INPUT/OUTPUT 6

The standard input/output device for the LGP-21 is the Model 121 Tape Typewriter unit. It consists of an electric typewriter, a paper-tape reader, and a paper-tape punch. The reader and punch cannot be used separately from the typewriter, but the typewriter may be used alone. That is, the typewriter is normally dependent upon the computer for electrical power, and therefore can be used only when the computer is ON. However, an extra cable is provided for connecting the typewriter to a standard outlet instead of to the computer. While this connection is used, the typewriter functions as an off-line device.

The typewriter has a standard keyboard which has been modified so that it can use the LGP-21 codes shown in Appendix C. Keys which represent commands are of a different color than the others. There is one additional key: the CONDITIONAL STOP CODE ('). It produces a code on tape which has two functions: to stop the paper-tape reader, and to send the "start" signal to the computer. In addition to the keys, a number of levers are part of the tape-typewriter unit. Their functions are described in Appendix B.

While optional input/output equipment is also available which provides higher operating speeds, if desired, the following discussion will be restricted to the standard unit entirely.

Information may be input to the computer from the typewriter keyboard (the manual mode of entering information), or it may be read from tape. In either case, a typed or "hard" copy of the information is produced. Similarly, information may be output from the computer to the typewriter, which will produce a hard copy and, if desired, a punched tape.

INPUT INFORMATION

When information is input to the computer, it enters the low end (i. e. , bit position 31) of the Accumulator in binary-coded decimal format. Each new character moves the preceding character to the left until the Accumulator is filled. If too many characters are entered, the left-most characters in the Accumulator will be lost. This, however, does not cause overflow. Before studying how the characters enter the Accumulator, their representation on punched tape shall be discussed.

CHARACTER REPRESENTATION ON TAPE

When a typewriter character is typed while the PUNCH ON lever on the typewriter is depressed, a pattern of holes-unique for each character-is punched across the six positions or channels of the tape.

For instance, if the characters 7 and M are punched consecutively, the pattern of holes on the tape would appear as shown in Figure 6.1.

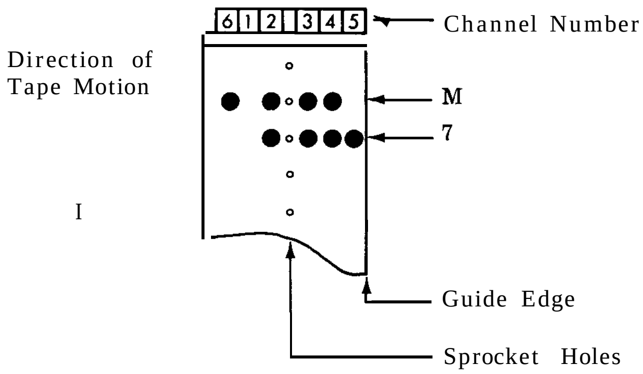

FIGURE 6.1 Character Representation on Tape

All the holes for a given character are punched simultaneously. Note that channel 6 is located next to channel 1.

Channels 5 and 6, on opposite edges of the tape, are called the zone channels; channels 1 through 4, the numeric channels. Thus the example in Figure 6.1 shows that the tape codes for 7 and M differ only in their zoning. The numeral 7 is one of the 16 hexadecimal characters (0 through 9, F, G, J, K, Q, W); M is one of the 16 letters which denote commands. The tape codes for all hexadecimal characters and all commands are given in the following table, Figure 6.2. Holes are presented by 1's; unpunched channels by 0's.

Character	Tape Code. 6 1 2 3 4 5	Decimal Value	Tape Code 6 1 2 3 4 5	Character
0	0 0 0 0 0 1	0	1 0 0 0 0 0	Z
1	0 0 0 0 1 1	1	1 0 0 0 1 0	B
2	0 0 0 1 0 1	2	1 0 0 1 0 0	Y
3	0 0 0 1 1 1	3	1 0 0 1 1 0	R
4	0 0 1 0 0 1	4	1 0 1 0 0 0	I
5	0 0 1 0 1 1	5	1 0 1 0 1 0	D
6	0 0 1 1 0 1	6	1 0 1 1 0 0	N
7	0 0 1 1 1 1	7	1 0 1 1 1 0	M
8	0 1 0 0 0 1	8	1 1 0 0 0 0	P
9	0 1 0 0 1 1	9	1 1 0 0 1 0	E
F	0 1 0 1 0 1	‘10	1 1 0 1 0 0	U
G	0 1 0 1 1 1	11	1 1 0 1 1 0	T
J	0 1 1 0 0 1	12	1 1 1 0 0 0	H
K	0 1 1 0 1 1	13	1 1 1 0 1 0	C
Q	0 1 1 1 0 1	14	1 1 1 1 0 0	A
W	0 1 1 1 1 1	15	1 1 1 1 1 0	S

FIGURE 6.2 List of Tape Codes

The second column of this table shows that the hexadecimal characters have zones O----l. Column 4 shows that the letters used for commands have zones l----O. Column 3 gives the decimal value of the binary number formed by the holes in the numeric channels for both types of characters. A look at K and C in this table shows that both have numeric punches 1101 (8 + 4 + 1 = 7); they can be distinguished only by their zones.

The remaining characters have either zone O----O or l----l. While sixteen codes are possible with each zone, only those actually used with the LGP-21 typewriter are listed in Figure 6.3.

Character	Tape Code 6 1 2 3 4 5	Decimal Value	Tape Code 6 1 2 3 4 5	Character
(Blank Tape)	0 0 0 0 0 0	0	1 0 0 0 0 1	Space
Lower Case	0 0 0 0 1 0		1 0 0 0 1 1	–
Upper Case	0 0 0 1 0 0	2	1 0 0 1 0 1	+ =
Color Shift	0 0 0 1 1 0	3	1 0 0 1 1 1	; :
Carriage Return	0 0 1 0 0 0	4	1 0 1 0 0 1	/ ?
Back Space	0 0 1 0 1 0	5	1 0 1 0 1 1	. 1
Tabulate	0 0 1 1 0 0	6	1 0 1 1 0 1	, [
		7	1 0 1 1 1 1	V
Cond. Stop	0 1 0 0 0 0	8	1 1 0 0 0 1	0
		9	1 1 0 0 1 1	X
		15	1 1 1 1 1 1	Delete

FIGURE 6.3 LGP-21 Special Character Codes

When information is entered into the Accumulator, the 4 numeric punch characters always enter, but the zone punches enter only if the programmer specifies the 6-bit mode of input. The bits corresponding to the six channels enter in l-2-3-4-5-6 order, not 6-l-2-3-4-5 as they appear on tape. The 4- or B-bit mode is optional for every character, but the convention for the LGP-21 is to enter decimal and hexadecimal data in 4-bit mode, and alphanumeric data in B-bit mode.

THE INPUT INSTRUCTION

The I instruction determines the mode of input as follows: a negative Input instruction (8001) selects 4-bit mode; a positive Input instruction (I) selects 6-bit mode. The track address of the Input instruction determines what input device will be used: track address 00 selects the Model 141 Tape Reader; track address 02, the Model 121 Typewriter. The sector portion of the address has no effect on the Input instruction. When the typewriter is selected for input, information may be typed from the keyboard or read from tape, depending on how the MANUAL INPUT lever is positioned (see Appendix B).

Up to 31 input devices may be connected to a single LGP-21 system. Each device has an individual track address which is assigned at the time of its installation.

Examples of Input Instructions:

Instruction	Explanation
10200	B-bit input from Typewriter
10000	6-bit input from 141 Reader
80010200	4-bit input from Typewriter
80010000	4-bit input from 141 Reader

Examples:

1. Illustrated below is the contents of the Accumulator before and after reading the decimal digits 125' in 4-bit mode. (Note: The apostrophe represents the stop code which must be present to inform the reader when to sto reading, but it does not enter the Accumulator.) The X's represent the original bits in the accumulator before input (normally, all zeros).

   before input XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

   after input XXXXXXXXXXXXXXXX0000000100100101

   1 2 5

   The 125 enters in binary-coded decimal in the twelve right-most positions of the Accumulator after causing its original contents to shift left in 4-bit increments to accomodate each of the incoming characters. In addition, four binary zeros have been inserted between the first character read and the pre-input contents of the Accumulator.

2. Illustrated below is the contents of the Accumulator after reading the alpha numeric characters LGP' in 6-bit mode.

   XXXXXXXX000000000110101110100001

   L G P

   The original contents of the Accumulator was shifted left, and the 6-bit code for each of the incoming characters was inserted in the far right positions. Also, six binary zeros have been inserted between the first character read and the pre-input contents of the Accumulator.

In both examples a "1" is in bit position 31. This can occur only immediately following input. If the word is stored in memory, the 1 bit in position 31 in memory will be lost (that is, set to 0). Significance in that bit position can only be saved by shifting the contents of the Accumulator left at least 1 place (using either the N, D, or the shift instruction explained in the next chapter) before the value is stored in memory.

Describing the input instruction in more general terms, the computer performs the following operations for each input instruction:

1. It shifts the contents of the Accumulator left 4 or 6 places, depending on the specified mode of input, inserting zeros in the vacated positions.

2. It reads a character from the selected device and holds the B-bit code for this character in a 6-bit register.

3. If the character in the 6-bit register is a stop code (binary code 100000), reading terminates, and the computer proceeds to the instruction following the input instruction. If a non-entering character other than the stop code is in the register, the computer returns to step (2); otherwise it goes to step (4).

4. It shifts the contents of the Accumulator left 4 or 6 places and inserts the 4-bit or 6-bit code for the character read into the low order 4- or 6-bit positions. Then it returns to step (2) above.

NON-ENTERING CHARACTERS

When input is through the 121 Typewriter, the following conditions are true:

1. In the 4-bit mode all bit combinations enter the Accumulator except the O----O zone combinations, Delete, and those combinations not specifically listed in Figure 6.3.

2. In the B-bit mode only legal codes enter the Accumulator.

When input is through the 141 Reader, these conditions are true:

1. In the 4-bit mode all bit combinations which have a "1" zone bit, enter the Accumulator. Thus, tape codes such as 110101 and 111101 are legal input codes for the 141 Reader but can not be read on the 121 Typewriter.

2. In the 6-bit mode the only bit configurations which do not enter the Accumulator are Delete and Conditional Stop.

THE PRINT INSTRUCTION

The Print Instruction selects the output device to be used and the mode of output, and causes one character to be recorded by the selected output device. A negative Print instruction (800P) selects the 4-bit mode of output; a positive Print instruction (P), the 6-bit mode of output. Decimal and hexadecimal data are output in 4-bit mode; alphanumeric data in 6-bit mode. The track address selects the output device: 02 selects the Model 121 Typewriter, 06 selects the Model 151 Tape Punch. The sector portion of the address has no effect on the Print instruction. If 4-bit output is selected the upper 4 bits of the accumulator are output through the selected device with zone bit 10 in channels 5 and 6. If 6-bit output is selected, the upper six bits of the accumulator are output through the selected device.

Examples of Print instructions:

Instruction	Explanation
800P0200	Record via typewriter the character whose zone bits are l----O and whose numeric bits are in positions 0 through 3 of the Accumulator (4-bit output).
800P0600	Record via 151 Punch the character whose zone bits are l----O and whose numeric bits are in positions 0 through 3 of the Accumulator (4-bit output).

Instruction	Explanation
PO200	Record via typewriter the character whose 6-bit code is in positions 0 through 5 of the Accumulator (6-bit output).
PO600	Record via 151 Punch the character whose 6-bit code is in positions 0 through 5 of the Accumulator (6-bit output).

If binary-coded decimal information in the computer is to be recorded in decimal; the 800P instruction is used. It is also used to record information in hexadecimal format, regardless of the internal representation of such information. The P instruction is used to record alphanumeric data which is represented internally in this form.

THE SHIFT INSTRUCTION

The I instruction is available in two special forms which can be used to shift the contents of the Accumulator. The negative form, 80016200 causes a 4-place shift, the positive form, 16200, a 6-place shift. The bits which are shifted out of the Accumulator at the extreme left are lost, while thevacated positions on the right are filled with zeros. The track-address portion of the Shift instruction is 62; the sector portion has no effect on the instruction.

Instruction	Explanation
80016200	Shift left 4
16200	Shift left 6

EXAMPLES OF OUTPUT OPERATIONS

1. Location 1806 contains the 3-digit, binary-coded decimal number 125 at a q of 30. Print this number, in decimal: via the typewriter.

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'					
	'	☒				
		0000	B1806	'	Bring 125@q = 30	
		0001	N0008	'	Shift the 3 digits into positions 0-11	
		0002	800P0200	'	Print "1"	
		0003	800I6200	' ☒	Shift left 4.	
		0004	800P0200	'	Print "2"	
		0005	800I6200	'	Shift left 4	
		0006	800P0200	'	Print "5"	
		0007	Z0000	' ☒	Halt	
		0008	80000	'	1@q=12 in hexadecimal	
				'		

2. Location 2753 contains the number 724 in binary at a q of 30. Print this number in decimal via the typewriter.

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	X					
		0000	B	2753	'	Bring 724@30	
		0001	D	0011	'	(724@30)÷(1000@27)= .724@3	
		0002	N	0012	'	(.724@3) N-Multiplied by (10@31) =	
					'	X 7.24@3	
		0003	800P	0200	'	Print "7"	
		0004	E	0013	'	Leaves .24@3	
		0005	N	0012	'	(.24@3) N-Multiplied by (10@31)=2.4@3	
		0006	800P	0200	'	X Print "2"	
		0007	E	0013	'	Leaves .4@3	
		0008	N	0012	'	(.4@3) N-Multiplied by (10@31)=4.0@3	
		0009	800P	0200	'	Print "4"	
		0010	Z	0000	'	X Halt	
		0011		3Q80	'	1000@27 in hexadecimal	
		0012		F	'	10@31 in hexadecimal	
		0013	WWW	WWWQ	'	Mask in hexadecimal	
					'	X	

3. Record the contents of Location 5513 in hexadecimal on the 151 Punch.

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	X					
		0000	B	5513	'	Bring the word from 5513	
		0001	800P	0600	'	Record first hexadecimal character	
		0002	800I	6200	'	Shift left 4	
		0003	800P	0600	'	X Record second hexadecimal character	
		0004	800I	6200	'	Shift left 4	
		0005	800P	0600	'	Record third hexadecimal character	
		0006	800I	6200	'	Shift left 4	
		0007	800P	0600	'	X Record fourth hexadecimal character	
		0008	800I	6200	'	Shift left 4	
		0009	800P	0600	'	Record fifth hexadecimal character	
		0010	800I	6200	'	Shift left 4	
		0011	800P	0600	'	X Record sixth hexadecimal character	
		0012	800I	6200	'	Shift left 4	
		0013	800P	C600	'	Record seventh hexadecimal character	
		0014	800I	6200	'	Shift left 4	
		0015	800P	0600	'	X Record eighth hexadecimal character	
		0016	Z	0000	'	Halt	
					'		

4. Location 0555 contains the 5-character, alphanumeric word LGP21 at a q of 29. Perform a carriage return and print this word via the typewriter.

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		0000	B	0012		Bring 01000_2 into positions 0-5 of	
						Accumulator	
		0001	P	0200		Execute carriage return	
		0002	B	0555		Bring the alphanumeric word	
		0003	P	0200		Print "L"	
		0004	I	6200		Shift left 6	
		0005	P	0200		Print "G"	
		0006	I	6200		Shift left 6	
		0007	P	0200		Print "P"	
		0008	I	6200		Shift left 6	
		0009	P	0200		Print "2"	
		0010	I	6200		Shift left 6	
		0011	P	0200		Print "1"	
		0012		40000000		HALT— entered as a hexadecimal word.	
						Will also cause a carriage return, since	
						the 6-bit code for this function (010000)	
						is in bits 0 through 5 of this word. To get	
						this dual-purpose effect with an instruc-	
						tion whose address is not 0000, the add-	
						ress must be written in hexadecimal.	

In the above example, "LPG" will print in lower case, as no provision has been made to change to upper case. The alphanumeric information could have specified upper case preceding the "L" and a change to lower case between the "P" and "2". However, this would have resulted in seven alphanumeric characters, requiring representation as two words in memory.

INPUT TO THE COMPUTER

Information may be input to the computer manually or under program control. Both methods will be discussed here.

Manual input

If the typewriter and computer are ON and the Mode switch is positioned to MANUAL INPUT, typing a character on the keyboard causes the bits representing channels 1 through 4 of the character's tape code to appear in the last four bit positions (28, 29, 30, and 31) of the Accumulator. As was pointed out in the discussion of the Input instruction: the information-in binary-coded decimal format-enters the low-order portion of the Accumulator, one character at a time, and moves to the high-order portion as each additional character is entered. If more than eight characters are typed during such an input operation, only the last eight are preserved in the Accumulator, since it has only 32 bit positions. The same characters which enter the computer in response to an Input instruction can also be entered manually (see "Non-entering Characters").

Suppose that a punched tape, such as the one containing the codes for 7 and M which was illustrated earlier, is placed in the typewriter-reader. With the computer in Manual Input mode, depressing the START READ lever on the typewriter activates the reader. This causes "7M" to be printed and the four principal bits of each character's tape code to enter the Accumulator, just as if the characters had been typed by hand. Depressing the START READ lever once causes automatic successive reading of the characters punched on tape. Reading will continue until a stop code is read on the tape or until the STOP READ lever or the START COMPUTE lever is depressed.

Notice that the form of input discussed here allows information to enter the Accumulator only; nothing is stored in memory and no instructions are executed.

Program-Controlled Input

As has been shown, characters can be entered into the Accumulator from the keyboard or from tape when the computer is in Manual Input mode. Input can also be activated by programming. For this purpose, an Input instruction must be stored in memory and executed during program operation.

This presupposes that some information is already stored in the computer, namely an Input instruction. But even before such an instruction is in memory, there must be a way to enter information into memory.

STORING INFORMATION IN MEMORY

In the following discussion, a number of computer switches will be mentioned which are instrumental in entering information into any desired memory locations. Since the mechanical aspects of this process are of no particular concern within the context of this chapter, no attempt is made to introduce the subject at this point. A detailed discussion of the computer controls and their functions will be found in Appendix A; a similar discussion of the input/output controls in Appendix B.

Input to Memory from Typewriter

To enter 19 at a q of 21 into Location 2003, a C2003 instruction must first be placed in the Instruction Register and executed. To do this, the MODE switch is set to MANUAL INPUT, and C140J (the hexadecimal form of the decimal instruction C2003) is typed. Next the FILL CLEAR switch is depressed. This copies the contents of the Accumulator (the C2003 instruction) into the Instruction Register and sets the Counter to zero. Then 00004500 is typed. This places 19 at a q of 21 in the Accumulator. Now it only remains to execute the instruction in the Instruction Register. To do this, the EXECUTE switch on the computer must be depressed. However, this switch is not active when the computer is in Manual Input mode. Therefore, to complete the operation, position the MODE switch to ONE OPERATION and depress EXECUTE. The Clear instruction will be executed, and the number 19 at a q of 21 will be stored in Location 2003. If other words are to be stored in other memory locations, the MODE switch must first be positioned to MANUAL INPUT.

Input to Memory from Tape

Returning to the problem of input initiated by programming, suppose that the sequence of instructions 10200, C2003, Z0000, is in memory. If 19 at a q of 21 is to be entered into Location 2003 from tape, a tape punched 00004500' must be in the typewriter-reader. When the execution of the sequence of instructions is initiated, the reader will begin reading the tape almost immediately and will stop when the stop code (') is sensed. A fraction of a second later the computer stops on the ZOO00 instruction, with 19 at a q of 21 in Location 2003 and zero in the Accumulator . The computer had been stopped momentarily by the 10200 instruction, but the reading of the stop code restarted it automatically.

If no such sequence of instructions is in memory and the constant is to be stored into Location 2003 without any typing, a tape punched C140J'00004J00' must be put in the tape reader. To load this constant, the following steps are necessary:

1. Position the MODE switch to MANUAL INPUT.
2. Depress the START READ lever on the typewriter. (C140J enters the Accumulator.)
3. Depress the FILL CLEAR switch on the computer. (C140J, the hexadecimal form of the instruction C2003, is copied into the Instruction Register.)
4. Depress START READ on the typewriter. (00004J00 enters the Accumulator .)
5. Position the MODE switch to ONE OPERATION.
6. Depress the EXECUTE switch. (00004J00 is cleared into Location 2003.)

LGP-21 BOOTSTRAP

Once a pair of I, C instructions is stored in memory, the programmer can store other words under program control. The manual operationof storing the original instructions in memory is called a bootstrap procedure, and the sequence of instructions which is stored is called a bootstrap. A bootstrap consists of a set of instructions which, when stored in memory: transfers control to itself in order to input a hexadecimal fill sequence, which in turn loads a program. While there are several ways of programming a bootstrap, the manual procedure remains the same for all. The discussion in this manual describes the bootstrap which loads Program Input 2 (program J1-10.1).

The bootstrap program consists of three instructions which are stored in Locations 0002, 0003, and 0004, and a fourth instruction which transfers control to Location 0002. The hexadecimal fill sequence consists of eleven instructions, stored in Track 63, and a twelfth instruction to transfer control to the beginning of this sequence.

One reason for using a program input routine in the LGP-21 is to convert decimal instructions to binary. Without such a routine, decimal instructions can not be entered. Consequently, the bootstrap, hexadecimal fill sequence, and the program input routines themselves must be written in hexadecimal. The following discussion will explain the bootstrap, its function, and how it is loaded.

The basic bootstrap consists of three instructions, shown here in decimal notation, to be loaded in Track 00.

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		0,0,0,0			'		
		0,0,0,1			'		
		0,0,0,2	8,0,0,I	0,2,0,0	'		
		0,0,0,3	C	0,0,0,5	'	☒	
		0,0,0,4	8,0,0,I	0,2,0,0	'		
					'		
					'		

These instructions must be stored in the computer manually. Therefore, each must be preceded by a Clear instruction which will enter the Instruction Register and, when executed, will store a word in the appropriate memory location. Finally, this set of instructions must be followed by an Unconditional Transfer instruction which is executed but not stored in memory. Thus, it takes eight instructions to actually store the bootstrap and transfer control to it. Figure 6-4, below, lists these instructions in proper sequence. Column one contains the decimal equivalent of each instruction; column two, the hexadecimal word as it appears on tape; and column three, the designation of the switches which must be activated, as well as the resultant action.

Decimal nstruction	Hexadecimal Word	Console Switch and Interpretation
		Turn computer and typewriter ON.
		Position MODE switch to MANUAL INPUT.
		Depress START READ. The following instruction enters the Accumulator.
coo02	000C0008'	Depress FILL CLEAR. Places COO02 in the Instruction Register. Depress START READ.
-10200	80010200'	The instruction -10200 enters the Accumulator. Position MODE switch to ONE OPERATION; depress. EXECUTE. Clears -10200 into Location 0002.
		Position MODE switch to MANUAL INPUT. Depress START READ to enter the following instruction into the Accumulator.
coo03	000C000J'	Depress FILL CLEAR. Places COO03 in the Instruction Register. Depress START READ.
coo05	000C0014'	COO05 enters the Accumulator. Position MODE switch to ONE OPERATION; depress EXECUTE Clears COO05 into Location 0003.
		Position MODE switch to MANUAL INPUT. Depress START READ to enter the following instruction into the Accumulator.
coo04	000C0010'	Depress FILL CLEAR. Places COO04 in the Instruction Register. Depress START READ.
-10200	80010200'	-10200 enters the Accumulator. Position MODE switch to ONE OPERATION; depress EXECUTE Clears -10200 into Location 0004.
		Position MODE switch to MANUAL INPUT. Depress START READ to enter the following instruction into the Accumulator.
U0002	000U0008'	Depress FILL CLEAR. Places UOO02 in the Instruction Register. Depress START READ.
Z0000	00020000'	ZOO00 enters the Accumulator. Position MODE switch to NORMAL.

FIGURE 6.4 Basic Bootstrap

At this point the Counter Register contains the address 0002. This indicates that, when the START switch is depressed, the computer will execute instructions beginning in 0002. After the START switch is depressed, the hexadecimal fill sequence is loaded in Track 63, and control is transferred to it.

The decimal coding for the hexadecimal fill sequence is given in Figure 6.5, below:

Location	Command	Address
6300	8001	0200
6301	GWC	0000
6302	U	6308
...	...	...
6308	B	6301
6309	S	6317
6310	T	6313
6311	C	6301
6312	U	6300
6313	Z	0000
6314	U	0000
...	...	...
6317	W	WWWJ

FIGURE 6.5 Decimal Coding for Hexadecimal Fill Sequence

The hexadecimal words which appear on the tape,together with their decimal equivalents, are listed in Figure 6.6. The bootstrap will store this sequence in memory and transfer control to it. The sequence of events is as follows: The first of each pair of instructions (except the last pair) is a Clear instruction. Thus, the instruction in Location 0002 reads it into the Accumulator. Then the instruction in 0003 places the Clear instruction into Location 0005. Next, the instruction in 0004 reads into the Accumulator the instruction which is actually to be stored. The instruction in Location 0005 stores the contents of the Accumulator into the proper location. Finally, the instruction in 0006 transfers control back to 0002 to repeat the process for the next pair of instructions.

Decimal Equivalent	Hexadecimal Word
C0006	000C0018'
uooo2	U0008'
C6300	C3W00'
80010200	80010200'
C6301	C3W04'
191coooo	GWCOOOO'
C6302	C3W08'
U6308	U3W20'
C6308	C3W20'
B6301	B3W04'
C6309	C3W24'
S6317	S3W44'
C6310	C3W28'
T6313	T3W34'
C6311	C3W2J'
C6301	C3W04'
C6312	C3W30'
U6300	U3W00'
C6313	C3W34'
Z0000	
C6314	C3W38'
U0000	U0000'
C6317	C3W44'
WWWWJ	WWWWJ'
U6300	U3W00'
zoooo	

FIGURE 6.6 Hexadecimal Fill Sequence

Notice the last pair of instructions. The U3W00 is read into the Accumulator by the instruction in 0002; then the instruction in 0003 places it in Location 0005. The instruction in 0004 reads a zero (conditional stop code). The instruction in 0005 (U6300) then transfers control to 6300, and Program Input 2 is loadedinto Tracks 00, 01, and 02.