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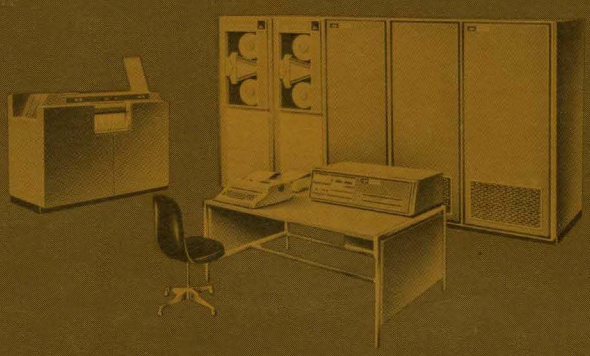
SIMULATING THE IBM 1620
On The
RAYTHEON 520



RAYTHEON COMPUTER

SIMULATING THE IBM 1620
On The
RAYTHEON 520

A User's Reference Manual

NOVEMBER 1965

PREFACE

This volume is but one of a number in the Raytheon Data Processing Library. Like its companion volumes, this one is dedicated to telling a particular story to a special audience: no attempt is made herein to be almost everything to almost everybody. The reader is invited to consult the catalog of this Library – or his Raytheon Computer Sales Representative – if this is not the volume in which he discovers himself to be interested.

"Simulating the IBM 1620 on the RAYTHEON 520. A User's Reference Manual," contains the skeletal information that is essential to operating the 520 when it simulates the 1620 – and little more. The detailed documentation of the Simulator itself – narrative descriptions, block diagrams, flow charts, code – is published in a separate package which ought not to be required by a user except in the extraordinary circumstance that the Simulator doesn't do what it is asserted to do in this document. Of course, the documentation is readily available to those who need it.

Every reasonable effort has been expended to make this volume error free. Experience tells us that the result will not be perfect. The editors and publishers will appreciate it, therefore, if errors of omission or commission are called to their attention. Communications of this kind should be addressed to:

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Simulating the IBM 1620

on the

RAYTHEON 520

A User's Reference Manual

CHAPTER 1

1. Introduction

The 1620 Simulator is a Raytheon 520 program that allows the 520 to execute 1620 machine code without alteration. To be more precise, the 520 simulates the 1620 Mod 1 computer; all basic and optional commands of the 1620, with the exception of those that refer to disk, are represented.

The Simulator can execute 1620 programs from approximately twice to approximately four times as fast as the same programs can be executed on the 1620 itself. The exact speed advantage is a function of many variables, of course, but experience indicates that, on the average, 1620 programs will be executed on the 520 in about one-third the time required to execute them on the 1620.

The simulation of 1620 input-output functions takes place at the rated speeds of the corresponding 520 peripheral devices. Hence, the advantage of the Simulator is determined simply by the ratio of the rated speeds of the peripheral devices of the 520 to those of the 1620.

CHAPTER 2

2. General Description

2.1 Initialization

Once the Simulator is loaded, control is transferred to a set-up routine. First, the set-up routine requests information about 1620 core size, program type, etc. Then, the set-up routine initializes the Simulator to operate as the 1620 specified by the user, after which the Simulator may be entered. After the Simulator is entered, the set-up routine is destroyed.

2.2 User Control

The user controls the Simulator through a console routine that resides in core throughout the simulation process. Users can enter data and examine the console status through the console routine. Error conditions, halts, and peripheral equipment status are also a function of the console routine.

2.3 The Simulation Process

The simulation process is controlled by a control routine that examines the 1620 location counter and jumps to the proper operation code routine. The operation code routine then converts the P and/or Q address portion of the 1620 instruction via an address conversion subroutine. The instruction is then simulated and control returned to the control sequence or the console routine.

In order to achieve the best speed ratio, two versions of the Simulator exist. The faster of the two versions does not expect 1620 memory wrap and assumes that the standard 1620 multiply and add tables will be simulated by using the fast version. The other version differs only in the execution of a few centralized subroutines. The insertion of the correct routines is handled by the set-up routine.

2.4 Environmental Requirements

Table 2.1 displays the correspondence between 1620-1 equipment to be simulated and the Raytheon equipment required for simulation. Controllers are not enumerated in the Table.

The execution speeds quoted in the Introduction are for a 520 with two-μs main memory and 512 words of BIAX, as indicated in Table 2.1. However, the Simulator can be executed without BIAX. If the one-μs memory is used in the 520, Simulation will proceed at a significantly faster rate; on the other hand, if two-μs memory is used throughout, the simulation will be somewhat slower. If the Simulator is to be used on a 520 without BIAX, the first three entries in Table 2.1 should be modified as shown in Table 2.2.

2.5 Memory Organization

2.5.1 Simulator Layout

Maps of 520 memory corresponding to each 1620 simulated are shown in Table 2.3.

Table 2.1

Raytheon 520	IBM 1620
520 CPU	1620-1 CPU
8,192 words, 512 BIAX	20,000 digits
16,384 words, 512 BIAX	40,000 digits
20,480 words, 512 BIAX	60,000 digits
Paper-Tape Reader	1620 Paper-Tape Reader
Paper-Tape Punch	1624 Paper-Tape Punch
Typewriter	Console Typewriter
Card Read/Punch	1622 Card Read/Punch
Line Printer	1443 Printer, Model 1
520-008 - 300 lpm - 120 columns	150 lpm - 120 columns
520-012 - 300 lpm - 160 columns	150 lpm - 144 columns
	1443 Printer, Model 2
520-008 - 300 lpm - 120 columns	240 lpm - 120 columns
520-012 - 300 lpm - 160 columns	250 lpm - 144 columns

Table 2.2

Raytheon 520	IBM 1620
520 CPU	1620-1 CPU
12,288 words	20,000 digits
16,384 words	40,000 digits
20,480 words	60,000 digits

Table 2.3

Usage	520 Addresses (Octal) 1620 Memory Size		
	20K	40K	60K
Special jump tables and working storage	00000 - 00377	00000 - 00377	00000 - 00377
Special add tables	00400 - 00445	00400 - 00445	00400 - 00445
I/O tables and buffers	00446 - 01225	00446 - 01225	00446 - 01225
Simulator routines	01226 - 06167	01226 - 06167	01226 - 06167
1620 memory	06170 - 17777	06170 - 31617	06170 - 43417
Not used	- - - -	31620 - 37777	43420 - 47777
Simulator routines (in BIAX)	70000 - 70777	70000 - 70777	70000 - 70777

2.5.2 Character Format

Four 1620 characters are packed in each 520 word:

1620 Character	520 Location
C	L [18–23]
C+1	L [12–17]
C+2	L [6–11]
C+3	L [0– 5]

The six bits used in the 520 are allocated to each 1620 character as follows:

1620	520			
Flag bit F	L [0–0],	L [6– 6],	L [12–12],	L [18–18]
Record mark, R	L [1–1],	L [7– 7],	L [13–13],	L [19–19]
Data bits, 8,4,2 and 1	L [2–5],	L [8–11],	L [14–17],	L [20–23]

2.5.3 Character Organization

The last 1620 character is always in 6170 [0–5]. The first 1620 character of the 20K memory is in 17777 [18–23]; of the 40K memory is in 31617 [18–23]; of the 60K is in 43417 [18–23]. Note that the order of increasing addresses in the 1620 is reversed in the 520. One result of this organization is improved efficiency of execution of arithmetic operations. Even though input-output functions suffer slightly, the Simulator is more than fast enough to satisfy input-output demands

Figure 2.1 is a more explicit representation of the memory layouts of the 520 and 1620 showing the correspondence between the two. In the Figure, the 40K 1620 memory is used.

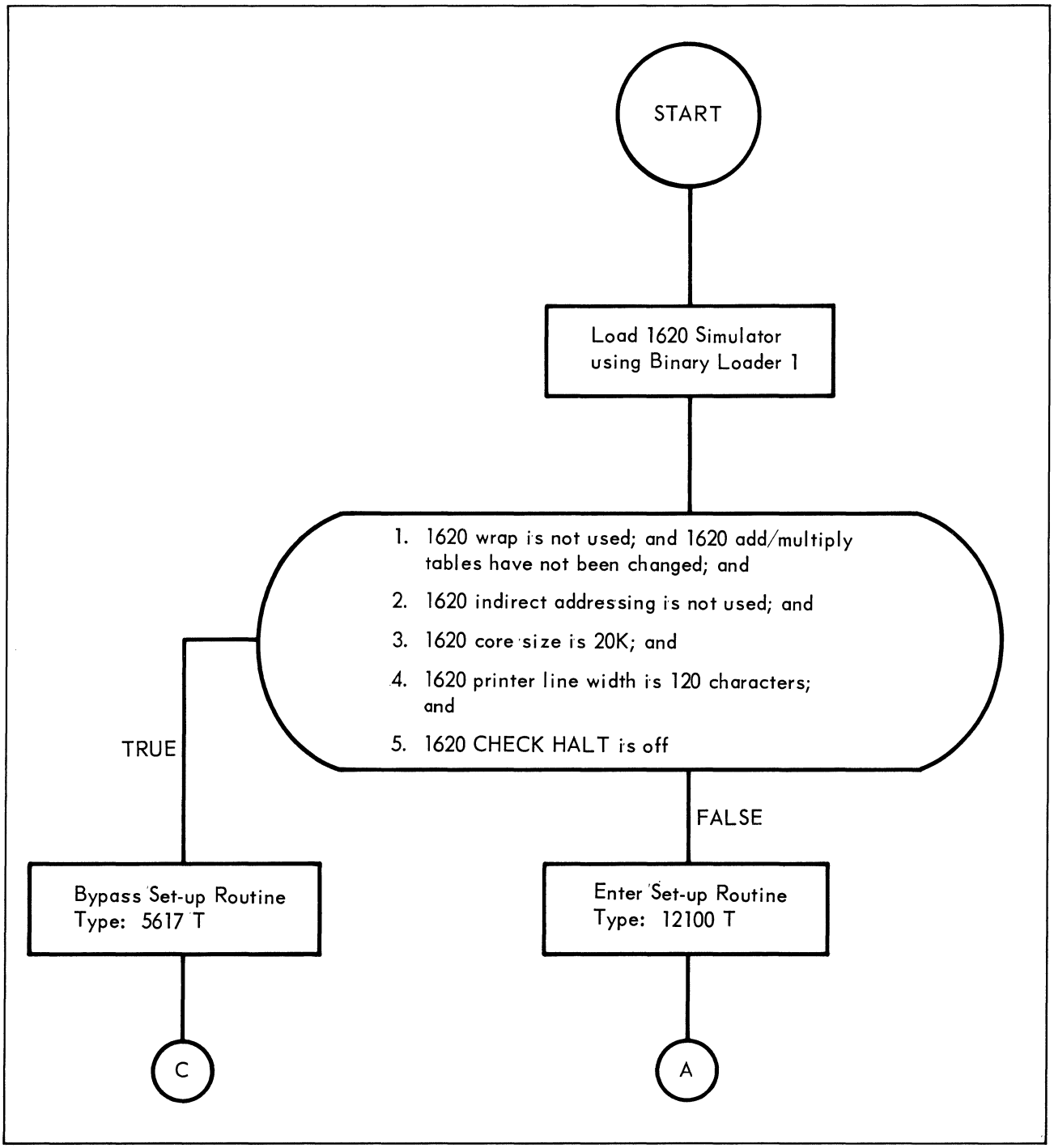
1620 Location (decimal)	520 Location (octal)
00000	31617 [18–23]
00001	31617 [12–17]
00002	31617 [6–11]
00003	31617 [0–5]
00004	31616 [18–23]
00005	31616 [12–17]
.	.
.	.
.	.
39994	6171 [6–11]
39995	6171 [0–5]
39996	6170 [18–23]
39997	6170 [12–17]
39998	6170 [6–11]
39999	6170 [0–5]

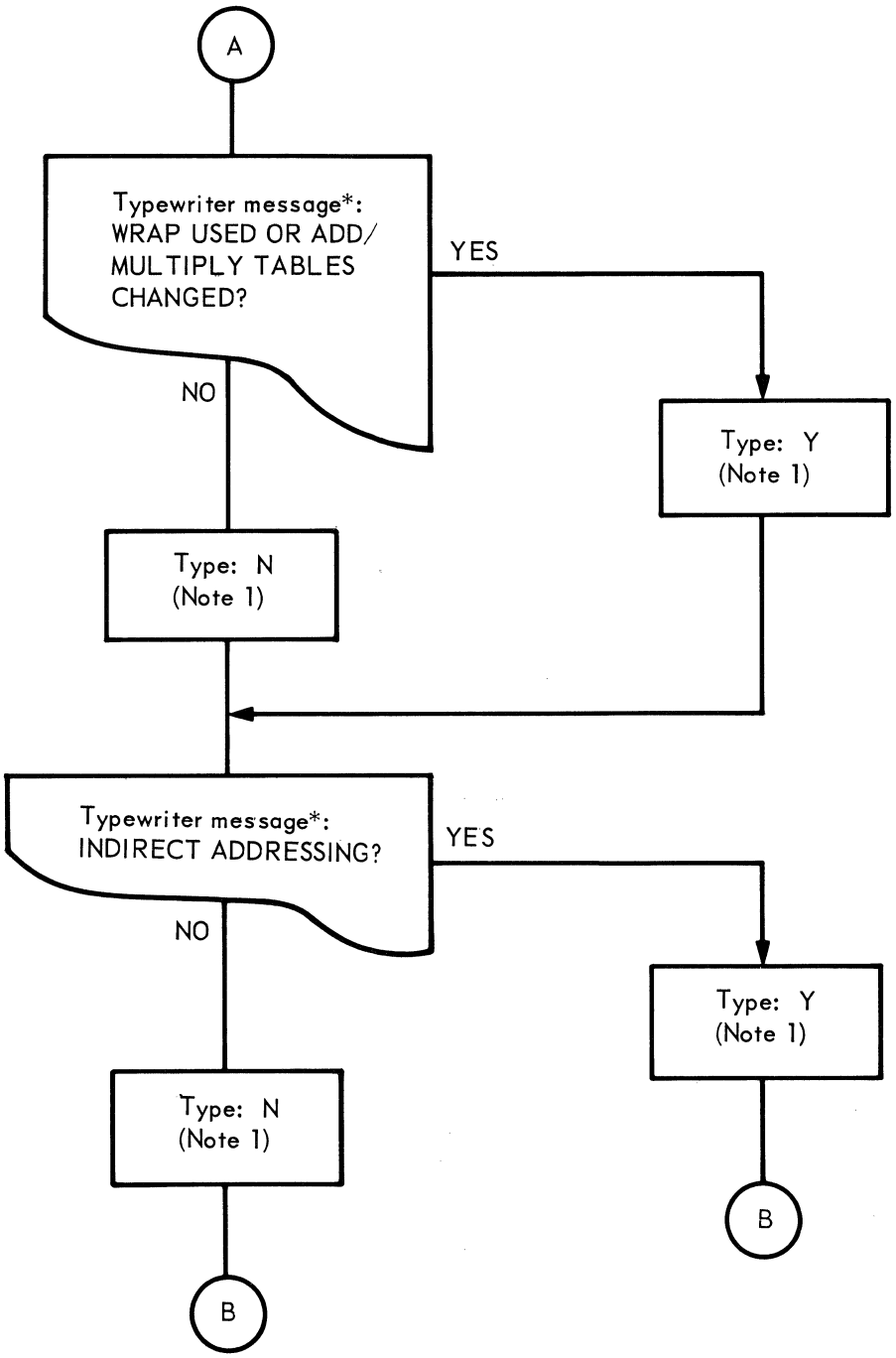
Figure 2.1

CHAPTER 3

Operating Instructions

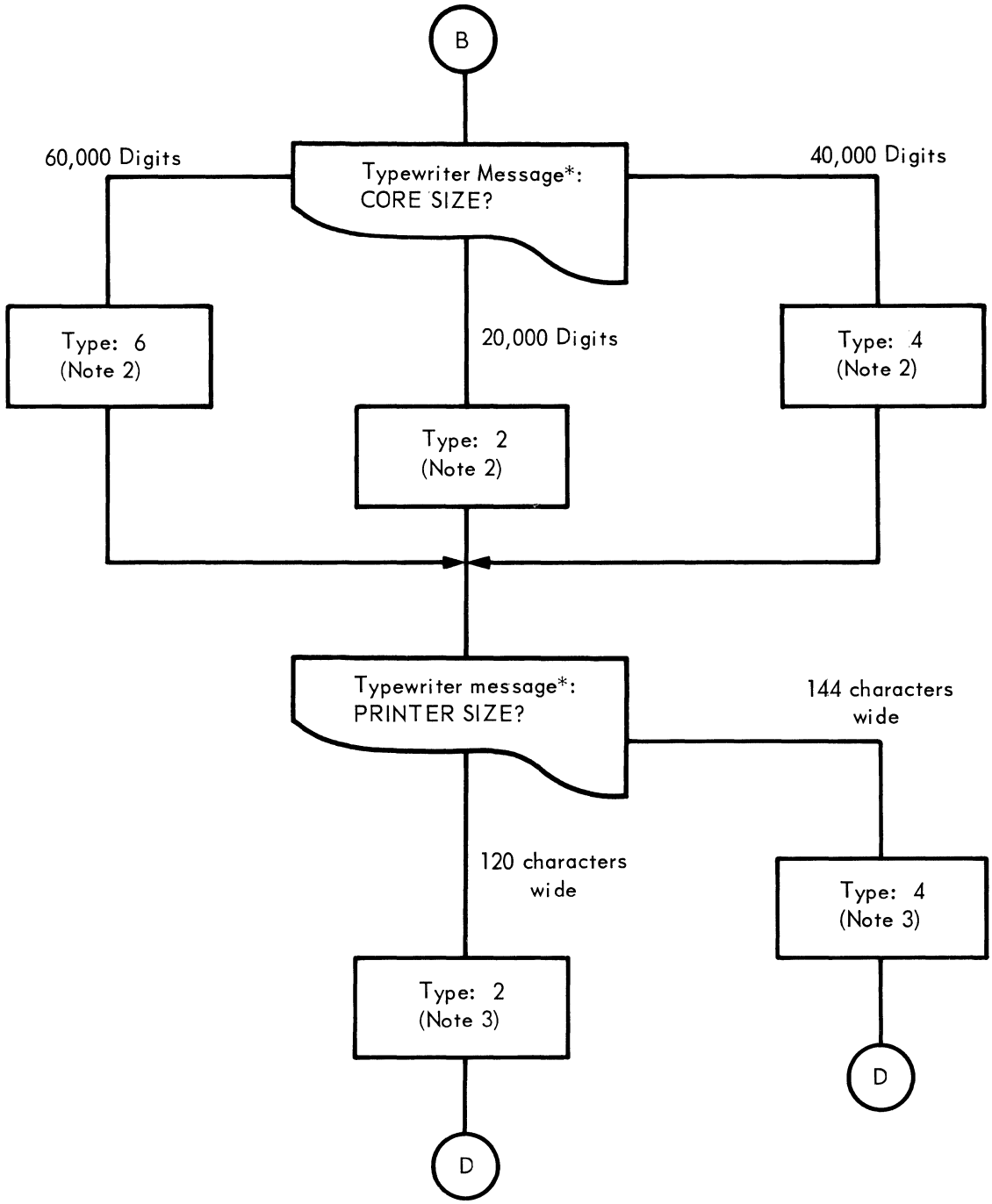
3.1 Loading the Simulator





*The question concerns 1620 features.

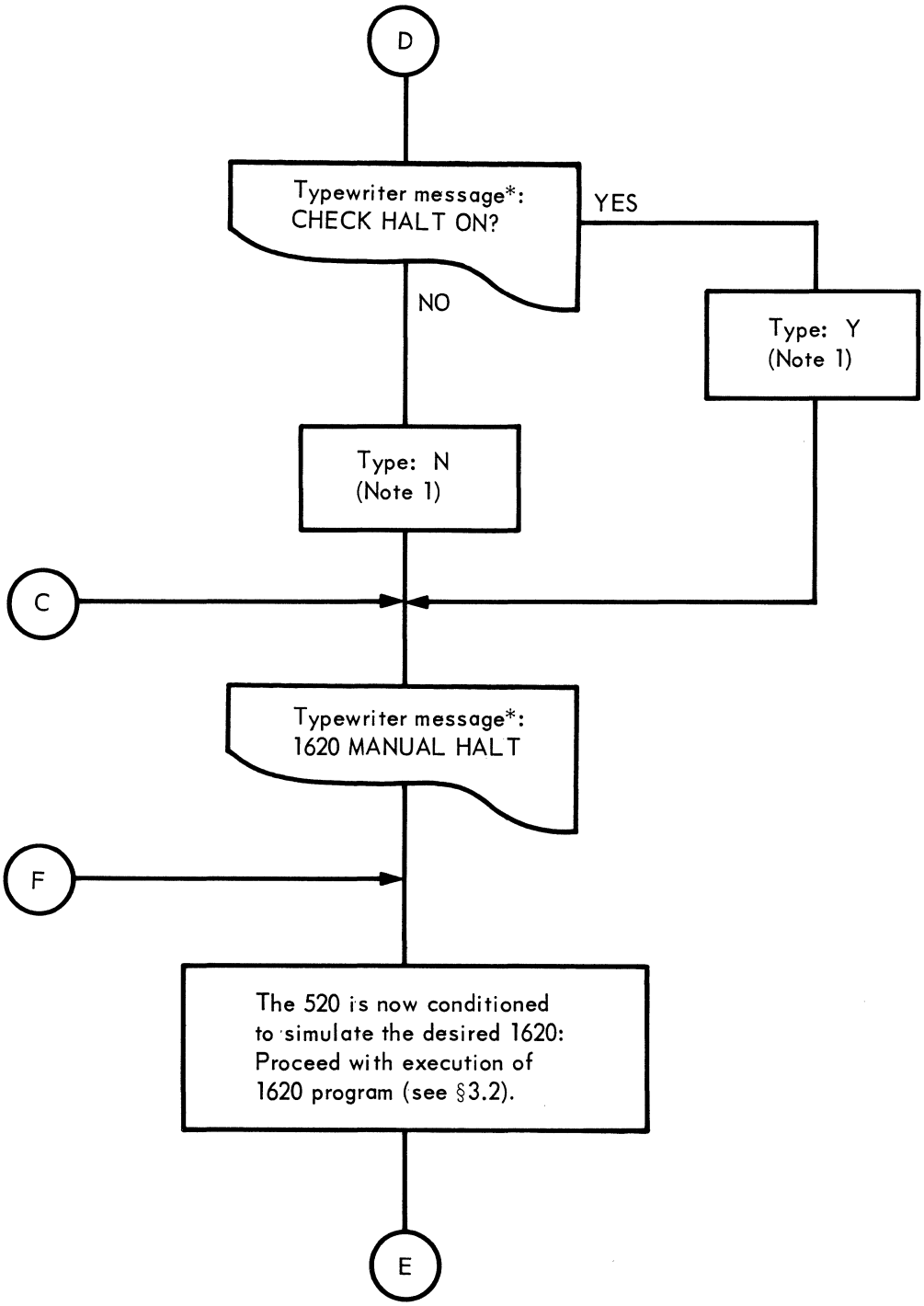
Note 1. If this question is answered with any character except Y or N, the question will be typed again. To proceed, simply type the correct one of the acceptable responses.



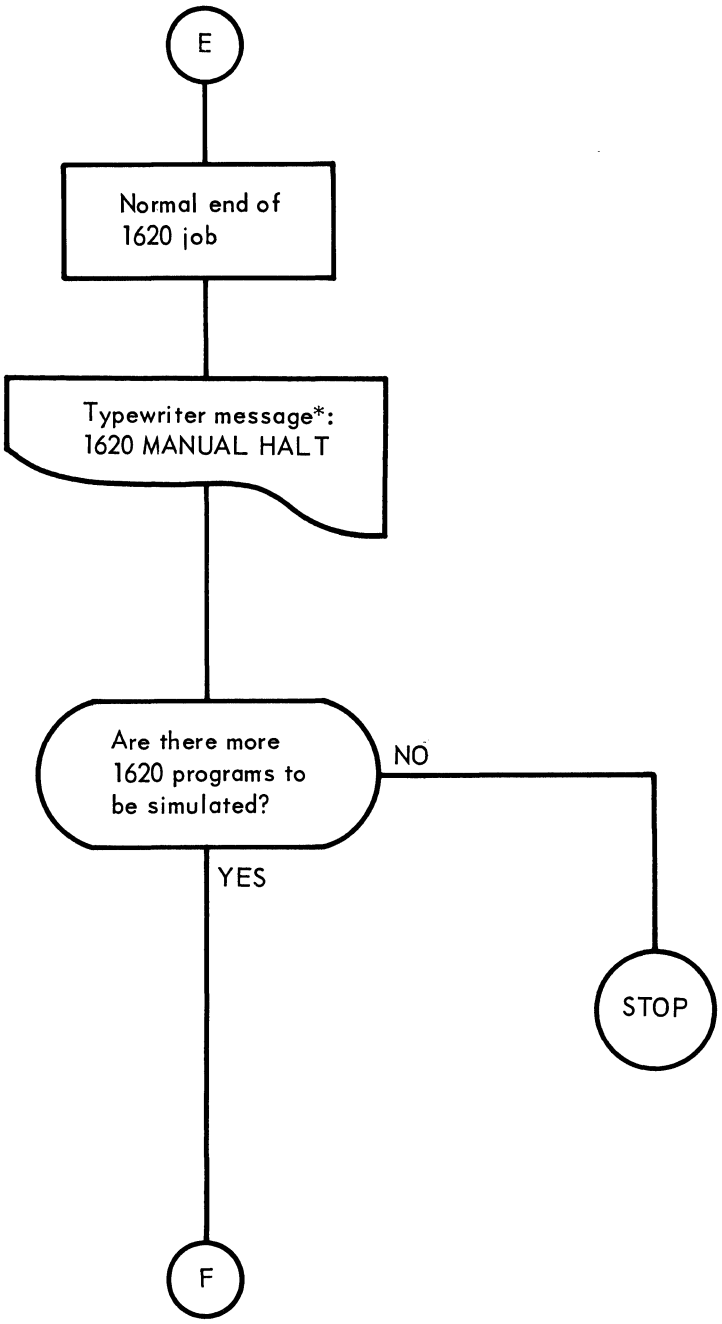
*The question concerns 1620 features.

Note 2. If this question is answered with any character except 2, 4 or 6, the question will be typed again. To proceed, simply type the correct one of the acceptable responses.

Note 3. If this question is answered with any character except 2 or 4, the question will be typed again. To proceed, simply type the correct one of the acceptable responses.



*The question concerns 1620 features


E
Normal end of
1620 job
Typewriter message*:
1620 MANUAL HALT
Are there more
1620 programs to
be simulated?
NO
YES
STOP
F

3.2 Console Operating Procedures

3.2.1 1620 Program Entry from Typewriter

1. Type R for Reset.

2. Type I for Insert.

3. Type 36XXXXX0010049YYYYY. This message conditions the Simulator to Read Numeric from the typewriter; the first character will be copied into 1620 location XXXXX. The next character will be copied into XXXXX+1; and so forth. The message also conditions the Simulator to branch, on signal, (see step 7, below) for execution of the instruction at location YYYYY.

4. Type m for Release-Start. The Read Numeric is executed.

5. Type program steps and data.

6. Type last character with Sense Switch 6 set TRUE (or ON or up). This setting of SW6 causes the Simulator to release the Read Numeric. After typing the last character, set SW6 to FALSE (or OFF or down).

7. Type S for Start to begin execution of the program. The Simulator executes the Branch to location YYYYY entered in step 3.

3.2.2 1620 Program Entry from Paper-Tape Reader

1. Type R for Reset.

2. Type I for Insert.

3. Type 36XXXXX0030049YYYYY. This message conditions the Simulator to Read Numeric from the Paper-Tape Reader; the first character will be copied into 1620 location XXXXX. The next character will be copied into XXXXX+1; and so forth. The message also conditions the Simulator to branch, on signal (see Step 4, below), for execution of the instructions at location YYYYY.

4. Type m for Release-Start. The Read Numeric instruction entered in step 3 is executed. The End-of-Line character punched in the end of the paper tape terminates execution of the Read Numeric instruction. The next instruction executed by the Simulator is the Branch to location YYYYY entered in step 3.

3.2.3 1620 Program Entry from Card Reader

1. Type R for Reset.

2. Type L for Load. Characters on the first loader card are copied into the 80 consecutively-addressed 1620 locations beginning with 00000. After the first loader card is read, the Simulator branches to location 00000 to execute the instructions on the loader card.

3.2.4 1620 Program Alteration or Data Entry from Typewriter

1. Type H for Stop to enter manual mode.

2. Type T for Save.

3. Type I for Insert.

4. Type 36XXXXX0010042. This message conditions the Simulator to Read Numeric from the typewriter; the first character will be copied into 1620 location XXXXX. The next character will be copied into location XXXXX+1; and so forth. The message also conditions the Simulator to execute a Branch Back (see step 8, below).

5. Type m for Release-Start to execute the Read Numeric instruction entered in step 4.

6. Type instructions or data.

7. Set Sense Switch 6 to TRUE (or ON) and type the last numeric entry, or type a carriage return for no entry to core storage. This setting of SW6 causes the Simulator to release the Read Numeric. After typing the last character, set SW6 to FALSE (or OFF).

8. Type S for Start. This causes the Simulator to execute the Branch Back instruction entered in step 4. The Branch is to the address saved by the Save key in step 2.

3.2.5 Interruption of Non-Ending Instruction

1. Type H for Stop. If the depression of the H key does not cause the Simulator to pause (see step 2, below), type Q for Instant Stop. The resort to Instant Stop should be had only after attempting to interrupt with the H key because the integrity of the Simulator cannot be assured when Instant Stop is used. That is, after use of Instant Stop it may be necessary to reload the Simulator.

2. Type D for Display. (If the depression of the H key at step 1 did not cause the Simulator to pause, depression of the D key at this step will result in the typewritten message "ERR, REPEAT LAST KEY" (see § 3.2.8.1, paragraph 2).)

3. Type T for Save.

4. Type I for Insert.

5. Type 38XXXXX0010048. This message conditions the Simulator to Write Numeric on the typewriter,

followed by a Halt instruction. XXXXX, the starting location of the write instruction, should be chosen to include the fields which are believed to contain the looping instructions. When the difficulty is identified, the program can then be corrected or reloaded and altered as in the description of previous console operations.

3.2.6 Typewriter Output

1. Type I for Insert.

2. Type one of the following:

38XXXXX00100	Write Numeric,
39XXXXX00100	Write Alphanumerically,
35XXXXX00100	or Dump Numeric, beginning at XXXXX.

3. Type m for Release-Start to execute the instruction entered in step 2.

3.2.7 Check Program Step Sequence and Operation

1. Type H to enter manual mode.

2. Type E to execute a single 1620 instruction, namely the next one in sequence.

3. Type D for Console Display. (See Chapter 4 for a description of the Console Display.)

4. Repeat step 2 or steps 2 and 3 as many times as desired.

3.2.8 Operator Messages

3.2.8.1 ERR, REPEAT LAST KEY

1. When the Simulator is in the manual mode this message is typed by the Simulator if the operator typed an illegal character or a legal character was transmitted with a parity error. The operator should attempt to type the correct key again.

2. If the Simulator is in automatic mode, this message will be typed if any key other than H or Q is depressed.

3.2.8.2 1620 MANUAL HALT

This message is typed by the Simulator under the following circumstances:

1. After normal 1620 program termination.

2. After halt on overflow, exponent check or parity error. Program Flag 3 will be ON if overflow occurred. Program Flag 4 will be ON for exponent check. If neither PF3 nor PF4 is ON, display the console to determine if a Halt or I/O instruction is responsible for the typewritten message.

3.2.8.3 1620 AUTOMATIC HALT

This message is typed by the Simulator because of an inoperative I/O device or an invalid I/O code. Display the console to determine which device was addressed and to check its status or to check the instruction for validity. Ready the device or correct the instruction as necessary, and restart the program.

CHAPTER 4

Console Routine

4.1 General Description

The purpose of the Console Routine is to provide the Simulator user with a console at least functionally equivalent to that of the 1620. To accomplish this, the Console Routine has several functions:

1. Simulation of 1620 console switches, keys and indicators.
2. Program loading, alteration, and manual or automatic control of the system.
3. Data or instruction entry.
4. Centralized processing of all error conditions and halts.
5. Status and display of the simulated 1620 program and console.

1620 control keys – Start, Reset, Insert, Save, Display, Stop and Instant Stop – are simulated by typing a one-character code on the 520 typewriter. Stop and Instant Stop can be activated only when the Simulator is in automatic mode; the other 1620 control keys can be activated only when the Simulator is in the manual mode.

The Start code is used to start 1620 program processing and put the Simulator into automatic mode.

The Reset code is used to restore all simulated machine status and check indicators to their initial or reset condition.

The Insert code is used to put the Simulator in automatic mode and to condition it to enter 1-100 numeric characters into the consecutively-addressed 1620 storage locations beginning with 00000.

The Save code is used to preserve the address of the next sequential 1620 instruction. The preserved address is restored to the 1620's program counter by execution of a Branch Back instruction.

The Display code is used to exhibit on the 520 typewriter the status of the simulated console and 1620 program as shown below:

Display		Meaning
IR1	XXXXX	Address of next sequential instruction
OP-	XX	Last executed OP Code
D-BR	XX	Last indicator or I/O device addressed
IR2	XXXXX	Save key saved address
PR1	XXXXX	Branch-Transmit saved address
READ CHK Y or N LAST CRD Y or N		Y if on, N if off

The Stop code is used to interrupt automatic operation of the 1620 program and enter manual mode in the Console Routine after completion of the 1620 instruction currently being simulated.

(The Instant Stop code ("Q" on the typewriter) is used to interrupt automatic operation of the 1620 program, and to enter manual mode in the Console Routine without completion of the 1620 instruction under simulation. The Instant Stop code can be invoked only when the Simulator is in the automatic mode.)

The 1620 Release Key (SW6) is used to terminate any Input-Output operation, and to enter the manual mode in the Console Routine. These functions can be realized only when the Simulator is in the automatic mode and SW6 is set to TRUE (or ON). The Simulator will pause upon recognizing that SW6 is TRUE. After the Simulator pauses, SW6 should be set to FALSE before proceeding.

Two additional codes are supplied for correct Simulator operation. The normal method used in the 1620 to zero core storage is to execute a Transmit Field instruction with the Q address one greater than the even-numbered P address. Unless the wrap versions of the Simulator are in the 520 memory, this procedure would also zero the Simulator. To avoid the necessity of always using the wrap versions, a key is provided for use, in manual mode, to set the 1620 memory to zeros. The key used for this purpose is "Z."

The other additional code is used to enter automatic mode to load the 1620 program from the card reader, simulating the switch on the 1620 card reader. The key used for this purpose is "L."

Program loading, alteration, and control, data or instruction entry, and console display are accomplished by appropriate use of combinations of the above coded keys.

Error and halt conditions effect entry to the Console routine. A message on the 520 typewriter will alert the operator when necessary. The error and halt conditions are:

I/O parity error
Invalid I/O device code
Invalid I/O control code
Inoperative I/O device
1620 program halt
Halt on arithmetic overflow

The operator can restart the 1620 program, continue to the next sequential 1620 instruction, alter the 1620 program, ready the I/O device, or any combination of these options, depending on the condition(s). Provision is made for entry into manual mode or continuing in automatic mode on I/O parity error or arithmetic overflow.

4.2 1620 Indicators, etc. and their 520 Counterparts

Indicators, toggles, and associated lights of the 1620 console are simulated in the following manner:

1620 Function	520 Simulated Equivalent
Program switch 1	Sense Switch 1 (SW1)
Program switch 2	Sense Switch 2 (SW2)
Program switch 3	Sense Switch 3 (SW3)
Program switch 4	Sense Switch 4 (SW4)
Read check	Sign bit of specific memory location
Write check	No 520 equivalent
Last card	Sign bit of specific memory location
High-positive	Program Flag 1 (PF1)
Equal-zero	Program Flag 2 (PF2)
Hi-Pos. or Eq.-Zero	PF1 and PF2 combined
Arithmetic check (overflow)	Program Flag 3 (PF3)
Exponent check	Program Flag 4 = 1
MBR-E check	No 520 equivalent
MBR-O check	No 520 equivalent
Any check	Write check
Printer check	No 520 equivalent
Overflow Program/Stop	Sense Switch 5 (TRUE for Stop)
I/O check Program/Stop	See Set-up; Chapter 5

Simulator console functions are summarized as follows:

1620 Key	520 Typewriter Key	Use-In Manual Mode
Reset	R	Reset simulated 1620 indicators and checks; ready the card reader to read the next card in the read hopper.
Save	T	Save address of next sequential 1620 instruction for Branch Back instruction.
Display	D	Display status of console and program.
Insert	I	Enter automatic mode to insert 1-100 numeric characters in consecutively-addressed 1620 locations beginning with 00000.
Single Instruction Execute	E	Enter automatic mode to execute one simulated 1620 instruction, and return to manual mode.
Start	S	Enter automatic mode to begin or continue 1620 program processing.
– –	Z	Zero 1620 core storage.
– –	L	Load the 1620 program from the card reader.
Stop	H	Interrupt 1620 program on completion of instruction and enter manual mode.
Instant Stop	Q	Interrupt 1620 program and enter manual mode without completion of the 1620 instruction.

Release-Start	m	Release insert function and enter automatic start mode.			termination of the I/O operation, SW6 should be set FALSE.
	520 Toggle		Overflow Stop	Sense Switch 5	Set TRUE to enter manual mode on any arithmetic check (overflow).
Release	Sense Switch 6	Set TRUE to terminate an I/O operation and enter manual mode; after	I/O Check Stop		Refer to Set-up; Chapter 5.

CHAPTER 5

The Set-up Routine

It is the responsibility of the Set-up Routine to initialize the Simulator and to insert the correct subroutine set depending upon the type of 1620 computer and program being simulated.

The Set-up Routine is read into core using the standard Binary I Loader located at 1000_8. All of the normal versions of the subroutines will be in the correct places. The Set-up Routine and all other subroutines will be temporarily located in simulated 1620 memory. The Set-up Routine is entered by transferring to location 12100_8.

The Set-up Routine asks the operator about the 1620 computer/program type and, if necessary, overlays subroutines and constants. Five questions are asked by the Set-up Routine via the typewriter. They are as follows:

1. Wrap used or add/multiply tables changed?
2. Indirect addressing?
3. Core size?
4. Printer size?
5. Check halt on?

The questions are answered by typing in one of the letters or numbers identified below. If the question is answered incorrectly, the phrase "ERR, REPEAT LAST KEY" is typed to indicate that the operator should try again.

For questions 1, 2 and 5, Y indicates "yes," N indicates "no." For question 3, a 2, 4 or 6 indicates 20K, 40K or 60K core size, respectively. For question 4, a 2 indicates a 120-character printer and a 4 indicates a 144-character printer.

The following table indicates the action taken by the Set-up Routine after the questions are answered.

Question Number	Answer	Action
1	N	None
1	Y	Wrap subroutines moved into BIAX. PF5 set to on.
2	N	None
2	Y	If PF5 is on, wrap indirect address conversion routines are moved into core. Otherwise, the indirect routines are moved.
3	2	None
3	4 or 6	Wrap constants are changed and address conversion modified
4	2	None
4	4	Constant for 144 character printer inserted into the I/O routines
5	N	None
5	Y	The CHECK HALT switch is turned on

SALES OFFICES

Alabama

RAYTHEON COMPUTER
Holiday Office Center, Suite 47
Huntsville, Alabama 35801
Phone (205) 881-2844
TWX 510 579-2113

California

RAYTHEON COMPUTER
2700 South Fairview Street
Santa Ana, California 92704
Phone (714) 546-7160
(From Los Angeles 625-7645)
TWX 714 546-04[illegible]

Massachusetts

RAYTHEON COMPANY
Bedford Laboratory
P. O. Box 508
Bedford, Mass. 01730
Phone: (617) 274-7100, Ext. 643 and 644
TWX 617 274-6487

Texas

RAYTHEON COMPUTER
204 East Main
Arlington, Texas
Phone (817) CR 5-5361
TWX 817 274-3917

Houston, Texas
Phone (713) WA 3-1144

Washington, D. C.
Eastern Regional Office

RAYTHEON COMPUTER
4217 Wheeler Avenue
Alexandria, Va. 22304
Phone (703) 836-7616
TWX 703 931-4247

RAYTHEON

RAYTHEON COMPUTER

2700 SOUTH FAIRVIEW ST., SANTA ANA, CALIFORNIA 92704

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