La Fay Stuart

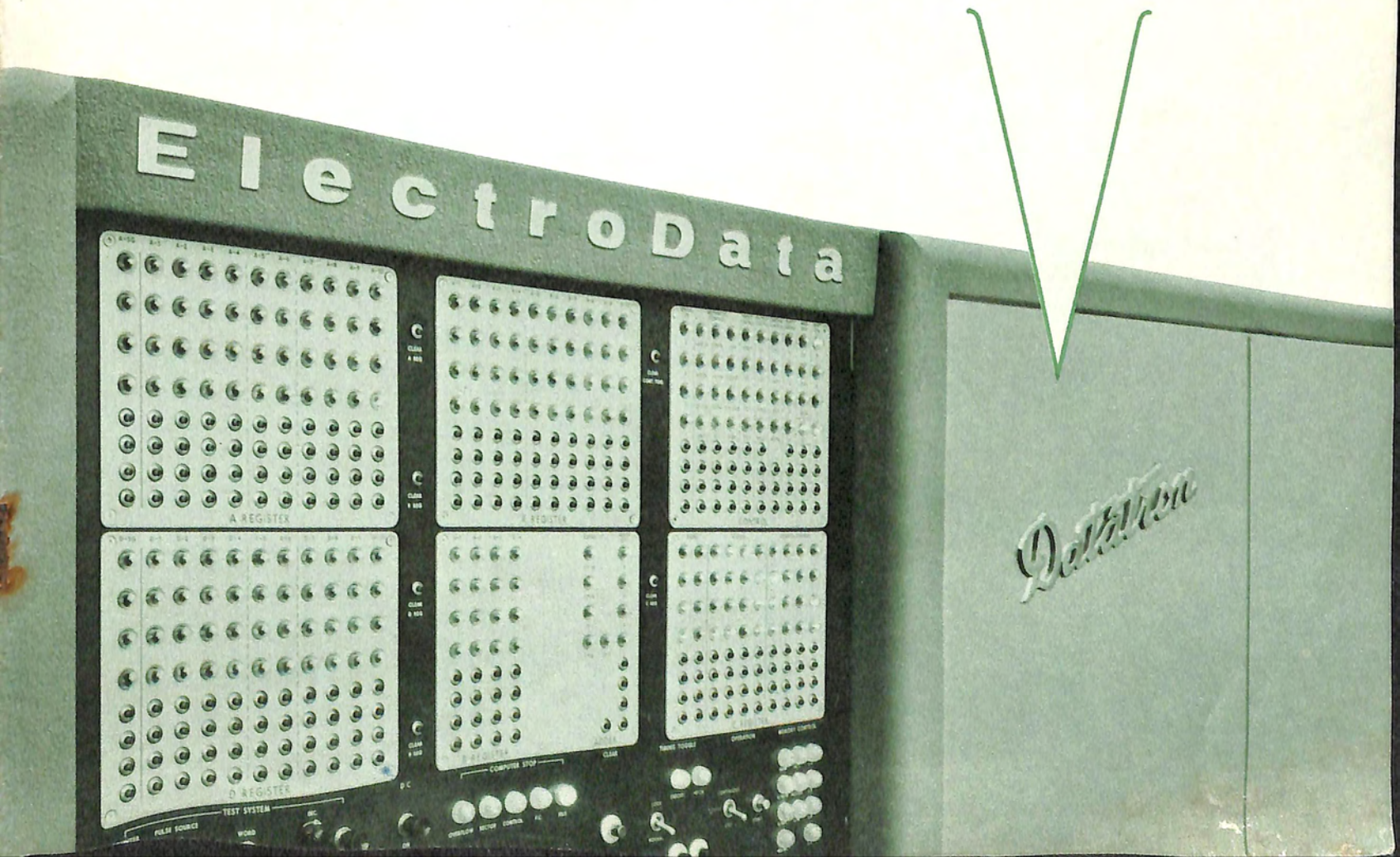
BULLETIN 3027

DATATRON

ELECTRONIC DATA PROCESSING SYSTEMS

HANDBOOK

control console and consolette



This Handbook supersedes and replaces previous editions of Bulletin 3040 A. Symbols and nomenclature used to designate commands conform to the revised standard practice adopted in March, 1956.

First printing May 1956

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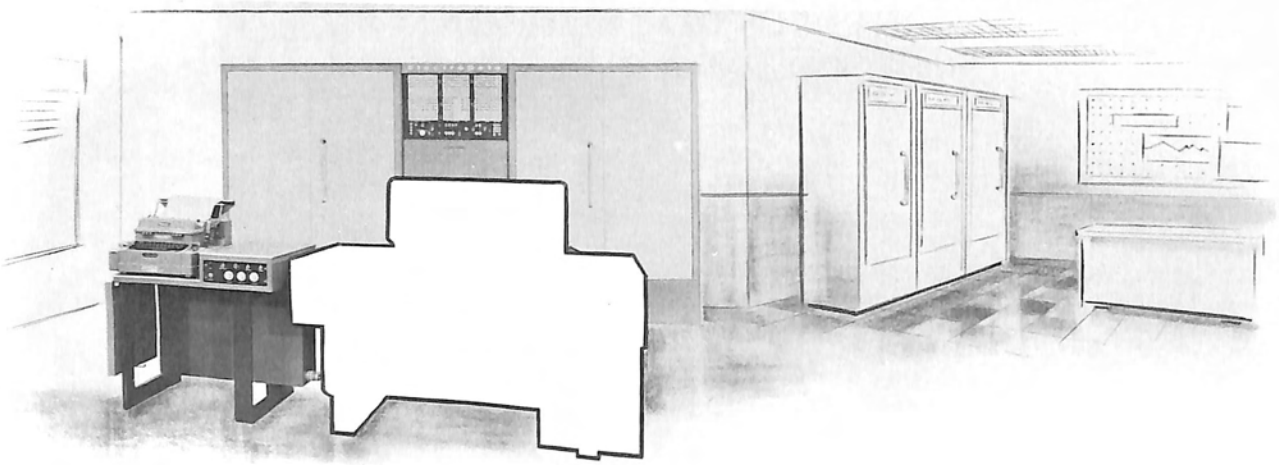


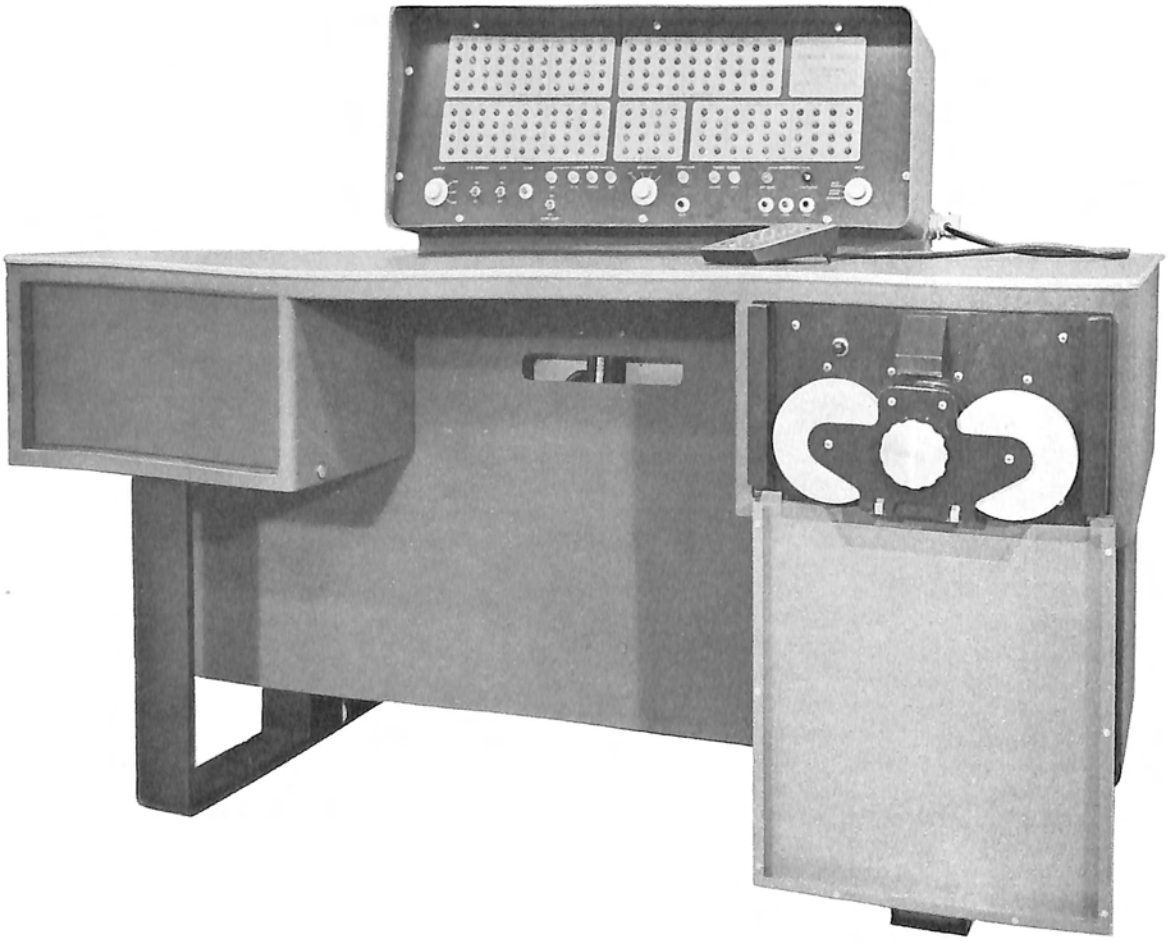


Figure 1 – Control Console

SECTION I—CONTROL CONSOLE

GENERAL

Control Console Model 403 (Figure 1) is a convenient desk-size operations center from which the machine operator can exercise complete supervision of the DATATRON system.

All indicators and controls used in program checking and in operating the DATATRON are grouped together in a Control Panel which is mounted on a pedestal at the rear of the Control Console. A decimal keyboard is provided for rapid and convenient manual input of data.

(Control Console Model 409 includes a Photoelectric Reader for high speed input of data punched into paper tape. Control Console Model 406 includes the Photoelectric Reader and a High Speed Tape Punch, housed in a separate cabinet, for output of data into punched paper tape.)

INDICATOR FUNCTIONS

1. Register Displays

The array of neon bulbs on the Control Panel indicates the contents of all registers in the computer **(A, B, C, D, and R)**. Each vertical column of four neon bulbs represents a decimal digit whose value is the sum of the values of the lighted bulbs. Reading from top to bottom, the bulbs represent **8, 4, 2, and 1**, respectively. No value greater than a decimal digit **9** normally appears in a single column of any register. Decimal digits are represented according to the following table:

	0	1	2	3	4	5	6	7	8	9
8 LIGHT	0	0	0	0	0	0	0	0	1	1
4 LIGHT	0	0	0	0	1	1	1	1	0	0
2 LIGHT	0	0	1	1	0	0	1	1	0	0
1 LIGHT	0	1	0	1	0	1	0	1	0	1

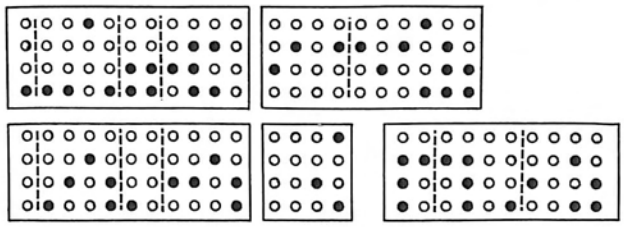
Information is represented in the registers as fixed length numbers, each of which contains ten decimal digits. Each ten digit number in the A Register and in the D Register is preceded by an additional digit which

– represents the algebraic sign of the number, or
– is sometimes used to control machine operation, or
– is an arbitrary zero having no special significance.

In the A Register, this digit is designated as A-SG. In the D Register, this digit is designated as D-SG. Other digits in all registers (Figure 2) are designated by the letter of the register and the number of the digit position from the left, not including the SG digit. For example: A-5, R-10, B-4, C-6 (Figure 3).

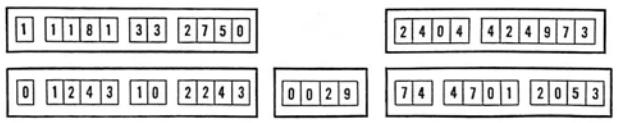
The three parts of the C Register separated by dotted lines are the Order Register (C-1, C-2), the Address Register (C-3, C-4, C-5, C-6), and the Control Counter (C-7, C-8, C-9, C-10).

A typical register display which looks like this:



o = off
● = on

represents these numbers:



which indicates that:

a. (–.1181 33 2750) is in the A Register.

b. (+.1243 10 2243) has been brought from the magnetic drum to the D Register.

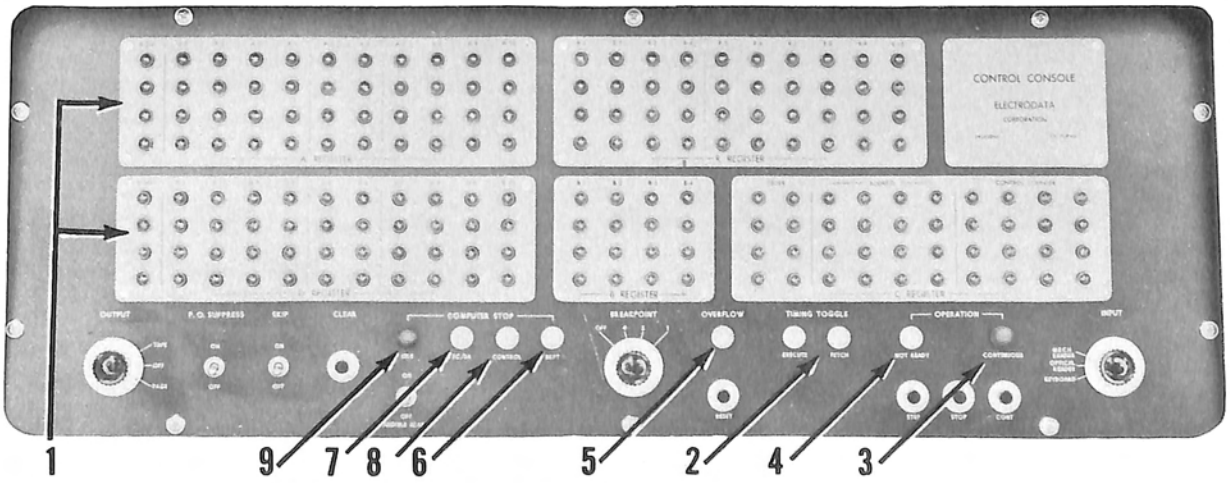


Figure 2 – Control Console Indicator Functions

c. The R Register and the B Register contain the numbers (2404 424973) and (0029) respectively.

d. The command that has been executed is (74).

e. The number in the D Register came from Storage Cell 4701.

f. The next command to be executed is in Storage Cell 2053.

2. Timing Toggle

This flip-flop determines the phase of the basic timing cycle of the DATATRON which alternates between the fetching of a command from the drum to the C Register and the execution of the command fetched. The state of the Timing Toggle is indicated on the console panel by two neon indicators labeled "FETCH" and "EXECUTE." The toggle is set to the opposite state at the beginning of each phase of the timing cycle. As a result, when the DATATRON is operating one step at a time, the Timing Toggle Indicators will show which of the two phases will be performed **next**. This means that FETCH will be lighted while the "execute" phase proceeds, and EXECUTE will be lighted while the "fetch" phase proceeds. During normal operation, the two phases alternate so rapidly that the indicators will not convey any useful information to the operator.

3. Continuous Indicator

CONTINUOUS will be lighted whenever the DATATRON is set to run continuously, or is in actual continuous operation.

4. Not Ready Indicator

NOT READY will be lighted whenever one or more of the switches on the computer cabinet control panel is not in its normal position.

5. Overflow Indicator

OVERFLOW will be lighted if any of the following conditions occur:

(a) Arithmetic overflow (a result exceeding the capacity of the A Register) during the execution of the various addition and subtraction commands, division, extracting, or rounding.

(b) Detection of a sign difference during the execution of an OSGD command.

If any command which causes overflow is not followed by a conditional change of control command, the DATATRON will stop with OVERFLOW, IDLE, and CONTROL lighted. The fractional sum or difference remains in the A Register after an overflow on addition or subtraction, but the A and R Registers are cleared after an overflow on division.

The conditional change of control commands CNZ, DB, and NOR will light OVERFLOW momentarily when the control change is to be executed.

6. Breakpoint Indicator

BREAKPOINT will be lighted when the DATATRON stops after executing a command with a controlled breakpoint code in the fifth control digit position of the command word.

7. FC/SA Indicator

FC/SA serves a dual purpose; it will be lighted, and the DATATRON will stop, whenever the checking circuitry detects the presence of either a "forbidden combination" or a "sector alarm."

A "forbidden combination" stop indicates the detection of a digit combination greater than **9** in any one of a number of locations. Forbidden combinations can be detected in A-10, D-10, R-10, B-4, C-6, C-10, and in the units column of the Shift Counter (not displayed on the Control Panel).

A "sector alarm" stop indicates that the DATATRON'S checking circuits have lost count of word positions on the drum. This stop prevents information from being read from or written in incorrect storage cells.

8. Control Indicator

CONTROL will be lighted when the DATATRON stops for a STOP command or an overflow.

9. Idle Indicator

IDLE will be lighted if the DATATRON stops for any reason. Also, when the DATATRON must wait for single operations to be completed, IDLE may light momentarily.

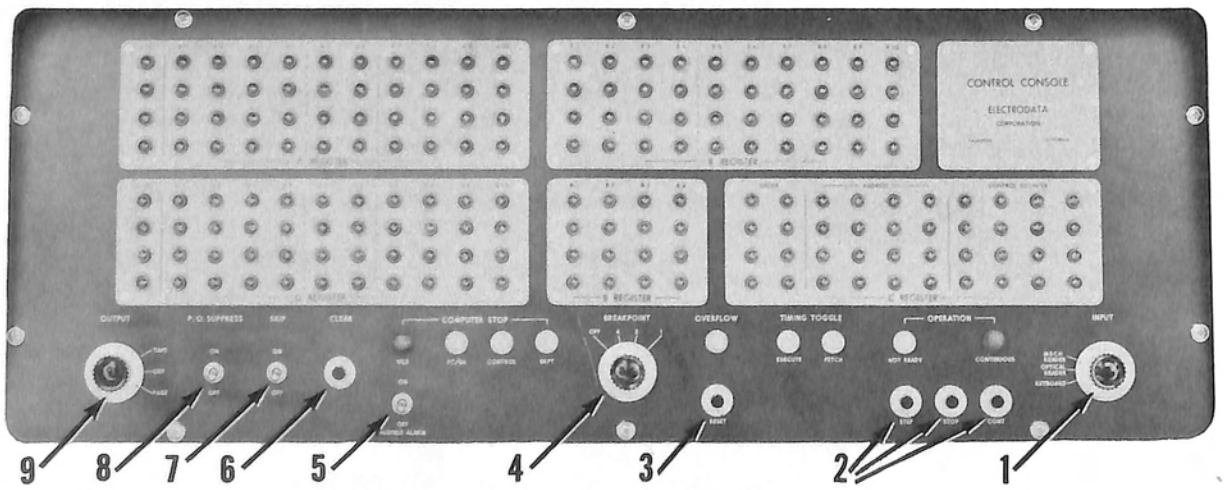


Figure 3 – Control Console Control Functions

CONTROL FUNCTIONS

1. Input Selector

INPUT has three positions: MECHANICAL READER, OPTICAL READER, and KEYBOARD. MECHANICAL READER selects a reader attached to the Flexowriter which can be included in the DATATRON system for input from paper tape. OPTICAL READER selects the Photoelectric Reader which can be included in the console for input from paper tape. Selecting KEYBOARD permits use of the decimal keyboard for manual input.

2. Operation Switches

The OPERATION switches are a group of three push buttons labeled STEP (2a), STOP (2b), and CONTINUOUS (2c). CONTINUOUS starts the DATATRON in continuous operation, turning on the CONTINUOUS indicator. The first operation will be to perform the function indicated by the Timing Toggle (fetch or execute) on the contents of the C Register. Thereafter, the DATATRON will continue in automatic sequential operation.

STOP will stop the DATATRON after termination of the current fetch or execute cycle. No information will be lost from the registers. The CONTINUOUS indicator will be turned off.

STEP controls single cycle operation of the DATATRON. When the CONTINUOUS indicator has been turned off by means of the STOP push button, the computer is in the STEP position. Pressing STEP will cause the DATATRON to perform the phase of the operation cycle specified by the Timing Toggle. This may be either "execute the command in the C Register," or "fetch the next command to the C Register." When this one phase is completed, the Timing Toggle indicates the next phase to be performed and the machine is idling. By repeatedly pressing STEP, an entire program may be stepped through one operation at a time.

3. Overflow Reset

OVERFLOW can be reset by pressing RESET located below the OVERFLOW indicator.

4. Breakpoint Switch

BREAKPOINT is a four-position switch with settings labeled OFF, **4**, **2**, and **1**. With BREAKPOINT in the OFF position, the breakpoint codes in the program will be ignored. When BREAKPOINT is not in the OFF position, the DATATRON will stop after executing a command containing a breakpoint digit with a binary component corresponding to the switch setting—**4**, **2**, or **1**.

Switch Setting	Breakpoint Digits Which Stop Computer
4	4, 5, 6, 7
2	2, 3, 6, 7
1	1, 3, 5, 7, 9
OFF	NONE

Pressing CONTINUOUS will start the DATATRON after a breakpoint stop.

5. Audible Alarm Switch

When this switch is ON, a buzzer will sound whenever the DATATRON stops. The buzzer is disabled if the switch is OFF.

6. Clear Button

Pressing CLEAR will clear all registers and indicators with the exception of the Shift Counter (not displayed on console), which will be set to **19**. The cleared position of the Timing Toggle is "execute." It should be noted that the operation of clearing all registers actually inserts the PTR command (00 0000 0000) into the C Register. Pressing CLEAR does not affect any information on the drum. CLEAR may also be used as an emergency stopping device.

7. Skip Switch

When SKIP is in the ON position, the DATATRON will skip the execute phase of any command with the digits **8** or **9** coded in the breakpoint position. When SKIP is in the OFF position, the DATATRON will ignore skip codes. If the skip code is a **9** (binary digits **8** and **1**), the **9** can also be used as a breakpoint code.

8. Printout Suppress Switch

PRINTOUT SUPPRESS, when ON, will cause the DATATRON to ignore paper tape system printout commands.

9. Output Selector

OUTPUT is a three-position switch with the settings OFF, TAPE, and PAGE. This switch controls paper tape system output. If a paper tape system printout command comes up for execution while the switch is in the OFF position, the DATATRON will stop and the IDLE indicator will be lighted.

10. Input Keyboard

INPUT KEYBOARD contains a key for each decimal digit and an F key (Figure 4). Pressing the F key completes the entry of a word into the computer. The keyboard is generally used to read in a few words at a time, as for inserting corrections or inserting or deleting breakpoint codes.

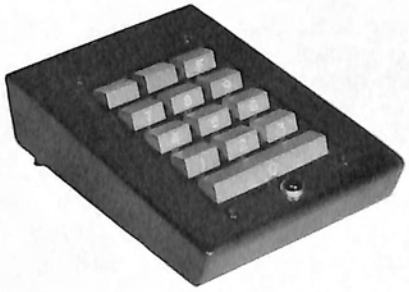


Figure 4 — Input Keyboard

METHODS OF OPERATION

1. To Insert Commands Into The C Register From The Keyboard

1) Press CLEAR button
2) Set Input Selector to KEYBOARD
3) Set DATATRON operation to STEP by pressing the STOP button
4) Press STEP button

The DATATRON is now ready to receive information. The "clear" operation set the PTR command (00 0000 0000) into the C Register, and switched the DATATRON to the "execute" phase. Pressing STEP initiated the execution of the input command, which in this case consisted of readying the DATATRON to receive (in the D Register) the information typed on the keyboard.

If the input is a single command, type a **6** on the keyboard (for the first control digit position) and then type the ten digits of the command word. After the **11** digits have been typed, examine the D Register display to see if the typing has been done correctly. If so, press the F key (end of word) to transfer the command portion (the last **6** digits typed) of the word to the C Register. Press STEP to execute the command.

If the input is a series of commands for individual execution (for example, a series of CLEAR ADD commands to examine the contents of various memory locations), follow the same procedure, but precede each command with a **4** for the first control digit position. The control digit **4** will keep the keyboard activated to accept the subsequent commands.

If the input is a command to change control to a starting point in a program already stored on the drum, press CONTINUOUS to execute the change of control command. The DATATRON will continue thereafter in automatic sequential operation.

2. To Insert One Word Into a Given Storage Location From The Keyboard

1) Press CLEAR button
2) Set Input Selector to KEYBOARD
3) Set DATATRON operation to STEP by pressing the STOP button
4) Press STEP button
5) Type on the keyboard the input command (4 0000 00 xxxx), where xxxx is the desired storage location. Press the F key to transfer the command to the C Register.
6) Type the desired word on the keyboard, using the standard 0 or 1 (+ or −) as the first control digit.
7) Press the F key to transfer the word to the A Register.
8) Press the STEP button to transfer the word to storage location xxxx. The word is not retained in the A Register.

3. To Load Consecutive Storage Locations From The Keyboard

1) Press CLEAR button
2) Set Input Selector to KEYBOARD
3) Set computer operation to CONTINUOUS by pressing the CONTINUOUS button
4) Type on the keyboard the input command (4 0000 00 xxxx), where xxxx is the storage location into which the first word is to be inserted. Press the F key to transfer the command to the C Register.
5) Type the first word to be inserted on the keyboard, using the standard 0 or 1 (+ or −) as the first control digit.
6) Press the F key to transfer the word to the drum.
7) Subsequent words are inserted into consecutive storage locations by repeating steps 5 and 6.

4. To Insert Breakpoints In A Program From The Keyboard

Follow the procedure described above for inserting a single word into storage to load each appropriate storage location with the command and breakpoint digit from the keyboard.

5. To Start The Datatron After A Manual Stop Or A Breakpoint Stop

Assuming that the stop was made for checking purposes, press CONTINUOUS.

6. To Start The Datatron On A New Program Already Loaded On The Drum

1) Follow the procedure given above for inserting a single command in the C Register to insert a CUxxxx into the C Register, where xxxx is the storage location of the first command.
2) Press CONTINUOUS button.

7. To Execute A Program Or A Portion Of A Program One Command At A Time

1) Insert a CUxxxx command into the C Register from the keyboard, where xxxx is the storage location of the first command to be checked.
2) Press STEP button. This will execute the CUxxxx command standing in the C Register, transferring control to the first command of the program being checked.
3) Continue to press the STEP button, alternately fetching a command from the drum to the C Register, and executing the command. Results of each operation may be checked visually in the Registers.

8. To Check A Program Already Loaded On The Drum

It may sometimes be desirable to check a program or a portion of a program after it has been loaded into storage without actually executing any of the commands. To accomplish this:

1) Insert a CUxxxx command into the C Register from keyboard, where xxxx is the address of the first command to be checked.
2) On the DATATRON Computer Cabinet Control Panel, set the Timing Toggle to FETCH and the Timing Toggle Lock to the LOCK position.
3) Press the STEP button to transfer the command into the C Register where it may be checked visually.
4) Continue to press the STEP button to transfer each command into the C Register in sequence.

An alternate method which will permit checking the control digit positions of each command word follows:

1) Insert via keyboard the following three commands into any convenient unoccupied storage locations, say, for example, addresses 6000, 6001, 6002.

6000	1	0001	CAD	xxxx
6001	0	0000	IB	0000
6002	0	0000	CU	6000

The address of the first command to be checked is xxxx.

2) Insert a CU 6000 command into the C Register from the keyboard.
3) Set the Breakpoint Selector to 1.
4) Press the CONTINUOUS button. Each time this is done, the DATATRON will cycle through the above short checking program to the breakpoint 1 stop. Each cycle will leave the next sequential command of the main program displayed in the A Register, where all **11** digits of the command word can be inspected.

9. To Stop The Datatron

Press the STOP button.

STOPS

The DATATRON may stop for any of the following reasons:

1. Stop Code

CONTROL and IDLE indicators will be lighted, and a STOP code (08) will be present in the C Register.

2. Breakpoint Stop

BREAKPOINT indicator and IDLE indicator will be lighted, and the command with the coded breakpoint digit will have been executed and will be present in the C Register.

3. Overflow Stop

OVERFLOW, CONTROL, and IDLE indicators will be lighted. The next command in sequence after the command which turned on the Overflow will be present in the C Register. The address of the command which caused the overflow can be determined by subtracting **2** from the contents of the Control Counter. On an Overflow stop, all registers retain their information except when the overflow is caused by division. After division overflow, the A and the R Registers will be cleared and the Special Counter will contain a binary **15**.

4. Forbidden Combination Stop

FC/SA and IDLE indicators will be lighted if the DATATRON stops on a forbidden combination. Forbidden combinations are detected in the last columns of the A, R, D, and B Registers, in columns C-6 and C-10 of the C Register, and in the units column of the Shift Counter (not displayed on the console). The operator can determine the location of the forbidden combination by inspecting the above locations.

5. Sector Alarm Stop

FC/SA and IDLE indicators will be lighted if the DATATRON stops on a sector alarm. This stop, which occurs if the memory tracking circuits lose count of word positions on the drum, prevents information from being read from or written in incorrect storage cells.

6. Stops For No Apparent Reason

A stop which lights only the IDLE indicator may be caused by:

1) Output selector switch set to OFF when a paper tape system printout command is to be executed.
2) A meaningless command in the Order Register.

PROGRAM DEBUGGING

1. General

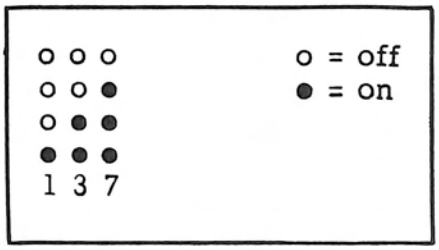
After a program has been coded and punched on tape or cards, it must be given a trial run on the computer. During this trial run, the programmer checks his routine for any errors in coding, scaling, or punching. This is called "debugging."

Points in the routine at which the operator can compare computer results with precalculated or predetermined data are called check points. If the coding is in error, the operator must retrace the computational path up to the point of error starting from a portion of the code which he knows to be correct.

2. Check Points

Check points can be identified easily by a system of breakpoints, or predetermined automatic stops. These stops are obtained by positioning the BREAKPOINT switch. This switch may be placed at the settings OFF, **4**, **2**, and **1**. The **4**, **2**, and **1** positions refer to binary components of the decimal digit used for the breakpoint code in the command word. The computer will stop after executing a command with a breakpoint code if the breakpoint digit contains a binary component which agrees with the setting of the breakpoint switch.

A convenient system of breakpoint codes is provided by the decimal digits **1**, **3**, and **7**, which provide three selectable levels of breakpoint stops. Shown below are the binary representations of **1**, **3**, and **7** as they would appear in the breakpoint digit:



With the switch set at **4**, a breakpoint **7** will cause a stop, but a **3** or **1** will not.

With the switch set at **2**, a breakpoint **7** or **3** will cause a stop, but **1** will not.

With the switch set at **1**, a breakpoint **7**, **3**, or **1** will cause a stop.

3. Using The Breakpoint

The stratification of stops, made available by the breakpoint switch makes it possible for an operator to run a routine with proper breakpoint coding first on a **4** setting of the switch to determine in which major portion of the code an error lies. By changing the switch setting first to **2** and then to **1**, the operator can narrow the range of points bounding the error. In the following table, the commands of the routine are omitted, leaving only the arrangement of breakpoint digits. Between any two breakpoint digits there might be only a few commands or a long section of coding.

On the first time through the program, with the BREAKPOINT switch set at **4**, the DATATRON stops only on the **7**'s; the operator discovers an error at the third **7** breakpoint. The error lies between it and the second **7** breakpoint.

Setting the switch at **2** and sending the program back to the second **7** breakpoint, the operator narrows the range of error location to the section of coding between the third and fourth **3** breakpoints.

Sending the program back to the third **3** breakpoint and proceeding with the BREAKPOINT switch set at **1**, the operator finds that the error is between the third **3** breakpoint and the third **1** breakpoint.

Returning once more to the third **3** breakpoint and proceeding by STEP operation, the operator can quickly and easily determine the exact location of the error.

- **a** first indication of error
- **b** first range of error location
- **c** second indication of error
- **d** second range of error location
- **e** third indication of error
- **f** third range of error location
- **g** exact location of error

	First Trial	Second Trial	Third and Fourth Trials
	Breakpoint Switch Setting 4	Breakpoint Switch Setting 2	Breakpoint Switch Setting 1
Breakpoint Digits	7	7	7
	3	3	3
	1	1	1
	7	7	7
	3	3	3
	1	1	1
	3	3	g 3 } f
	1 } b	1	e 1
	1	1 } d	1
	1	1	1
	3	c 3	3
	a 7	7	7
	3	3	3
	7	7	7

4. Correcting Errors

Once an error has been found, the operator may correct it in storage by inserting new words via the keyboard, or he may correct it on tape or cards and then reload the program. If correcting the error involves only a change in an order or an address, a trailer tape (or set of cards) can be added to the input. The trailer contains a few commands to record the correct information over what is already on the drum.

If correcting the error involves inserting missing instructions, the coder may store in the cell just preceding the one where the omitted command(s) should be, a CU command which will change control to a group of unused cells. Into these cells he puts the command replaced by the CU, the omitted command(s), and a CU back to the program. Renumbering the commands after inserting missing instructions involves a good deal of alteration of addresses and is usually not done unless the error is discovered before the program is run on the computer.

The following program, for example, will probably result in an error since the DIVIDE command has not been preceded by a CR command. It could, of course, be a small part of a much larger program.

Location Main	Location Loop	S	Control Digits	Operation No	Operation Alpha	Operand Address
0	4000 0				M	5000
1	4001 1				STC	5005
2	4002 2	1			CAD	1000
3	4003 3				SU	4008
4	4004 4				DIV	4009
5	4005 5	1			STC	2000
6	4006 6				DB	4002
7	4007 7				CUB	0360
8	4008 8			OPERAND		
9	4009 9			OPERAND		
0	0					
1	ORIGINAL PROGRAM					
2	2					

Location Main	Location Loop	S	Control Digits	Operation No	Operation Alpha	Operand Address
0	4000 0				M	5000
1	4001 1				STC	5005
2	4002 2	1			CAD	1000
3	4003 3				CU	4010
4	4004 4				DIV	4007
5	4005 5	1			STC	2000
6	4006 6				DB	4002
7	4007 7				CUB	0360
8	4008 8		OPERAND			
9	4009 9		OPERAND			
0	4010 0				SU	4008
1	4011 1				CR	0000
2	4012 2				CU	4004
3	3					
4	4	CORRECTION TO ORIGINAL PROGRAM				

Location		Control		Operation		Operand
Main	Loop	S	Digits	No	Alpha	Address
0	4000 0				M	5000
1	4001 1				STC	5005
2	4002 2	1			CAD	1000
3	4003 3				SU	4009
4	4004 4				CR	0000
5	4005 5				DIV	4010
6	4006 6	1			STC	2000
7	4007 7				DB	4002
8	4008 8				CUB	0360
9	4009 9		OPERAND			
0	4010 0		OPERAND			
1	1					
FINAL CORRECTED PROGRAM						

SECTION II — CONSOLETTE

GENERAL

Consolette Model 405 is a desk-top remote control unit for DATATRON installations which do not require the auxiliary features of the Control Console.

INDICATORS AND CONTROLS

The indicators and controls mounted on the Consolette are (Figure 5):

The purpose and use of these switches and indicators are explained in the preceding description of the Control Console. The only variation to be noted is that the three operation push button switches on the Control Console have been replaced on the Consolette by a START button and a two-position OPERATION switch labeled CONTINUOUS-STEP.

1. Operation Switch

When the Operation switch is in the CONTINUOUS position, the DATATRON is set for automatic sequential operation. With the switch in the STEP position, the DATATRON is set for single phase operation, i.e., to fetch or execute a single command at a time. The Operation switch also serves as a STOP switch, since the DATATRON can be stopped at any time by throwing the switch to the STEP position.

2. Start Button

Pressing the Start button performs the function specified by the state of the Timing Toggle (fetch a command, or execute a command) on the contents of the C Register, and the DATATRON will thereafter proceed in CONTINUOUS or STEP operation as dictated by the setting of the Operation switch.

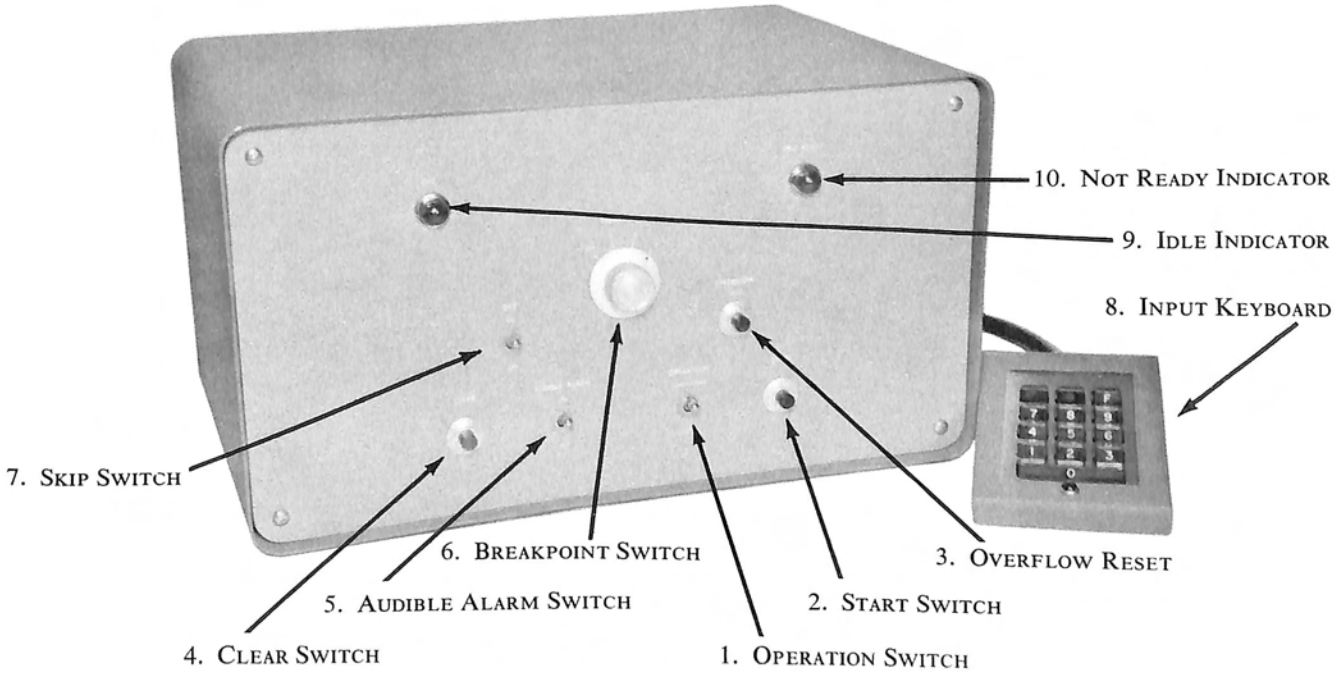


Figure 5 — Consolette (Indicators and Controls)

DATATRON

ELECTRONIC
DATA
PROCESSING
SYSTEMS

ElectroData
DIVISION OF BURROUGHS CORPORATION
460 SIERRA MADRE VILLA, PASADENA, CALIFORNIA

Printed in U.S.A.