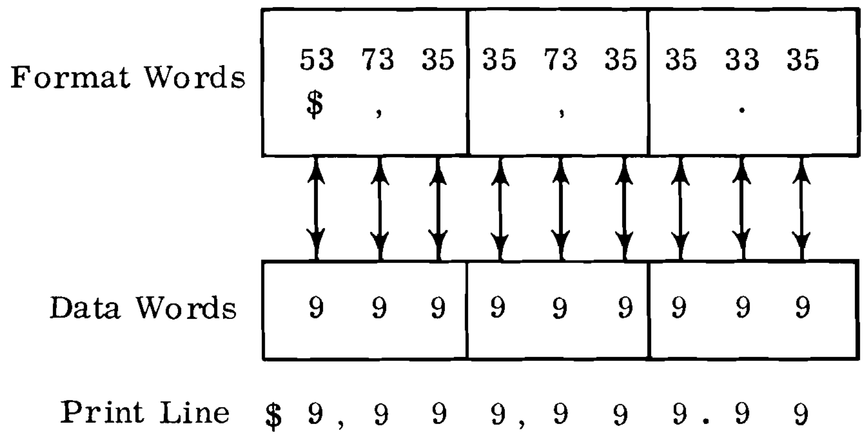
IGNORE/SKIP (OCTAL: 36). On Ignore/Skip, a blank is printed and the next data character is considered.

DELETE (OCTAL: 37). On Delete, the next data character is ignored, and the next character considered is the next format character.

DELETE/SKIP (OCTAL: 56). On Delete/Skip, a blank is printed, the next data character is ignored, and the next character considered is the next format character.

ZERO SUPPRESS (OCTAL: 57). On Zero Suppress, the next data character is ignored; and the next format character is printed if it is a printable character. After considering this last format character, spaces will be inserted in the print line until: (a) a non-zero data character is detected, or (b) a period appears in the format data. It should be noted that once a Zero Suppress has been put into effect, the print line data is inspected only for a non-zero data character, and the format control data is inspected only for a period. A $ symbol in the format data also initiates spaces in the print line in the same manner as Zero Suppress except that the next data character is not ignored after the $ symbol is printed.

The following is an example of how editing is performed with the printer controller:



Depending upon the value contained in the data words, the following amounts (using nines for example) would be printed on the high speed printer under control of the format control characters above.

```
$9,999,999.99
$  999,999.99
$   99,999.99
$    9,999.99
$      999.99
$       99.99
$        9.99
$         .99
$         .09
$         .00
```

When zero suppression on the print line is in effect as a result of a dollar sign or an octal 57 (zero suppress) in the format words, a comma in the format word is not printed (but a blank is printed instead) unless the data character preceding the comma in the format word is a non-zero character.

CHECKING FEATURES

The control panel on the Printer Controller contains indicator lights that show status of the printer and indicate alert conditions. In addition to the Ready and Off-Line indicators, there are the Parity Alert to show when a parity error has occurred and a Paper Alert to show when paper is torn or used up.

Printer Control Instructions

A single Print instruction will cause printing of up to 120 characters on one line from a block of 40 words of BCD data in memory. When the PRINT instruction is given, the printer receives information directly from the main memory through the appropriate numbered controller selector priority channel.

Printer operations are time shared with other processing. The printer can be interrogated for "ready" status (completion of previous PRINT instructions) by the BCS instructions.

The WPL, WFL, SLW, and SLT commands must be preceded by the SEL P instruction, which selects the specific controller selector channel. These instructions cannot be modified.

Printer Control Instructions

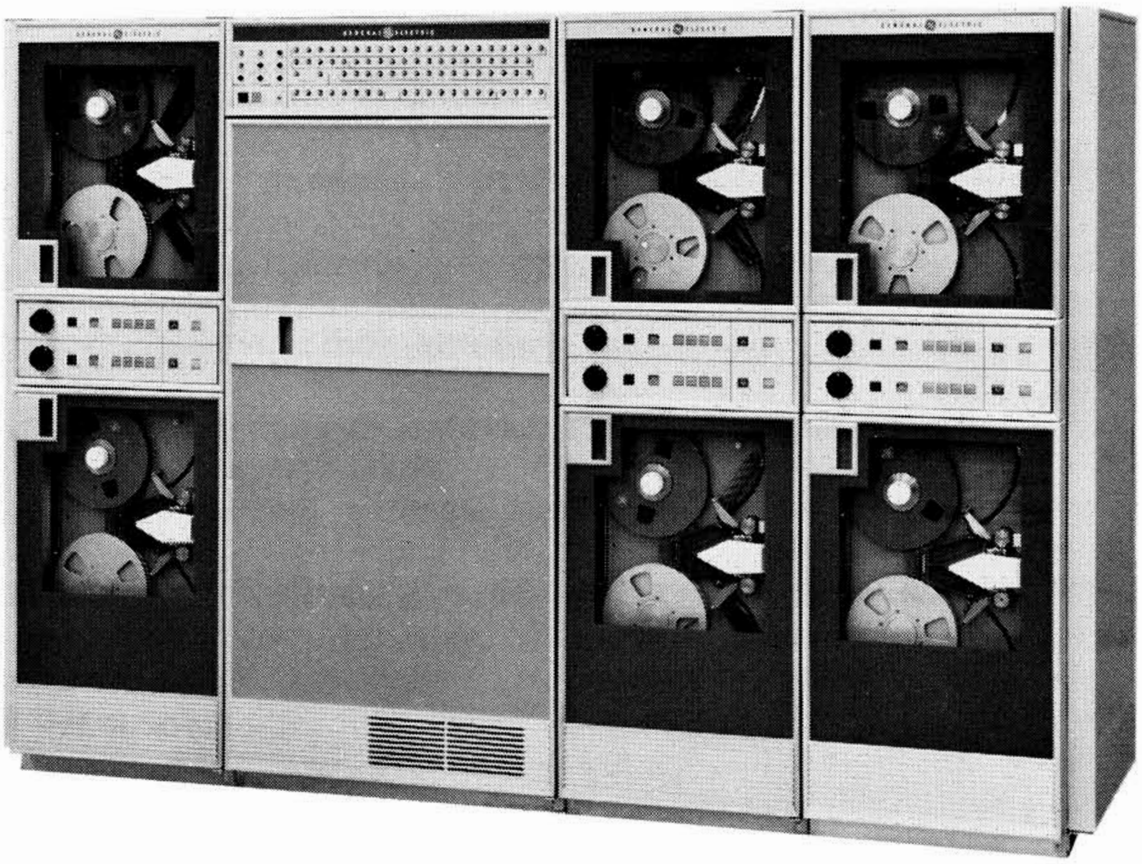
Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SLT	K		36	SLEW PAPER TO TAPE PUNCH. The printer paper is spaced until a hole is detected in the vertical format tape in channel K.
SLW	N		36	SLEW PAPER N LINES. The printer paper is spaced N (0 to 63) number of times.
WFL WPL	Y X	 N	36	WRITE FORMAT LINE. One line of BCD information is printed under automatic format control. Y is the starting location in memory of a series of format control words. Instruction should always be followed by a WPL instruction to specify the location (X) of the first word of information to be printed and whether the information is alphanumeric or numeric (N).
WPL	Y	N	36	WRITE PRINT LINE. Print one line of BCD information (1 to 120 characters long), starting at memory location Y. The N indicates that information is numeric only (if N is blank, information is alphanumeric). Printer paper is automatically spaced one line.

Printer Test and Branch Instructions

The following branch instructions test whether a particular printer controller condition is true or false. If the condition tested is true, the computer executes the next sequential instruction. If false, the computer skips the next instruction and executes the second sequential instruction. P stands for printer controller connected to controller selector channel P; thus referred to as printer controller P.

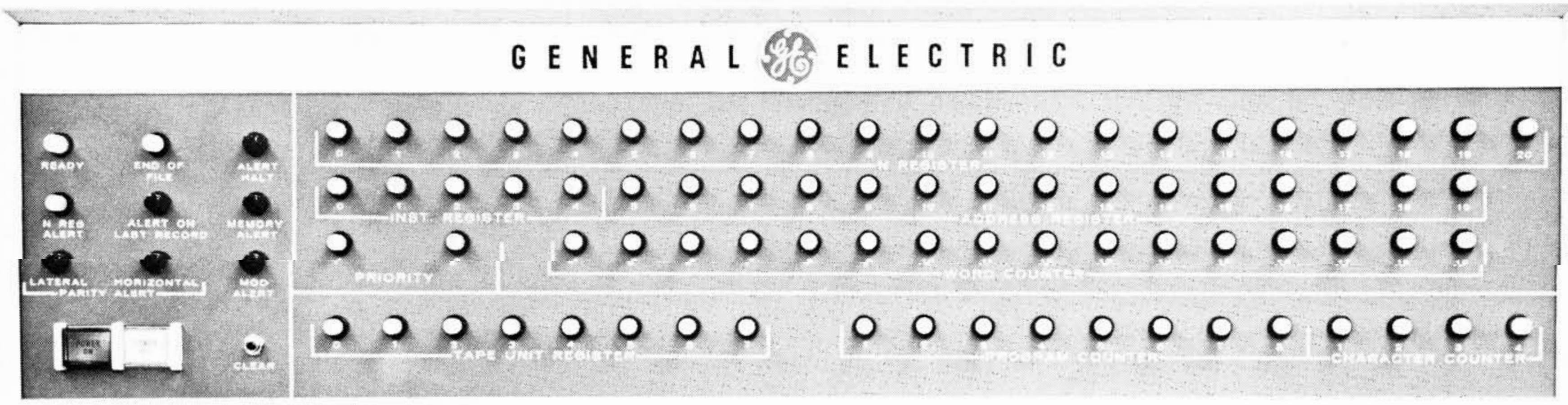
Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BCS	BPR	P	24-36	BRANCH ON PRINTER READY. P is tested for the ready status.
BCS	BPN	P	24-36	BRANCH ON PRINTER NOT READY. P is tested for the not ready status.
BCS	BOP	P	24-36	BRANCH OUT OF PAPER. P is tested to determine if the printer is out of paper.
BCS	BNP	P	24-36	BRANCH ON NOT OUT OF PAPER. P is tested to determine if the printer is not out of paper.
BCS	BER	P	24-36	BRANCH ON ERROR. P is tested for parity error.
BCS	BNE	P	24-36	BRANCH ON NO ERROR. P is tested for a no parity error condition.
BCS	BAA	P	24-36	BRANCH ON PRINTER ANY ALERT. P is tested for any alert condition.
BCS	BNA	P	24-36	BRANCH ON PRINTER NO ALERT. P is tested for no alert condition.
BCS	BSA	P	24-36	BRANCH ON PRINTER SLEW ALERT. P is tested for a slew alert condition.
BCS	BNS	P	24-36	BRANCH ON PRINTER NO SLEW ALERT. P is tested on a no slew alert condition.
BCS	BOV	P	24-36	BRANCH ON PRINTER BUFFER OVERFLOW. P is tested for a buffer overflow condition.
BCS	BNO	P	24-36	BRANCH ON PRINTER NO BUFFER OVERFLOW. P is tested for no buffer overflow condition.

THE GE-235 MAGNETIC TAPE SUBSYSTEM



CONTROLLER WITH TAPE HANDLERS

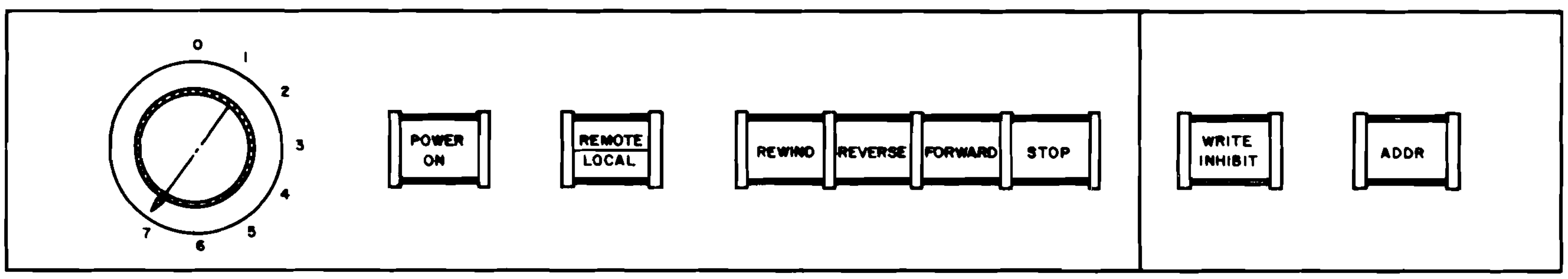
The GE-235 magnetic tape subsystem provides a fast method for transmission of extensive files and other large quantities of information into and out of the GE-235 central processor. It consists of two sections; magnetic tape controllers, and magnetic tape handlers.



TAPE CONTROLLER INDICATOR AND CONTROL PANEL

TAPE CONTROLLER

- Each controller can direct the operations of up to 8 tape handlers.
- Up to 7 controllers (with a total of 56 tape handlers) can be connected to the GE-235 system.
- Provides logic for selecting the tape handler, and for reading, writing and rewinding the magnetic tape.
- Monitors the flow of data between tape handlers and memory.
- Initiates and times the starting and stopping of the selected tape handler.
- Detects the beginning of tape, end-of-tape, and end-of-file record.
- Ensures reliability for the magnetic tape subsystem through its error-checking circuitry.
- Two controllers provide simultaneous tape reading and writing in a GE-235 system.
- Two controllers available: one for low-density tape; and one for high-density tape.



TAPE HANDLER CONTROL AND INDICATOR PANEL

TAPE HANDLERS

- Reads from and writes on tape at 75 inches per second.
- Two character densities are available:
  1. Low Density - 200 characters per inch (15,000 characters per second);
  2. High Density - 555.5 characters per inch (41,600 characters per second).
- Millions of characters may be recorded on a single reel of tape.

- Tapes may be used as on-line storage during a computer run.
- Tapes may be used as off-line storage to retain masses of information as a file for subsequent related computer runs.
- Magnetic tapes may be erased and used repeatedly.
- Each cabinet contains two magnetic tape handlers.
- Each handler holds two 10-1/2 inch diameter reels, one for feeding, and one for taking up the tape.
- Each reel holds up to 2,400 feet of standard 1/2-inch wide magnetic tape.
- Data is recorded in groups of words called blocks with short blanks in tape separating blocks.

FORMATS

The Tape Handler is capable of reading either backwards or forward in three formats: a Binary Coded Decimal, Binary, and Special Binary. The programmer selects the format he desires for his specific application. The tape has a width sufficient for the recording of seven tracks, or channels, of data. Six bits of data are recorded across the tape; a parity bit is recorded in the seventh track.

Parity, odd or even, depends on the format being used. In the binary format, the lateral one-bits will always be odd (known as odd parity). In BCD, the parity is even. This is simply a safeguard to prevent an inadvertent programming error that might arise if reading a tape prepared in the binary format with a Read Decimal type command.

Data is written on tape in groups of words called blocks of fixed or differing length. Inter-block gaps physically separate magnetic tape blocks. This gap is a 3/4-inch section of erased tape allowed for starting and stopping tapes between blocks. An end-of-file block separates groups of information, or marks the end of information on a specific tape. It is an erased section 3-3/4 inches long, followed by the code combination 0001111 and the parity character.

Binary Coded Decimal Format

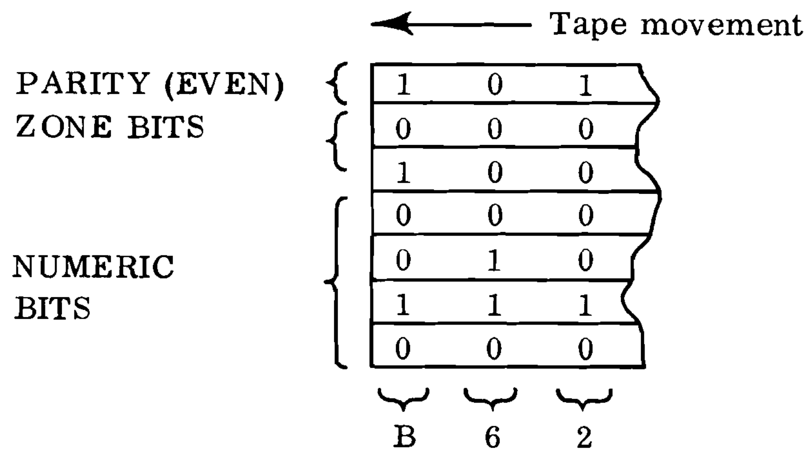
In the BCD format, in tape reading and writing operations, three 6-bit characters contained in the GE-235 word are transferred to and from tape. Thus, in the BCD format, some character bit configurations are altered so as to make the GE-235 system compatible with other tape systems in use. This alteration is accomplished automatically.

This is a significant feature because tapes written by the GE-235 may be read by another system's tape unit, and, tapes prepared by other units can be read by the GE-235 system. The alphanumeric ''962'' exists in memory as three BCD characters, as follows:

00	010 010	000 110	000 010
	B	6	2

Binary Coded Decimal Memory Format

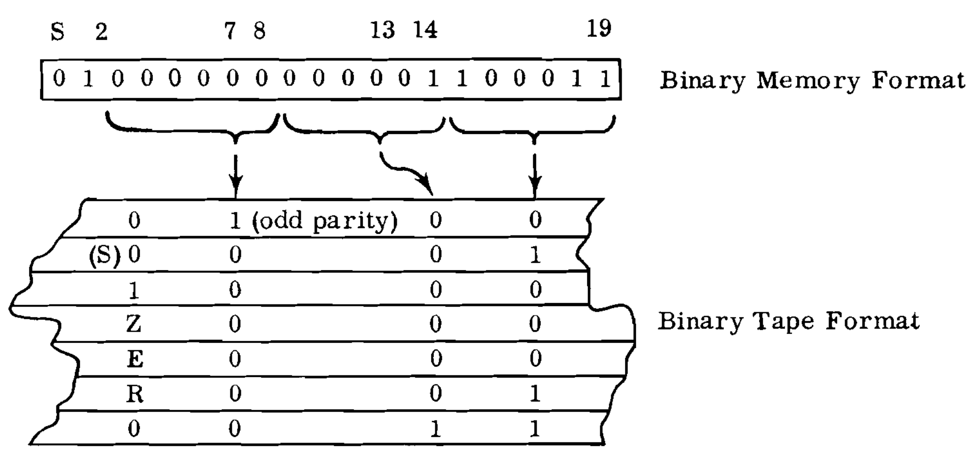
When written on magnetic tape these characters appear as three 6-bit characters accompanied by a parity bit, as:



Binary Format

In the binary format, the word in memory is written as four magnetic tape positions: three tape characters as in the BCD format, and a fourth character containing two bits of the data word. The remaining tape bits of this fourth position contain zeros which are automatically inserted when recording on tape and ignored when reading from tape.

As an illustration of the appearance of a binary word on tape, the decimal number 262243 appears in memory and on Magnetic Tape as follows:



It is advantageous to write numeric information in the binary format because the equivalent of 5-1/2 decimal digits in memory may be recorded in only 4 tape characters. In BCD format, however, 3 BCD characters require 3 tape positions. If memory data consists of mixed formats of both BCD and binary in memory, the binary writing format is employed.

Special Binary Format

The GE-235 system also operates in a special binary format. This records 3 positions on tape instead of 4 without altering the bit structure. This feature effectively expands compatibility to cover both the decimal and binary modes of other tape systems. The feature is also useful for GE-235 applications using mixed binary and decimal data.

CHECKING FEATURES

Each GE-235 tape handler has two sets of magnetic heads; read heads, and write heads. During reading operations, only the read heads are used. During write operations, both sets of heads operate, as follows:

Write Heads - Record the characters on tape as the tape passes;

Read Heads - Read each character immediately after it is written and checks its validity.

Thus, if errors occur, they are detected during the write operation and can be corrected under program control.

Write Permit Ring - Fits into a groove on the back side of the tape reel to permit writing on the tape. Removing the ring from the reel prevents writing or accidental erasure of data already on a tape.

The GE-235 magnetic tape system incorporates a wide variety of error detection circuits to ensure accurate data transfers between memory and tape. These circuits are:

CONTROLLER INPUT-OUTPUT REGISTER EXHAUST OR OVERFLOW. Checks against an excessive wait for memory access on the part of the Tape Controller during multiple input/output operations.

LATERAL PARITY. This parity check associated with each tape character ensures the accuracy of each character when read from, or written onto, tape.

LONGITUDINAL PARITY. This is a parity check on each of the seven record tracks, or channels, recorded as a parity character at the end of each tape record.

MODULO THREE OR FOUR. When information is read from, or written onto, tape, a check is made to determine that the proper number of characters (three in BCD and special binary formats, and four in binary formats) have been read or recorded.

All information words are parity checked when transferred between memory and the Tape Controller.

ECHO ALARM. Ensures against attempting to use any controller that is not in the ready status.

Checks are also made against the conditions which cause an ALERT HALT. This is indicated by the turning on of the ALERT HALT light on the tape controller display panel. These conditions are:

A parity error on instruction words 2 and 3 as these words are transferred from memory to the tape controller.

Addressing a tape unit that is rewinding.

Using an address which has not been assigned to any specific tape unit.

Any detectable malfunction of the tape handler.

Specifying a tape handler logical address which has been assigned to two or more units.

Giving a write command to a tape unit which does not have the write permit ring attached to the supply reel. Each tape unit is equipped with a file protection ring which is attached to the tape supply reel. When this ring is not attached, the controller does not permit writing on that tape.

Addressing a tape unit with a read backward instruction (RBB, RBD, or RBS) when the tape on the unit is initially positioned at its beginning.

Parity and other such errors detected while reading or writing tape do not cause an ALERT HALT but do give an indication on the tape controller display panel that a specific error has occurred on the last record. These errors can be detected under program control by means of the test-and-branch instructions for the Magnetic Tape System.

MAGNETIC TAPE INSTRUCTIONS

All instructions executed by the Magnetic Tape Controller consist of 3 memory words, the first of which has as its function the selection of the specified controller. This first word has the operation code SEL P. Similarly all test instructions pertaining to the status of a controller bear the common operation code BCS.

The general format of these instructions utilize the following conventions: P = controller assignment (channel number); M = memory location (starting); T = tape handler assignment (number); N = length of record (number of words).

Coding under the "Index Word" column is recorded in column 20 on the GAP coding sheet.

General Tape Instructions

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SEL	P		24-36	SELECT the peripheral controller connected to selector channel number P.
BCS	XXX	P	24-36	BRANCH ON CONTROLLER SELECTOR. The peripheral controller connected to the controller channel selector is tested for the condition indicated by a mnemonic placed in the operand address field identified by XXX.

Tape Movement Instructions

The RTD, RTB, RTS, RBD, RBB, RBS, RWD, WTD, WTB, WTS, and WEF tape movement instructions are preceded by the SEL P instruction to designate the specific controller channel number.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BKW		T	36	BACKSPACE AND POSITION WRITE HEAD. The tape on tape handler T is backspaced one record and is positioned for reading or writing. This instruction must be preceded by the SEL P instruction and it cannot be modified.
RBB (blank)	M N	T	36	READ BACKWARD BINARY. N words are read from tape T backward in Binary Mode into memory, starting at location A.
RBD (blank)	M N	T	36	READ BACKWARD DECIMAL. N words are read from tape T backward in binary coded decimal mode into memory, starting at location A.
RBS (blank)	M N	T	36	READ BACKWARD SPECIAL BINARY. N words are read from tape T backward in special binary mode, starting at location A.
RTB (blank)	M N	T	36	READ TAPE BINARY-FORWARD. N words are read from tape T forward in binary mode into memory, starting at location A.
RTD (blank)	M N	T	36	READ TAPE DECIMAL-FORWARD. N words are read from tape T forward in binary coded decimal mode into memory, starting at location A.
RTS (blank)	M N	T	36	READ TAPE SPECIAL BINARY-FORWARD. N words are read from tape T forward in special binary mode, starting at location A.
RWD	T		36	TAPE REWIND.
WEF	T		36	WRITE END-OF-FILE. The end-of-file is written on tape.
WTB (blank)	M N	T	36	WRITE TAPE BINARY. N words are written in binary mode on tape T, starting at memory location M.
WTD (blank)	M N	T	36	WRITE TAPE DECIMAL. N words are written in binary coded decimal mode on tape T, starting at memory location M.
WTS (blank)	M N	T	36	WRITE TAPE SPECIAL BINARY. N words are written in special binary mode on tape T, starting at memory location M.

Test and Branch Instructions

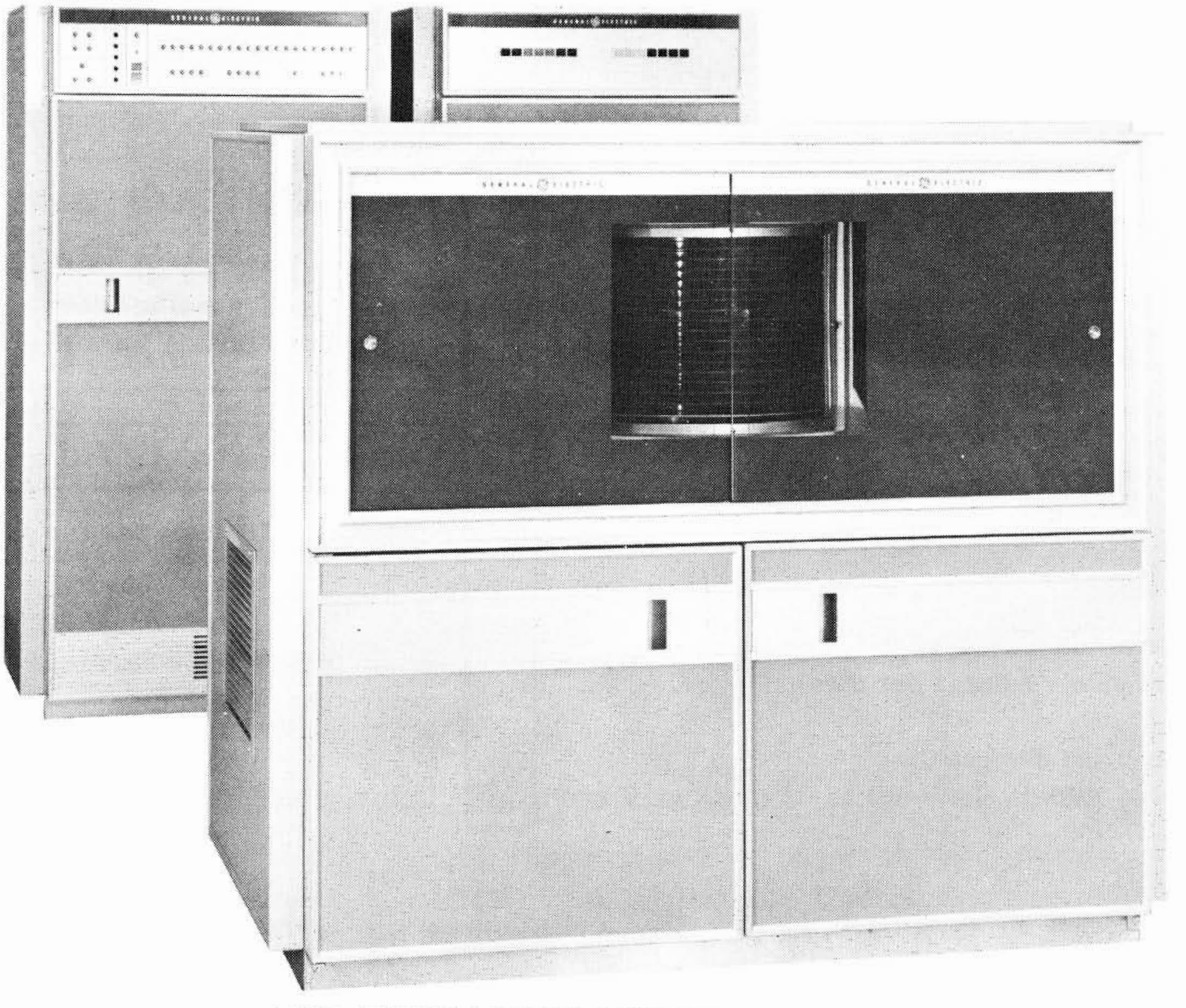
The following instructions test to determine whether a magnetic tape controller condition is true or false. If the condition tested is true, the computer executes the next sequential instruction. If false, the computer executes the second sequential instruction. Under Index Word and the Description, P stands for tape controller P.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BCS	BTR	P	24-36	BRANCH ON TAPE CONTROLLER READY. P is tested for the ready status.
BCS	BTN	P	24-36	BRANCH ON TAPE CONTROLLER NOT READY. P is tested for the not-ready status.
BCS	BEF	P	24-36	BRANCH ON END-OF-FILE. P is tested for end-of-file indicator ON.
BCS	BNF	P	24-36	BRANCH ON NO END-OF-FILE. P is tested for end-of-file indicator OFF.
BCS	BER	P	24-36	BRANCH ON ERROR. P is tested for any error indicator ON.
BCS	BNE	P	24-36	BRANCH ON NO ERROR. P is tested for no error indicator ON.
BCS	BIO	P	24-36	BRANCH ON INPUT/OUTPUT ERROR. P is tested for input/output buffer error indicator ON.
BCS	BIC	P	24-36	BRANCH ON INPUT/OUTPUT BUFFER CORRECT. P is tested for input/output buffer error indicator OFF.
BCS	BME	P	24-36	BRANCH ON MOD 3 OR 4 ERROR. P is tested for modulo 3 or 4 error indicator ON.
BCS	BNM	P	24-36	BRANCH ON NO MOD 3 OR 4 ERROR. P is tested for modulo 3 or 4 error indicator OFF.
BCS	BET	P	24-36	BRANCH ON END-OF-TAPE. P is tested for end-of-tape indicator ON. This indicator is turned ON by the detection of a photo reflective spot located on tape just prior to the trailer.
BCS	BNT	P	24-36	BRANCH ON NO END-OF-TAPE. P is tested for end-of-tape indicator OFF.
BCS	BPE	P	24-36	BRANCH ON TAPE PARITY ERROR. P is tested for parity error indicator ON.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BCS	BPC	P	24-36	BRANCH ON TAPE PARITY CORRECT. P is tested for tape parity error OFF.
BCS	BRW	P	24-36	BRANCH ON TAPE REWINDING. P is tested for tape rewinding condition.
BCS	BNR	P	24-36	BRANCH ON NO TAPE REWINDING. P is tested for no tape rewinding condition.

GE-235 MASS RANDOM ACCESS DATA STORAGE

With the Mass Random Access Data Storage subsystem (abbreviated MRADS), information can be accessed directly, eliminating the need to search through unrelated information as is required in the sequential processing of punched card and magnetic tape files. Such random access is extremely valuable in applications where large volumes of information must be stored and retrieved with minimum delay. Each GE MRADS subsystem consists of a MRADS Controller, a rotating disc assembly (or MRADS unit), and an electronics control cabinet. One or two MRADS controllers can be connected to the Controller Selector of the GE-235 Computer, with each controller capable of controlling up to four MRADS units.



MASS RANDOM ACCESS DATA STORAGE UNIT

• Speed of rotation of disc	1200 rpm
• Effective transfer rate:	11,850 and 23,700 words/sec
• Average latency time	26 ms
• Maximum latency time	52 ms
• Average positioning time	199 ms
• Maximum positioning time	305 ms
• Average access time (including track verification)	225 ms

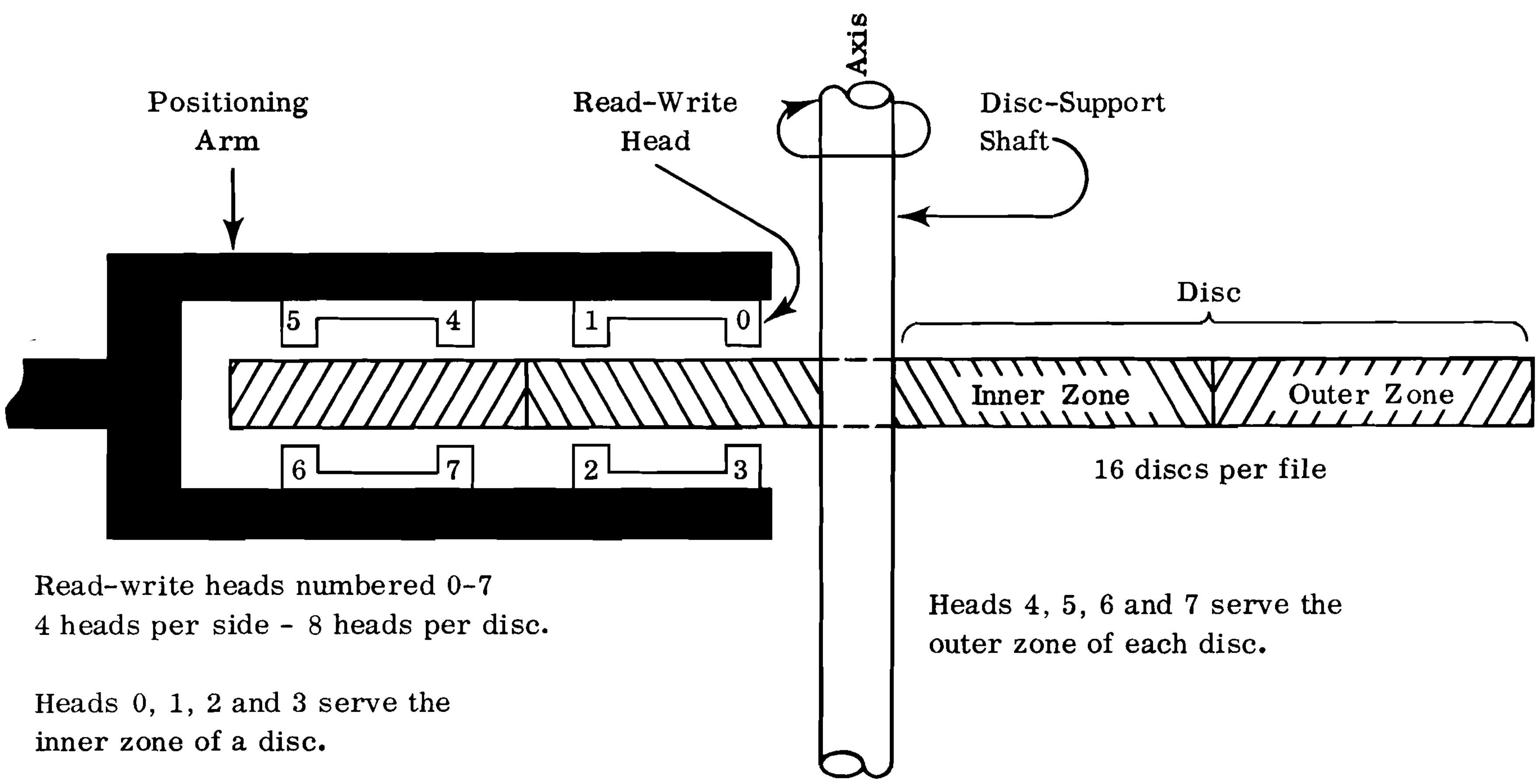
FORMATS

Each MRADS unit consists of 16 circular magnetic discs. Information is recorded serially in 256 circular tracks which make up each side of a disc. Eight 64-word records are recorded in each of the 128 inner tracks. Sixteen 64-word records are recorded in each of the 128 outer tracks.

Each word recorded on a disc is a replica of the word as it appears in the GE-235 core memory. Both binary and alphanumeric (BCD) configurations are retained without change.

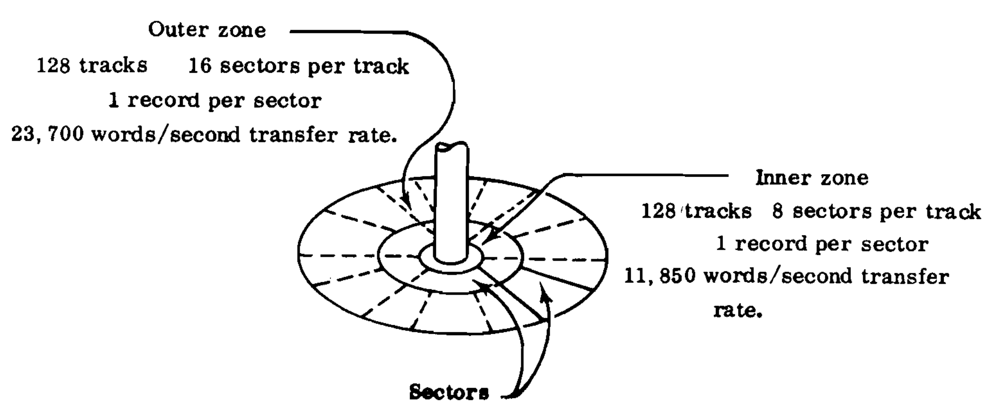
Between 1 and 16 records (64 words each) can be read or written with one command. Each data disc of the MRADS unit is served by its own positioning arm. Each arm contains eight read-write heads -- four heads for each side of the disc.

With the arm in one position, it is possible to transfer a total of 96 records (32 on inner heads, 64 on outer heads -- on both sides of the disc).



MRADS POSITIONING ARM AND HEADS

The diagram below shows one surface of a disc; the division of the surface into inner zones; and the zones into 8 and 16 sections with 128 tracks each.



CHECKING FEATURES

Customer-tailored error checking features include:

- Odd parity check on read-write transfers
- Memory access check
- Clocking check
- Address confirmation check
- Longitudinal parity word check
- Read-after-write check

Each word on the disc file contains parity plus an additional check word per record. If a word parity error should occur on reading, program reconstruction is possible through the use of the check word.

MRADS INSTRUCTIONS

The PRF, RRF, RRD, WRD, WRF, and RAW instructions must be preceded by the SEL P instruction, which selects the specific controller P. The general format of these instructions utilize the following conventions:

F = mass random access file number (0 to 3).

K = MRADS file number (0 to 3), test and branch instructions.

M = memory location of data.

N = number (1 through 16) of 64-word records to be transmitted from core storage to disc storage or vice versa.

P = controller assignment (plug number).

Note: File number (F) is normally recorded in column 20 of the GAP coding sheet.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
PRF		F	36	Positions arm of MRADS unit to receive or transmit a specific record.
OCT	(MRADS Address)			Contains actual address (in octal) of the selected MRADS.
RRF (blank)	N M	F	36	READ FROM MRADS UNIT. Reads N records from MRADS file F, into memory, starting at location M.
WRF (blank)	N M	F	36	WRITE ON MRADS UNIT. Writes N records on MRADS file F from memory, starting at location M.
RAW (blank)	N Zero	F	36	READ AFTER WRITE CHECK. A parity check is made on all words of a record(s) transferred to the file.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
RRD (blank)	N M	F	36	READ MRADS AND RELEASE ARM. Performs the same function as RRF except that the positioning arm is released after reading.
WRD (blank)	N M	F	36	WRITE MRADS AND RELEASE ARM. Performs same function as WRF except that the positioning arm is released after writing.

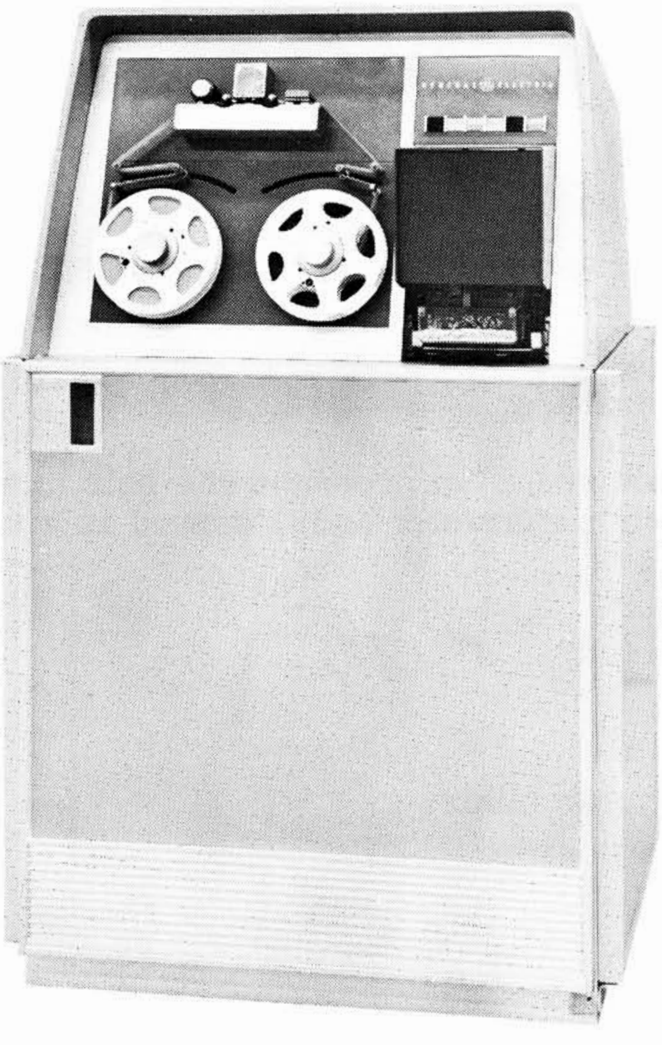
Branch and Test Instructions

The following branch instructions test to determine whether a particular MRADS condition is true or false. If the condition tested is true, the computer executes the next sequential instruction. If false, the computer skips the next instruction and executes the second sequential instruction.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BCS	BRR	P	24-36	BRANCH ON MRADS READY.
BCS	BRN	P	24-36	BRANCH ON MRADS NOT READY.
BCS	FKR	P	24-36	BRANCH ON FILE K READY.
BCS	FKN	P	24-36	BRANCH ON FILE K NOT READY.
BCS	BIO	P	24-36	BRANCH ON INPUT/OUTPUT BUFFER ERROR.
BCS	BIC	P	24-36	BRANCH ON INPUT/OUTPUT BUFFER CORRECT.
BCS	RPE	P	24-36	BRANCH ON PARITY ERROR.
BCS	RPC	P	24-36	BRANCH ON PARITY CORRECT.
BCS	BER	P	24-36	BRANCH ON ERROR.
BCS	BNE	P	24-36	BRANCH ON NO ERROR.
BCS	FAE	P	24-36	BRANCH ON FILE ERROR.
BCS	FAC	P	24-36	BRANCH ON FILE CORRECT.
BCS	FKE	P	24-36	BRANCH ON ERROR, FILE K.
BCS	FKC	P	24-36	BRANCH ON NO ERROR, FILE K.

GE-235 PERFORATED TAPE EQUIPMENT

Transactions are commonly recorded on perforated tape as by-products of equipment such as tape-punching typewriters, billing machines, remote terminal links and calculators. The GE-235 system provides a perforated tape reader, punch and spooler in one cabinet; or alternatively, a reader and punch, a reader and spooler, a reader only or a punch only.



Reader Mechanism

- The Reader operates at either of two speeds
    - 250 Characters per second (10 characters per inch at 25 inches per second).
    - 1000 Characters per second (10 characters per inch at 100 inches per second).
- Reads 5, 6, 7 and 8 channel tapes.
- Permits optional selection of spool feed at 250 characters per second, or strip feed at 1000 characters per second.
- Operates simultaneously with other Input/Output operations.

Punch Mechanism

- The Punch is capable of punching up to 110 characters per second (10 characters per inch).
- Punches 5 or 6, 7 and 8 channel tapes.
- Operates simultaneously with computation and other Input/Output operations.

Spooler Mechanism

- The Spooler has both takeup and supply spools for perforated tape, which automatically maintain proper tension during reading.

FORMATS

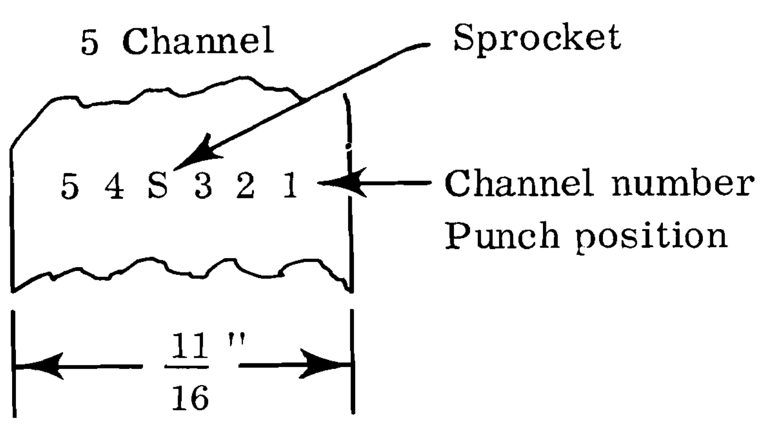
- Tapes may be read or punched in standard 5, 6, 7 or 8 channel codes using chad sprocket hole spacing and with the following tape widths:

5 channel	11/16 inch
6 or 7 channel	7/8 inch
8 channel	1 inch

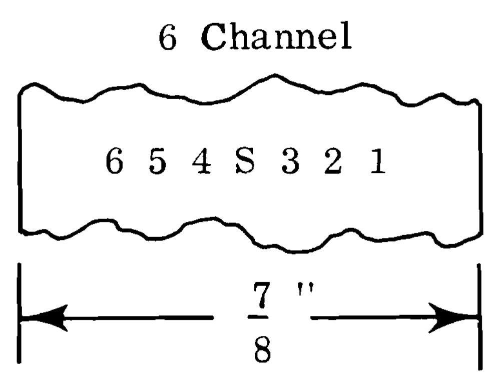
- The sprocket hole of the tape serves as a timing source and must be present with every tape character.

5 and 6 Channel Code Characters

All code combinations are recognized. The presence of a hole in the sprocket hole channel, only, **indicates a tape leader or tape strip character and is sensed as a valid character.**



Example of 5-channel Perforated Tape



Example of 6-channel Perforated Tape

7 and 8 Channel Code Characters

The characters of the 7 and 8 channel codes are entered into the N register in a like fashion.

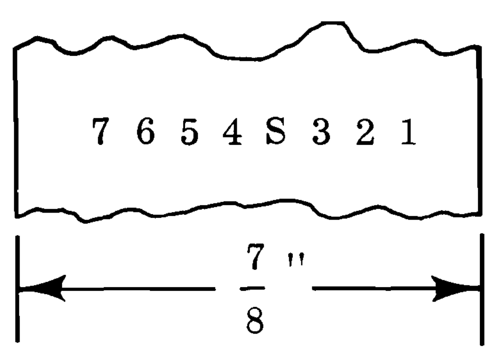
The presence of a hole in the 5th Position is not transferred to the N register as it is used for a Parity Check.

Sprocket hole punched only, indicating a tape leader or tape strip character, is ignored.

All holes punched in Positions 1 thru 7 are sensed as a Delete code and are not transferred to the N register.

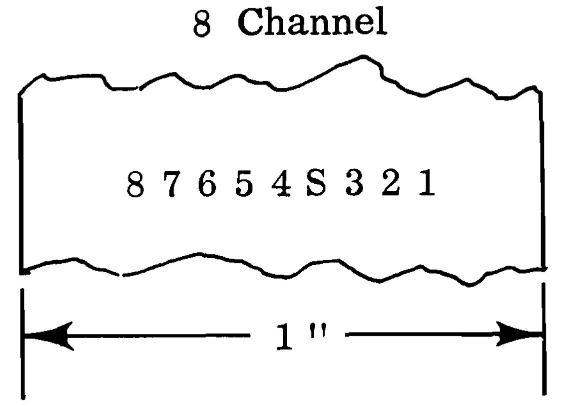
The transference of all positions of the 8 Channel code can be accomplished by a special optional feature.

7 Channel



Example of 7-channel Perforated Tape

8 Channel



Example of 8-channel Perforated Tape

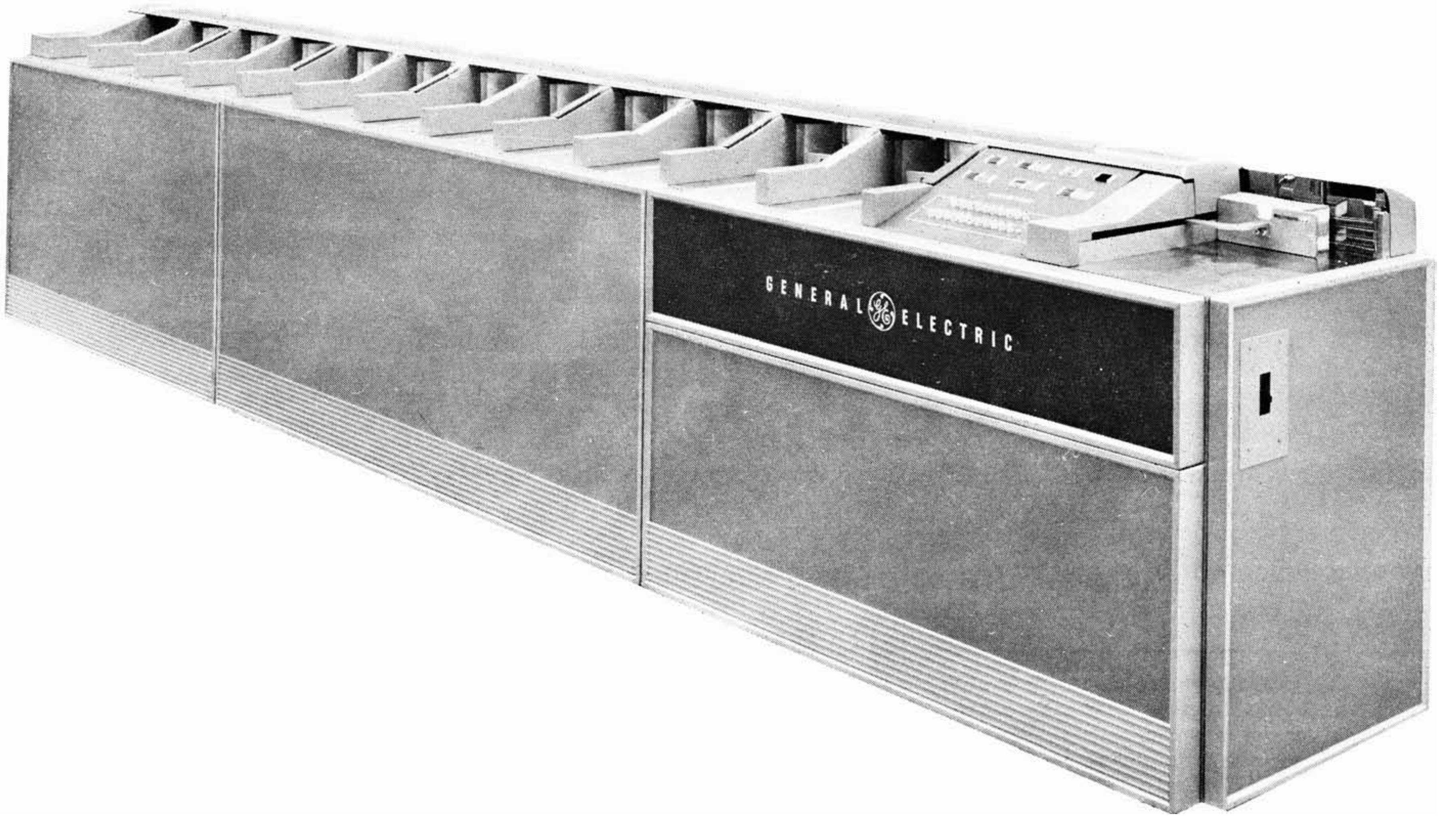
CHECKING FEATURES

Parity checking is performed when reading or punching 7 or 8 channel tape. Position 5 represents the parity bit.

PERFORATED TAPE INSTRUCTIONS

Mnemonic Oper Code	Operand Address	Time Microsec.	Description
BNN		12	BRANCH ON N REGISTER NOT READY. Branch if the N register is not ready for input or output.
BNR		12	BRANCH ON N REGISTER READY. Branch if the N register is ready for input or output.
HPT		12	HALT PERFORATED TAPE. Halts the reading of the tape.
PON		12	PUNCH ON. Punch is logically connected to the N register and other N register peripherals are disabled.
RON		12	READER ON. Reader is logically connected to the N register and other N register peripherals are disabled.
RPT		12	READ PERFORATED TAPE. Initiates the continuous reading of the tape.
WPT		12	WRITE PERFORATED TAPE. Initiates the continuous writing (punching) of the tape.

GE-235 12-POCKET DOCUMENT HANDLER

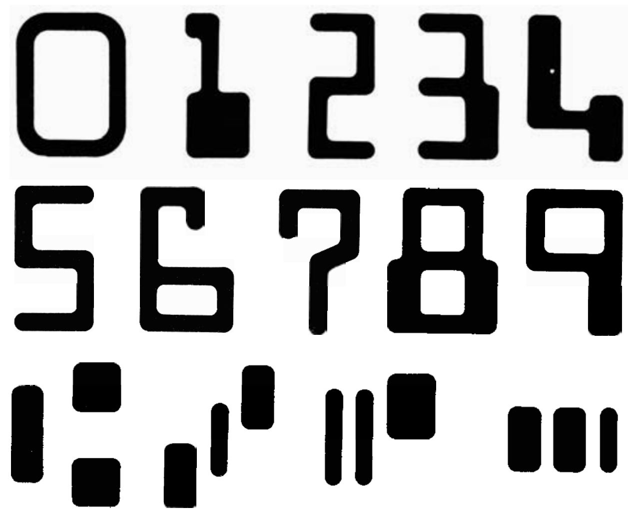


- Reads and sorts up to 1200 magnetically encoded source documents per minute.
- On-line, sends information to the central processor for further processing while sorting documents; off-line, acts as a sorter only.
- Sorts documents in a wide variety of formats and ranging in size from 2-1/2 by 5-1/4 inches to 3-3/4 by 8-3/4 inches.
- 2500 documents can be placed in the document handler feed hopper at one time; 1500 documents in each pocket.
- Handles defaced and mutilated documents also.
- Reads E13b font characters which are as easily recognizable to the human eye as to the document handler.

FORMATS

The six BCD bits occupy the six least significant bit positions of each memory location. If the BCD character is a numeric digit, all remaining bit positions are zeros. If the BCD character in memory is a cue character, a one bit is placed in the sign and the most significant bit positions. If the BCD character in memory is an invalid character, a one bit is placed in the sign position only.

MAGNETIC INK CHARACTER RECOGNITION SYSTEM



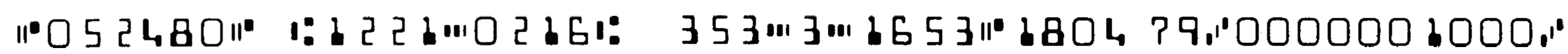
E13-B Font
Decimal Digits

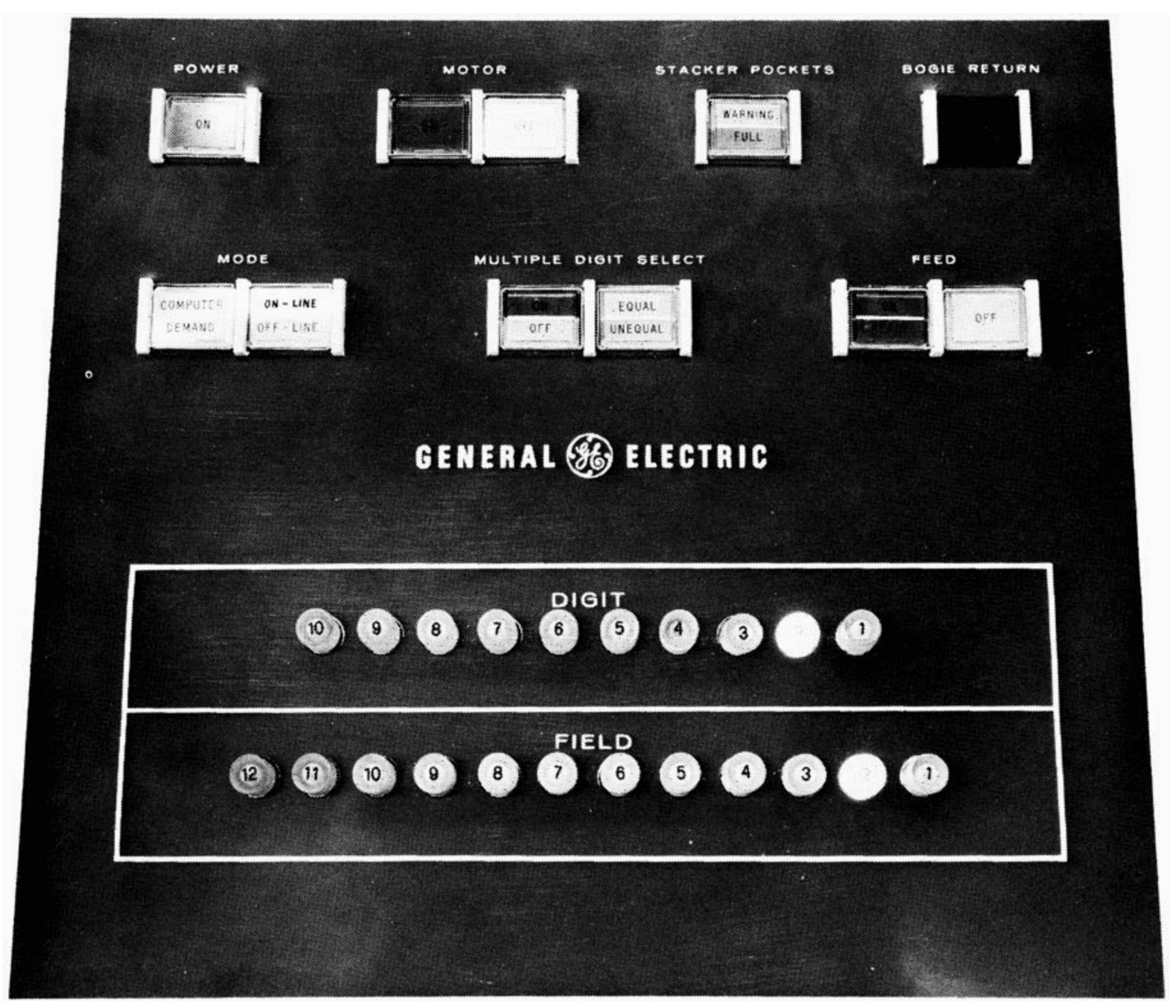
Cue Characters

EXAMPLE OF MICR CHARACTERS IN BANKING APPLICATION

Cue characters are normally used to separate fields of decimal digits. For example, in a banking application the cue characters separate fields of decimal digits in the following manner:

The cue characters in this illustration separate such fields as the Federal Reserve routing district, a number assigned to the bank by the American Bankers Association, the account, and the dollar amount.





VIEW OF CONTROL PANEL OF GE-235 DOCUMENT HANDLER

CHECKING FEATURES

Total Cue Check - Counts the total number of all cue symbols on the document to insure that all fields are read.

Long Character and Multiple Read - Checks for unusually "long" characters or multiple reads misinterpreted by the document handler due to the presence of magnetic ink particles just before or after the printed character.

Missing Digit Detection - Decides whether or not spaces encountered in the document's coding are legitimate and accepts or rejects the document accordingly.

Transposition Check Digit - Verifies the correctness of predetermined fields on the document.

Jam Sensing - Checks for stoppage of documents to prevent damage to both the documents and equipment.

DOCUMENT HANDLER INSTRUCTIONS

The following instructions must be preceded by an SEL P instruction. In the instructions shown below Y = memory location, N = document handler unit, X = pocket number 0 through 9, special, or reject, P = controller assignment number.

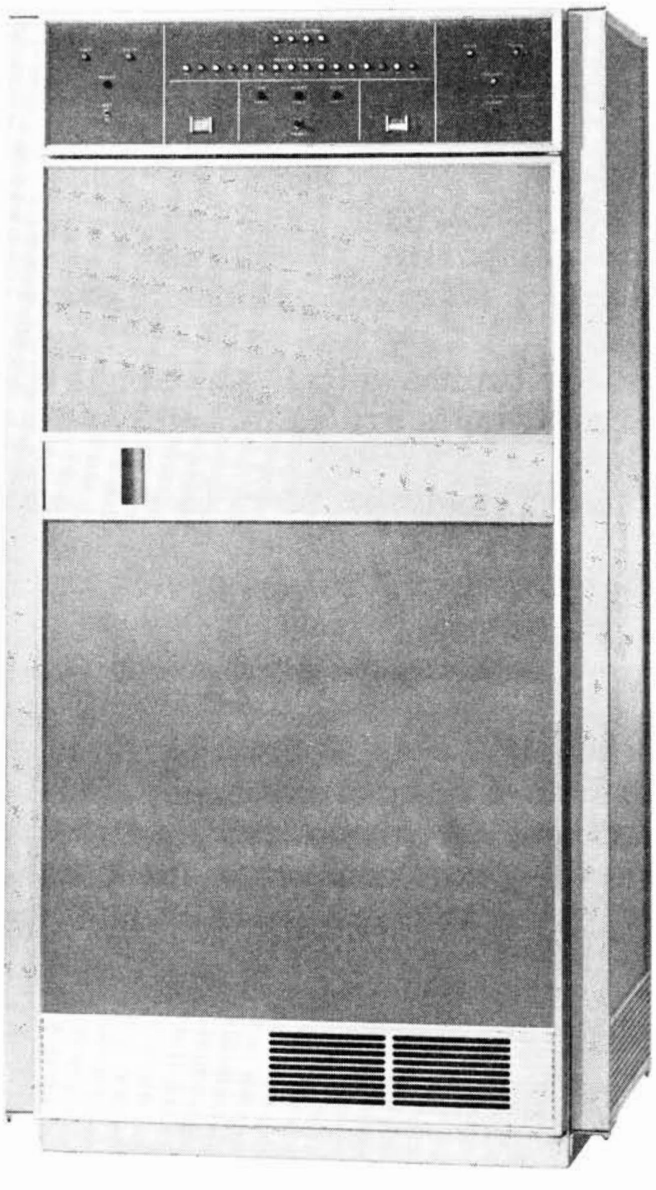
Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
RSD	Y	N	36	READ SINGLE DOCUMENT into memory. The first character goes into location Y + 63 (Y must be a multiple of 64).
RDC	Y	N	36	READ DOCUMENT into Y + 63 and CONTINUE feeding next document. (50 milliseconds are available for computation.)
PKT	X	N	36	POCKET SELECTED to receive document.
HLT	Y	N	36	HALT continuous feeding.

The following branch instructions test whether or not a particular document handler condition is true or false. If the condition tested is true, the computer executes the next sequential instruction. If false, the second sequential instruction is executed. The letter K in the mnemonic specifies document handler 1 or 2.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BCS	SKR	P	24-36	BRANCH ON SORTER K READY.
BCS	SKN	P	24-36	BRANCH ON SORTER K NOT READY.
BCS	PDK	P	24-36	BRANCH IN TIME FOR POCKET DECISION, SORTER K
BCS	NPK	P	24-36	BRANCH TOO LATE FOR POCKET DECISION, SORTER K.
BCS	FSK	P	24-36	BRANCH ON SORTER K READY AND FEED COMMAND GIVEN.
BCS	NFK	P	24-36	BRANCH ON SORTER K NOT READY OR FEED COMMAND NOT GIVEN.
BCS	VCK	P	24-36	BRANCH ON VALID CHARACTER, SORTER K.
BCS	ICK	P	24-36	BRANCH ON INVALID CHARACTER, SORTER K.
BCS	SKC	P	24-36	BRANCH ON SORTER K CORRECT (error indicator is off).
BCS	SKE	P	24-36	BRANCH ON SORTER K ERROR (error indicator is on).
BCS	DQK		24-36	BRANCH ON DOCUMENT TCD CORRECT, SORTER K.
BCS	NQK		24-36	BRANCH ON DOCUMENT TCD NOT CORRECT, SORTER K.

GE-235
DATANET-15 DATA TRANSMISSION SUBSYSTEM

The General Electric DATANET-15 enables the GE-235 Computer to automatically receive and process information originated at locations remote from the computer center and also to automatically send information (replies, results, etc.) to the remote locations.



DATANET-15 DATA TRANSMISSION CONTROLLER

The DATANET-15 serves as the primary control and connecting link between the GE-235 Computer and the transmission line and remote data-originating and receiving equipment.

Remote stations may be connected to the DATANET-15 through a variety of transmission facilities, including leased or public telephone and telegraph lines and privately owned, two-wire cables. The DATANET-15 can also be used to connect the GE-235 Computer to public message networks, such as AT&T's Teletypewriter Exchange Service (TWX) or Western Union's TELEX service.

EQUIPMENT

The basic DATANET-15 controller includes the equipment arrangements for connecting two channels.

The specific code level and speed of the DATANET-15 is determined by the type of remote station equipment used.

Code level may be any one of the following:

- Five channel
- Six channel
- Seven channel with or without odd parity
- Eight channel with or without odd parity

Speed of transmission is controlled by timing units. Any single speed between 60 and 2400 bits per second may be used. Standard timing units are as follows:

- 75 bits per second
- 100 bits per second
- 1050 bits per second

Options available include:

- 4 additional channels -- for 3-to-6 channel systems.
- 13 additional channels -- for 3-to-15 channel systems.
- Paper Tape Station Adapter -- for connection to GE Paper Tape Reader and Punch.
- Interface Adapters -- one for each teletype grade channel facility.

FUNCTIONS

The DATANET-15 will perform all of the following functions:

Receive Mode

- Recognize request for access by a remote station.
- Signal remote station that access is granted (under program control).
- Provide a remote station "Request for Access" queing arrangement.
- Initiate data flow (on instructions from computer program) from the remote station to the GE-235 Computer memory.
- Convert serial data to parallel form.
- Strip off special bits necessary for character transmission to GE-235 Computer.

- Supply own timing source for clocking bits of a received character.
- Receive inputs from interface adapters or digital subsets.
- Assemble data in GE-235 Computer memory for processing.
- Notify main computer program that data is ready for processing.
- Generate word parity for character to be transferred to GE-235.
- Signal GE-235 at the end of each finite character message block. (This is accomplished by recognition of a pre-selected end of message character code.)

Transmit Mode

- Recognize request from main computer program to transmit data to a designated remote station.
- Select the addressed remote station.
- Initiate data flow from the GE-235 memory to remote station.
- Accept parallel-bit code from GE-235 central processor and convert to serial form.
- Add special bits necessary for character transmission.
- Check parity on characters received from GE-235 Computer.
- Generate parity bit for seven and eight-channel code characters to be transmitted.
- Supply own timing source for transferring character bits serially into the transmission system.
- Supply transmission output to interface adapters or digital subsets.

CHECKING FEATURES

- Odd parity check when using seven and eight-channel codes.
- Automatic "Operator Error Code" detection.
- Two-to-thirty second delay alarm prevents noise pulses from giving false indication of remote station's request to transmit. Alarm will normally be set for a 15 second delay.
- Automatic alert halt upon detection of command word parity error.

DATANET-15 INSTRUCTIONS

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
SEL	P		24-36	SELECT. Selects the DATANET-15 connected to Controller Selector plug P.
RRM	C		36	RECEIVE REMOTE MESSAGE. Sets receive mode without affecting any other controller functions. Includes starting address in memory (Y) and maximum number of characters to be received (C).
(blank)	Y		36	
WRT	C+S		36	WRITE REMOTE MESSAGE. Positions DATANET-15 to correct station address, switches it to the transmit mode, and initiates transmission of data from GE-235 Computer memory.
(blank)	Y		36	
SCN	O		12	Places DATANET-15 in receive mode and scanning.
(blank)	O		12	
RRT	C		36	READ REMOTE TAPE. Turns DATANET-15 to not ready status, turns Paper Tape Reader on, and initiates the reading of paper tape. Includes the starting memory address and the maximum message length.
(blank)	Y		36	
WRT	C		36	WRITE REMOTE TAPE. Turns the DATANET-15 to the transmit mode, positions the scan counter on station number 00, gives the starting memory address from which data is to be removed, and controls the maximum message length.
(blank)	Y		36	

The following illustration shows the DATANET-15 command words as they appear in the GE-235 Computer memory. The Select command words which precede the DATANET-15 commands are not shown.

Command Word 1

Bits	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Set Transmit Mode	1	0	0	0	0	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S
Set Receive Mode	0	1	0	0	0	C	C	C	C	C	C	C	C	C	C	C	0	0	0	0
Start Scanning	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Read Paper Tape	0	1	0	1	0	C	C	C	C	C	C	C	C	C	C	C	0	0	0	0
Punch Paper Tape	1	0	0	0	1	C	C	C	C	C	C	C	C	C	C	C	0	0	0	0

Command Word 2

Bits	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	0	0	0	0	0	0	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

S = Station Address; 0-15

Y = Beginning memory location for input or output message.

C = Character Count; 1-2048 (must be 2's complement)

Test and Branch Instructions

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BCS	XXX	P	24-36	Branch on controller selector.
BCS	RCR	P	24-36	Branch if DATANET-15 is ready.
BCS	RCN	P	24-36	Branch if DATANET-15 is not ready.
BCS	RTD	P	24-36	Branch if N-Second delay occurred.
BCS	RNT	P	24-36	Branch if N-Second delay did not occur.
BCS	RAH	P	24-36	Branch on alert halt.
BCS	RNA	P	24-36	Branch on no alert halt.
BCS	REC	P	24-36	Branch if error code is detected.
BCS	RNC	P	24-36	Branch if error code is not detected.
BCS	RDP	P	24-36	Branch on data parity error.
BCS	RND	P	24-36	Branch on no data parity error.
BCS	RCP	P	24-36	Branch on command word parity error.
BCS	RNP	P	24-36	Branch on no command word parity error.
BCS	RSP	P	24-36	Branch if scanner is positioned on station requesting access.
BCS	RSN	P	24-36	Branch if scanner is not positioned on station requesting access.
BCS	RAE	P	24-36	Branch on any error.
BCS	RNE	P	24-36	Branch on no error.
BCS	REM	P	24-36	Branch if end of message code is detected.
BCS	RNM	P	24-36	Branch if no end of message code is detected.
BCS	REX	P	24-36	Branch on end of transmission.
BCS	RNX	P	24-36	Branch on no end of transmission.
BCS	RPH	P	24-36	Branch on paper tape halt.
BCS	RPT	P	24-36	Branch on no paper tape halt.

Mnemonic Oper. Code	Operand Address	Index Word	Time Microsec.	Description
BCS	ROV	P	24-36	Branch on character counter overflow.
BCS	RNO	P	24-36	Branch on no character counter overflow.
BCS	RAI	P	24-36	Branch if DATANET-15 attempted Automatic Program Interrupt.
BCS	RNI	P	24-36	Branch if DATANET-15 did not attempt Automatic Program Interrupt.

GE-235
CUSTOM DIGITAL INPUT/OUTPUT EQUIPMENT

- Enable the GE-235 to receive information from special peripherals such as sensors, readers, analog devices, etc.
- Operate, through the controller selector, simultaneously with the central processor and standard GE-235 peripherals.
- Are custom-tailored to fit special problems of customer's present needs and equipment.
- Perform parity checks on all input and output data transfers.
- Require only minor circuit changes to adapt the system to new applications in the interface area.

DIGITAL INPUT/OUTPUT ADAPTOR (DI/OA)

- Provides a single, one-directional channel for transferring data between the GE-235 and an external device.
- Transfers data at the rate of 50,000 twenty-bit words per second.
- Consists of swing-out modules located within the central processor.
- Requires no programming except for the use of the SEL P instruction.

DIGITAL INPUT/OUTPUT BUFFER (DI/OB)

- Moves data between two external buffers and the GE-235.
- Transfers data at the rate of 18,000 twenty-bit words per second.
- Housed in a cabinet 40-1/8 inches wide, 32-1/8 inches deep, 76 inches high; has its own power supply.

DIGITAL INPUT/OUTPUT CONTROLLER (DI/OC)

- Moves data between the GE-235 and up to 64 external devices.
- Transfers data at the rate of 18,000 twenty-bit words per second.
- Housed in a cabinet 40-1/8 inches wide, 32-1/8 inches deep, 76 inches high; has its own power supply.

DIGITAL INPUT/OUTPUT DISTRIBUTOR (DI/OD)

- Moves data between four external buffers and the GE-235.
- Transfers data at the rate of 50,000 twenty-bit words per second.
- Housed in a cabinet 40-1/8 inches wide, 32-1/8 inches deep, 76 inches high; has its own power supply.

For programming the DI/OB and DI/OC, the SEL P instruction is always followed by two command words. The first command word gives, in octal, the memory address of information coming from a peripheral. The second command word gives, in octal, the memory address of the information going to a peripheral.

For Multiple Cycle:

```
SEL P
OCT        10XXXXX
OCT        04XXXXX
```

For Single Cycle:

```
SEL P
OCT        12XXXXX
OCT        06XXXXX
```

For Multiple Cycle with Automatic Priority Interrupt:

```
SEL P
OCT        11XXXXX
OCT        05XXXXX
```

For Single Cycle with Automatic Priority Interrupt:

```
SEL P
OCT        13XXXXX
OCT        07XXXXX
```

The following branch conditions may be tested for through the use of the OCT command.

Octal	
2514P20	DI/OB (DI/OC) Not Ready
2516P20	DI/OB (DI/OC) Ready
2514P21	No parity error on DI/OB (DI/OC)
2516P21	Parity error on DI/OB (DI/OC)
2514P22	CW1 Not Busy
2516P22	CW1 Busy
2514P23	CW2 Not Busy
2516P23	CW2 Busy

GE -235 SYSTEM INSTALLATION DATA

The data in this appendix is furnished for general information only and should not be used in site design and preparation. Actual planning should be made on the latest revised information that will be furnished by GE Sales Representatives and Product Service Engineers.

Component Sizes and Weights

Component	Overall Dimensions (inches)			Weight (pounds)	Power Requirements (KVA)
	Width	Depth	Height		
Central Processor and Control Console (a 16K memory, typewriter, and card reader)	161-3/4	87-3/8	76	2000	9
Magnetic Tape Handler - Dual Rack	24	32-1/8	76	690	2
- Single Rack	24	32-1/8	76	400	1
Magnetic Tape Controller	35	32-1/8	76	808	3
High Speed Printer	40-1/8	25-3/4	50-1/2	850	5.7
Printer Controller	40-1/8	32-1/8	76	858	
Card Reader (1000 CPM)	47	33	37	450	3.6
Card Punch	35	33	47-1/2	465	3
Perforated Tape Reader and Punch - GE Free Standing	38-3/16	30	61	250	1.4
Auxiliary Arithmetic Unit	40-1/8	32-1/8	76	1470	3.6
Document Handler - 12 Pocket	176	28	42	2255	7.4
Document Handler Adapter	40-1/8	32-1/8	76	910	2
Mass Random Access Data Storage	71	37-7/8	63-1/4	2050	3.8
MRADS Controller	40-1/8	32	76	700	2.0
MRADS Electronics	40-1/8	32-1/8	76	450	0.9
DATANET-15	40-1/8	32-1/8	76	858	1.3

Electrical Requirements

The GE-235 system operates from a standard 208Y/120-volt, 4-wire, 3-phase, 60-cycle AC source of electrical power.

Environmental Requirements

For optimum operation, the system area temperature should remain within the range of 72 to 78 degrees F. Tape storage and handling areas should also meet these requirements. Relative humidity should be held within the range of 40 to 60 percent.

ALPHABETIC LIST OF GE-235 GAP INSTRUCTIONS

The following list gives the abbreviations used to indicate the type of instruction or the GE-235 system unit affected by each GE-235 General Assembly Program (GAP) instruction.

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
ADD	0100000	(ARITH)	Add to Accumulator	12
ADO	2504032	(ARITH)	Add One to A	18
ALF	*******	(PSUDO)	Alphanumeric	
ANQ	2511400	(SHIFT)	Shift A into N and Q	12+
BAR BAN	2516020	(AAU)	Branch on AAU Not Ready	12
BAR BAR	2514020	(AAU)	Branch on AAU Ready	12
BAR BER	2514027	(AAU)	Branch on AAU Error	12
BAR BMI	2514021	(AAU)	Branch on AAU Minus	12
BAR BNE	2516027	(AAU)	Branch on AAU No Error	12

TYPE	REFERENCE
Address Modification	ADMOD
Arithmetic	ARITH
Automatic Priority Interrupt	API
Auxiliary Arithmetic Unit	AAU
Card Reader or Punch	CARD
Console	CONSL
Controller Selector	SEL
DATANET-15	DN15
Data Transfer	TRANS
Document Handler	DOC

TYPE	REFERENCE
High Speed Printer	PRINT
Internal Test and Branch	ITAB
Magnetic Tape	MAG
Mass Random Access Data Storage	MRADS
Optional Instruction	OPTNL
Perforated Tape Punch or Reader	PAPTP
Pseudo Instruction	PSUDO
Real Time Clock	CLOCK
Shift	SHIFT
Typewriter	TYPE

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
BAR BNO	2516023	(AAU)	Branch on AAU No Overflow	12
BAR BNU	2516024	(AAU)	Branch on AAU No Underflow	12
BAR BNZ	2516022	(AAU)	Branch on AAU Non-Zero	12
BAR BON	2516725	(AAU)	Branch on Overflow Hold not On	12
BAR BOO	2514725	(AAU)	Branch on Overflow Hold On	12
BAR BOV	2514023	(AAU)	Branch on AAU Overflow	12
BAR BPL	2516021	(AAU)	Branch on AAU Plus	12
BAR BUF	2514024	(AAU)	Branch on AAU Underflow	12
BAR BUN	2516726	(AAU)	Branch on Underflow Hold not On	12
BAR BUO	2514726	(AAU)	Branch on Underflow Hold On	12
BAR BZE	2514022	(AAU)	Branch on AAU Zero	12
BCN	2516006	(CARD)	Branch on Card Reader Not Ready	12
BCR	2514006	(CARD)	Branch on Card Reader Ready	12
BCS BAA	2514021	(PRINT)	Branch on Printer any Alert	24 - 36
BCS BEF	2514021	(MAG)	Branch on Mag Tape End-of-File	24 - 36
BCS BER	2514027	(MAG)	Branch on Error	24 - 36
	2514027	(MRADS)		24 - 36
	2514027	(PRINT)		24 - 36
BCS BET	2514022	(MAG)	Branch on Mag Tape End-of-Tape	24 - 36
BCS BIC	2516025	(MAG)	Branch on I/O Buffer Correct	24 - 36
	2516025	(MRADS)		24 - 36
BCS BIO	2514025	(MAG)	Branch on I/O Buffer Error	24 - 36
	2514025	(MRADS)		24 - 36
BCS BME	2514026	(MAG)	Branch on Mod 3 or 4 Error	24 - 36
BCS BNA	2516021	(PRINT)	Branch on Printer No Alert	24 - 36
BCS BNE	2516027	(MAG)	Branch on No Error	24 - 36
	2516027	(MRADS)		24 - 36
	2516027	(PRINT)		24 - 36
BCS BNF	2516021	(MAG)	Branch on Mag Tape No End-of-File	24 - 36

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
BCS BNM	2516026	(MAG)	Branch on No Mod 3 or 4 Error	24 - 36
BCS BNO	2516023	(PRINT)	Branch on Printer No Buffer Overflow	24 - 36
BCS BNP	2516022	(PRINT)	Branch on Printer Not Out of Paper	24 - 36
BCS BNR	2516023	(MAG)	Branch on Mag Tape Not Rewinding	24 - 36
BCS BNS	2516024	(PRINT)	Branch on Printer No Slew Alert	24 - 36
BCS BNT	2516022	(MAG)	Branch on Mag Tape No End-of-Tape	24 - 36
BCS BOP	2514022	(PRINT)	Branch on Printer Out of Paper	24 - 36
BCS BOV	2514023	(PRINT)	Branch on Printer Buffer Overflow	24 - 36
BCS BPC	2516024	(MAG)	Branch on Mag Tape Parity Correct	24 - 36
BCS BPE	2514024	(MAG)	Branch on Mag Tape Parity Error	24 - 36
BCS BPN	2516020	(PRINT)	Branch on Printer Not Ready	24 - 36
BCS BPR	2514020	(PRINT)	Branch on Printer Ready	24 - 36
BCS BRN	2516020	(MRADS)	Branch on MRADS Not Ready	24 - 36
BCS BRR	2514020	(MRADS)	Branch on MRADS Ready	24 - 36
BCS BRW	2514023	(MAG)	Branch on Mag Tape Rewinding	24 - 36
BCS BSA	2514024	(PRINT)	Branch on Printer Slew Alert	24 - 36
BCS BTN	2516020	(MAG)	Branch on Mag Tape Contr. Not Ready	24 - 36
BCS BTR	2514020	(MAG)	Branch on Mag Tape Controller Ready	24 - 36
BCS DQ1	2514032	(DOC)	Branch on Sorter 1 Document TCD Correct	24 - 36
BCS DQ2	2514033	(DOC)	Branch on Sorter 2 Document TCD Correct	24 - 36
BCS FAC	2516031	(MRADS)	Branch on File Correct	24 - 36
BCS FAE	2514031	(MRADS)	Branch on File Error	24 - 36
BCS FS1	2514024	(DOC)	Branch on Sorter 1 Ready and Feed Command Given	24 - 36
BCS FS2	2514025	(DOC)	Branch on Sorter 2 Ready and Feed Command Given	24 - 36
BCS F0C	2516032	(MRADS)	Branch on File 0 Correct	24 - 36
BCS F0E	2514032	(MRADS)	Branch on File 0 Error	24 - 36

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
BCS F0N	2516021	(MRADS)	Branch on File 0 Not Ready	24 - 36
BCS F0R	2514021	(MRADS)	Branch on File 0 Ready	24 - 36
BCS F1C	2516033	(MRADS)	Branch on File 1 Correct	24 - 36
BCS F1E	2514033	(MRADS)	Branch on File 1 Error	24 - 36
BCS F1N	2516022	(MRADS)	Branch on File 1 Not Ready	24 - 36
BCS F1R	2514022	(MRADS)	Branch on File 1 Ready	24 - 36
BCS F2C	2516034	(MRADS)	Branch on File 2 Correct	24 - 36
BCS F2E	2514034	(MRADS)	Branch on File 2 Error	24 - 36
BCS F2N	2516023	(MRADS)	Branch on File 2 Not Ready	24 - 36
BCS F2R	2514023	(MRADS)	Branch on File 2 Ready	24 - 36
BCS F3C	2516035	(MRADS)	Branch on File 3 Correct	24 - 36
BCS F3E	2514035	(MRADS)	Branch on File 3 Error	24 - 36
BCS F3N	2516024	(MRADS)	Branch on File 3 Not Ready	24 - 36
BCS F3R	2514024	(MRADS)	Branch on File 3 Ready	24 - 36
BCS IC1	2514026	(DOC)	Branch on Sorter 1 Invalid Character	24 - 36
BCS IC2	2514027	(DOC)	Branch on Sorter 2 Invalid Character	24 - 36
BCS NF1	2516024	(DOC)	Branch on Sorter 1 Not Ready or Feed Command Not Given	24 - 36
BCS NF2	2516025	(DOC)	Branch on Sorter 2 Not Ready or Feed Command Not Given	24 - 36
BCS NP1	2514022	(DOC)	Branch too late for Pocket, Sorter 1	24 - 36
BCS NP2	2514023	(DOC)	Branch too late for Pocket, Sorter 2	24 - 36
BCS NQ1	2516032	(DOC)	Branch on Sorter 1 Document TCD not Correct	24 - 36
BCS NQ2	2516033	(DOC)	Branch on Sorter 2 Document TCD not Correct	24 - 36
BCS PD1	2516022	(DOC)	Branch in Time for Sorter 1 Pocket Decision	24 - 36
BCS PD2	2516023	(DOC)	Branch in Time for Sorter 2 Pocket Decision	24 - 36

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
BCS RAE	2514027	(DN15)	Branch on DATANET-15 Any Error	24 - 36
BCS RAH	2514022	(DN15)	Branch on DATANET-15 Alert Halt	24 - 36
BCS RAI	2514034	(DN15)	Branch on DATANET-15 API Attempted	24 - 36
BCS RCN	2516020	(DN15)	Branch on DATANET-15 Not Ready	24 - 36
BCS RCP	2514025	(DN15)	Branch on DATANET-15 Command Word Parity	24 - 36
BCS RCR	2514020	(DN15)	Branch on DATANET-15 Ready	24 - 36
BCS RDP	2514024	(DN15)	Branch on DATANET-15 Data Parity Error	24 - 36
BCS REC	2514023	(DN15)	Branch on DATANET-15 Error Code	24 - 36
BCS REM	2514030	(DN15)	Branch on DATANET-15 End of Message	24 - 36
BCS REX	2514031	(DN15)	Branch on DATANET-15 End of Transmission	24 - 36
BCS RNA	2516022	(DN15)	Branch on DATANET-15 No Alert Halt	24 - 36
BCS RNC	2516023	(DN15)	Branch on DATANET-15 No Error Code	24 - 36
BCS RND	2516024	(DN15)	Branch on DATANET-15 No Data Parity Error	24 - 36
BCS RNE	2516027	(DN15)	Branch on DATANET-15 No Error	24 - 36
BCS RNI	2516034	(DN15)	Branch on DATANET-15 API Not Attempted	24 - 36
BCS RNM	2516030	(DN15)	Branch on DATANET-15 No End of Message	24 - 36
BCS RNO	2516033	(DN15)	Branch on DATANET-15 No Counter Overflow	24 - 36
BCS RNP	2516025	(DN15)	Branch on DATANET-15 No Command Word Parity	24 - 36
BCS RNT	2516021	(DN15)	Branch on DATANET-15 No 15 Second Delay Occured	24 - 36
BCS RNX	2516031	(DN15)	Branch on DATANET-15 No End of Transmission	24 - 36
BCS ROV	2514033	(DN15)	Branch on DATANET-15 Counter Overflow	24 - 36

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
BCS RPC	2516026	(MRADS)	Branch on MRADS Parity Correct	24 - 36
BCS RPE	2514025	(MRADS)	Branch on MRADS Parity Error	24 - 36
BCS RPH	2514032	(DN15)	Branch on DATANET-15 Paper Tape Halted	24 - 36
BCS RPT	2516032	(DN15)	Branch on DATANET-15 Paper Tape Not Halted	24 - 36
BCS RSN	2516026	(DN15)	Branch on DATANET-15 Scanner Not Positioned	24 - 36
BCS RSP	2514026	(DN15)	Branch on DATANET-15 Scanner Positioned	24 - 36
BCS RTD	2514021	(DN15)	Branch on DATANET-15 Second Delay Occured	24 - 36
BCS S1C	2516030	(DOC)	Branch on Sorter 1 Correct	24 - 36
BCS S1E	2514030	(DOC)	Branch on Sorter 1 Error	24 - 36
BCS S1N	2516020	(DOC)	Branch on Sorter 1 Not Ready	24 - 36
BCS S1R	2514020	(DOC)	Branch on Sorter 1 Ready	24 - 36
BCS S2C	2516031	(DOC)	Branch on Sorter 2 Correct	24 - 36
BCS S2E	2514031	(DOC)	Branch on Sorter 2 Error	24 - 36
BCS S2N	2516021	(DOC)	Branch on Sorter 2 Not Ready	24 - 36
BCS S2R	2514021	(DOC)	Branch on Sorter 2 Ready	24 - 36
BCS VC1	2516026	(DOC)	Branch on Sorter 1 Valid Character	24 - 36
BCS VC2	2516027	(DOC)	Branch on Sorter 2 Valid Character	24 - 36
BCS 0+F	2516020	(SEL)	Controller Condition 0 False	24 - 36
BCS 0+T	2514020	(SEL)	Controller Condition 0 True	24 - 36
BCS 1+F	2516021	(SEL)	Controller Condition 1 False	24 - 36
BCS 1+T	2514021	(SEL)	Controller Condition 1 True	24 - 36
BCS 2+F	2516022	(SEL)	Controller Condition 2 False	24 - 36
BCS 2+T	2514022	(SEL)	Controller Condition 2 True	24 - 36
BCS 3+F	2516023	(SEL)	Controller Condition 3 False	24 - 36
BCS 3+T	2514023	(SEL)	Controller Condition 3 True	24 - 36
BCS 4+F	2516024	(SEL)	Controller Condition 4 False	24 - 36
BCS 4+T	2514024	(SEL)	Controller Condition 4 True	24 - 36

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
BCS 5+F	2516025	(SEL)	Controller Condition 5 False	24 - 36
BCS 5+T	2514025	(SEL)	Controller Condition 5 True	24 - 36
BCS 6+F	2516026	(SEL)	Controller Condition 6 False	24 - 36
BCS 6+T	2514026	(SEL)	Controller Condition 6 True	24 - 36
BCS 7+F	2516027	(SEL)	Controller Condition 7 False	24 - 36
BCS 7+T	2514027	(SEL)	Controller Condition 7 True	24 - 36
BCS 8+F	2516030	(SEL)	Controller Condition 8 False	24 - 36
BCS 8+T	2514030	(SEL)	Controller Condition 8 True	24 - 36
BCS 9+F	2516031	(SEL)	Controller Condition 9 False	24 - 36
BCS 9+T	2514031	(SEL)	Controller Condition 9 True	24 - 36
BEV	2516000	(ITAB)	Branch On Even	24 - 36
BKW	1600000	(MAG)	Backspace and Position Write Head	24 - 36
BMI	2514001	(ITAB)	Branch on Minus	24 - 36
BNN	2516005	(CONSL)	Branch on N Register Not Ready	12
	2516005	(PAPTP)		12
BNO	2516003	(ITAB)	Branch On No Overflow	12
BNR	2514005	(CONSL)	Branch On N Register Ready	12
	2514005	(PAPTP)		12
BNZ	2516002	(ITAB)	Branch On Non-Zero	12
BOD	2514000	(ITAB)	Branch On Odd	12
BOV	2514003	(ITAB)	Branch On Overflow	12
BPC	2516004	(ITAB)	Branch on Parity Correct	12
BPE	2514004	(ITAB)	Branch on Parity Error	12
BPL	2516001	(ITAB)	Branch On Plus	12
BPN	2516007	(CARD)	Branch On Card Punch Not Ready	12
BPR	2514007	(CARD)	Branch On Card Punch Ready	12
BRU	2600000	(ITAB)	Branch Unconditionally	6
BSS	*******	(PSUDO)	Block Started by Symbol	

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
BXH	0500000	(ADMOD)	Branch if Index Word is High or Equal	18
BXL	0400000	(ADMOD)	Branch if Index Word is Low	18
BZE	2514002	(ITAB)	Branch On Zero	12
CAB	2100000	(OPTNL)	Compare and Branch	12 - 24
CHS	2504040	(ARITH)	Change Sign of A	12
CPL	2504502	(ARITH)	Complement A	18
DAD	1100000	(ARITH)	Double Length Add	18
DCB	2200000	(OPTNL)	Double Length Compare and Branch	18 or 36
DDC	*******	(PSUDO)	Double Length Decimal	
DEC	*******	(PSUDO)	Decimal	
DLD	1000000	(TRANS)	Double Length Load	18
DNO	2513200	(SHIFT)	Double Length Normalize	18+
DST	1300000	(TRANS)	Double Length Store	18
DSU	1200000	(ARITH)	Double Length Subtract	30
DVD	1600000	(ARITH)	Divide	156 - 174
EJT	*******	(PSUDO)	Eject Printer Paper	
END	*******	(PSUDO)	End Of Program	
EQO	*******	(PSUDO)	Equals Octal	
EQU	*******	(PSUDO)	Equals	
ERB	0120000	(DOC)	End Document Handler, Read Busy	36
EXT	2000000	(TRANS)	Extract	18
FAD	3100000	(AAU)	Floating Point Add - Normalized	30 - 36
	3100000	(AAU)	Floating Point Add - Unnormalized	30 - 36
	3100000	(AAU)	Double Precision Fixed Point Add	24
FDC	*******	(PSUDO)	Floating Point Decimal	
FDV	3600000	(AAU)	Floating Point Divide - Normalized	72 - 78
	3600000	(AAU)	Floating Point Divide - Unnormalized	72 - 78
	3600000	(AAU)	Double Precision Fixed Point Divide	96 - 102

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
FLD	3000000	(AAU)	Floating Point Load	18
FMP	3500000	(AAU)	Floating Point Multiply - Normalized	36 - 78
	3500000	(AAU)	Floating Point Multiply - Unnormalized	36 - 78
	3500000	(AAU)	Double Precision Fixed Point Multiply	96 - 102
FST	3300000	(AAU)	Floating Point Store	18
FSU	3200000	(AAU)	Floating Point Subtract - Normalized	30 - 36
	3200000	(AAU)	Floating Point Subtract - Unnormalized	30 - 36
	3200000	(AAU)	Double Precision Fixed Point Subtract	24
HCR	2500004	(CARD)	Halt Card Reader	12
HLT	0100000	(DOC)	Halt Continuous Feed	36
HPT	2500016	(PAPTP)	Halt Perforated Tape Reader	12
INX	1400000	(ADMOD)	Increment Index Word	18
KON	2500013	(TYPE)	Keyboard On	12
LAC	2504202	(CLOCK)	Load Accumulator From Clock	18
LAQ	2504001	(TRANS)	Load A From Q	18
LAQA	3600002	(AAU)	Load AX From QX	6
LCA	2504210	(CLOCK)	Load Clock from Accumulator	18
LDA	0000000	(TRANS)	Load Accumulator	12
LDO	2504022	(TRANS)	Load One Into A	18
LDX	0600000	(ADMOD)	Load Index Word	18
LDZ	2504002	(TRANS)	Load Zero Into A	18
LMO	2504102	(TRANS)	Load Minus One Into A	18
LOC	*******	(PSUDO)	Location In Octal	
LQA	2504004	(TRANS)	Load Q from A	18
LQAA	3200002	(AAU)	Load QX from AX	6
LST	*******	(PSUDO)	List	
MAL	*******	(PSUDO)	Multiple Alphanumeric	

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
MAQ	2504006	(TRANS)	Move A to Q	18
MAQA	3100002	(AAU)	Move AX to QX	6
MOV	2400000	(OPTNL)	Move A Block of Data	24 + 12N
MPY	1500000	(ARITH)	Multiply	54 - 138
NAL	*******	(PSUDO)	Negative Alphanumeric	
NAM	*******	(PSUDO)	Print Name on GAP Listing	
NAQ	2511100	(SHIFT)	Shift N, A, and Q Right	12+
NEG	2504522	(ARITH)	Negate A Register	18
NLS	*******	(PSUDO)	No List	
NOP	2504012	(ITAB)	No Operation	18
NOR	2513000	(SHIFT)	Normalize A Register	18+
OCT	*******	(PSUDO)	Octal	
OFF	2500005	(CONSL)	Turn Off Typewriter, PT Punch + PT Reader	12
ORG	*******	(PSUDO)	Origin	
ORY	2300000	(TRANS)	Or Accumulator Into Y	18
PAL	*******	(PSUDO)	Printer Alphanumeric	
PKT	0060000	(DOC)	Pocket Select	36
PLD	*******	(PSUDO)	Punch Loader	
PON	2500015	(PAPTP)	Turn On Perforated Tape Punch	12
PRF	2500000	(MRADS)	Position Arm of MRADS Unit	36
RAW	1202000	(MRADS)	Read After Write Check	36
RBB	1500000	(MAG)	Read Backward Binary	36
RBD	1400000	(MAG)	Read Backward Decimal	36
RBS	3500000	(MAG)	Read Backward Special Binary	36
RCB	2500001	(CARD)	Read Cards Binary	12
RCD	2500000	(CARD)	Read Cards Decimal	12
RCF	2500010	(CARD)	Read Card Full	12
RCM	2500012	(CARD)	Read Card Mixed Modes, Alphanumeric & Binary	12

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
RCS	2500011	(CONSL)	Read Console Switches	12
RDC	0040000	(DOC)	Read Document and Feed Next Document	36
REM	*******	(PSUDO)	Remarks	
RIN	3500004	(AAU)	Reset Indicators	6
RON	2500014	(PAPTP)	Turn Perforated Tape Reader On	12
ROV	3100004	(AAU)	Reset Overflow Hold	6
RPT	2500006	(PAPTP)	Read Perforated Tape	12
RRD	1201000	(MRADS)	Read MRADS and Release Arm	36
RRF	1200000	(MRADS)	Read MRADS File	36
RRM	1000000	(DN15)	Read Remote Message	36
RRT	1200000	(DN15)	Read Remote Tape	36
RSD	0020000	(DOC)	Read Single Document	36
RTB	0500000	(MAG)	Read Tape Binary	36
RTD	0400000	(MAG)	Read Tape Decimal	36
RTS	2500000	(MAG)	Read Tape Special Binary	36
RUN	3200004	(AAU)	Reset Underflow Hold	6
RWD	2000000	(MAG)	Rewind	36
SAN	2510400	(SHIFT)	Shift A and N Right	12+
SBO	2504112	(ARITH)	Subtract One From A	18
SBR	*******	(PSUDO)	Call Subroutine	
SCA	2510040	(SHIFT)	Shift Circular A	12+
SCD	2511200	(SHIFT)	Shift Circular Double Accumulator	12+
SCN	1400000	(DN15)	Start Scanning	12
SEL P	2500P20	(SEL)	Select Controller Selector Address	24 - 36
SEQ	*******	(PSUDO)	Check Sequence Numbers	
SET BINMODE	2506012	(OPTNL)	Set Binary Mode	12
SET DECMODE	2506011	(OPTNL)	Set Decimal Mode	12
SET FIXPOINT	3500010	(AAU)	Set Fixed Point	6
SET NFLPOINT	3100010	(AAU)	Set Normalized Floating Point	6

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
SET PBK	2506016	(API)	Set Off Automatic Priority Interrupt	12
SET PST	2506015	(API)	Set On Automatic Priority Interrupt	12
SET UFLPOINT	3200010	(AAU)	Set Unnormalized Floating Point	6
SLA	2512000	(SHIFT)	Shift Left Accumulator	12+
SLD	2512200	(SHIFT)	Shift Left Double Accumulator	12+
SLT	0500000	(PRINT)	Slew Printer Paper to Tape Punch	36
SLW	0600000	(PRINT)	Slew Printer Paper Specified Number of Lines	36
SNA	2510100	(SHIFT)	Shift N and A Right	12+
SPB	0700000	(ITAB)	Store P Register and Branch	12
SRA	2510000	(SHIFT)	Shift Right Accumulator	12+
SRD	2511000	(SHIFT)	Shift Right Double Accumulator	12+
STA	0300000	(TRANS)	Store Accumulator	12
STO	2700000	(TRANS)	Store Operand	18
STX	1700000	(ADMOD)	Store Index Word	18
SUB	0200000	(ARITH)	Subtract From Accumulator	18
SXG	2506YY3	(ADMOD)	Select Index Group	12
TCD	*******	(PSUDO)	Punch Transfer Card	
TON	2500007	(TYPE)	Turn Typewriter On	12
TYP	2500006	(TYPE)	Type	12
WAI	2504010	(ITAB)	Who Am I?	18
WCB	2500003	(CARD)	Write Card Binary	12
WCD	2500002	(CARD)	Write Card Decimal	12
WCF	2500017	(CARD)	Write Card Full	12
WEF	0200000	(MAG)	Write End-of-File	36
WFL	3600000	(PRINT)	Write Format Line	36
WPL	2600000	(PRINT)	Write Print Line	36
WPT	2500006	(PAPTP)	Write Perforated Tape	12
WRD	3701000	(MRADS)	Write MRADS and Release Arm	36
WRF	3700000	(MRADS)	Write MRADS File	36

MNEMONIC	OCTAL CODE	USE	DESCRIPTION	TIME Microsec.
WRM	2000000	(DN15)	Write Remote Message	36+
WRT	2100000	(DN15)	Write Remote Tape	36+
WTB	0300000	(MAG)	Write Tape Binary	36
WTD	0200000	(MAG)	Write Tape Decimal	36
WTS	2300000	(MAG)	Write Tape Special Binary	36
XAQ	2504005	(TRANS)	EXCHANGE A and Q	18
XAQ A	3500002	(AAU)	Exchange AX and QX	6
ZXX	XX00000	(PSUDO)	XX Denotes Octal Configuration Desired	

REPRESENTATION OF GE-235 CHARACTERS

CHARACTER	HIGH SPEED PRINTER SYMBOLS	CONSOLE TYPEWRITER CHARACTER OR ACTION	CONSOLE TYPEWRITER CHARACTER OR ACTION	PAPER TAPE CHARACTER (8 CHANNEL)	HOLLERITH CODE (PUNCH IN ROWS)	BCD MEMORY (OCTAL)**	BCD MAGNETIC TAPE (OCTAL)
		INPUT	OUTPUT				
0	0	0		Space	0	00	12
1	1	1		1	1	01	01
2	2	2		2	2	02	02
3	3	3		3	3	03	03
4	4	4		4	4	04	04
5	5	5		5	5	05	05
6	6	6		6	6	06	06
7	7	7		7	7	07	07
8	8	8		8	8	10	10
9	9	9		9	9	11	11
A	A	A		/	12-1	21	61
B	B	B		S	12-2	22	62
C	C	C		T	12-3	23	63
D	D	D		U	12-4	24	64
E	E	E		V	12-5	25	65
F	F	F		W	12-6	26	66
G	G	G		X	12-7	27	67
H	H	H		Y	12-8	30	70
I	I	I		Z	12-9	31	71
J	J	J		J	11-1	41	41
K	K	K		K	11-2	42	42
L	L	L		L	11-3	43	43
M	M	M		M	11-4	44	44
N	N	N		N	11-5	45	45
O	O	O		O	11-6	46	46
P	P	P		P	11-7	47	47
Q	Q	Q		Q	11-8	50	50
R	R	R		R	11-9	51	51
S	S	S		B	0-2	62	22
T	T	T		C	0-3	63	23
U	U	U		D	0-4	64	24
V	V	V		E	0-5	65	25
W	W	W		F	0-6	66	26
X	X	X		G	0-7	67	27
Y	Y	Y		H	0-8	70	30
Z	Z	Z		I	0-9	71	31
+	+	&		0	12	20	60
-	-	-		-	11	40	40
Space	Blank	Blank		&	Blank	60	20
/	/	/		A	0-1	61	21
		ƀ	Index		2-8	12	12
#	#	∅	#	Stop	3-8	13	13
@	@	@			4-8	14	14
(Underline)	—	=			5-8	15	15
=	=	>			6-8	16	16
		√			7-8	17	
		?			12-2-8	32*	72
+0					12-0	32*	
.	.	.			12-3-8	33	73
*		⌑			12-4-8	34	74
		[			12-5-8	35	75
		<		Tab	12-6-8	36	76
		‡	Carriage Return		12-7-8	37	77
-0					11-0	52*	52
		!			11-2-8	52*	52
$	$	$		$	11-3-8	53	53
*	.	#			11-4-8	54	54
		]			11-5-8	55	55
		;			11-6-8	56	56
		Δ			11-7-8	57	57
		‡	Print Red		0-2-8	72	32
		,			0-3-8	73	33
%	%	%			0-4-8	74	34
(	=	⋎	Print Black		0-5-8	75	35
)	=	\	Tab		0-6-8	76	36
		⁕	Ignore	Delete	0-7-8	77	37

* The 400-card per minute card reader reads 11-0 and 11-2-8 as octal 152, and 12-2-8 as octal 32. If the BCD validity check switch is On, the 11-2-8 and 12-2-8 punches are treated as individual characters.

** The OCTAL notation is a shorthand for binary representation. Conversion between the two representations can be done mentally. In the OCTAL system, there are eight admissible symbols: 0, 1, 2, 3, 4, 5, 6, 7. Each may represent (when used) a maximum of three binary bits.

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