buffer and subroutine WRREC to write the record from the buffer to the output device. Each subroutine must transfer the record one character at a time because the only I/O instructions available are RD and WD. The buffer is necessary because the I/O rates for the two devices, such as a disk and a slow printing terminal, may be very different. (In Chapter 6, we see how to use channel programs and operating system calls on a SIC/XE system to accomplish the same functions.) The end of each record is marked with a null character (hexadecimal 00). If a record is longer than the length of the buffer (4096 bytes), only the first 4096 bytes are copied. (For simplicity, the program does not deal with error recovery when a record containing 4096 bytes or more is read.) The end of the file to be copied is indicated by a zero-length record. When the end of file is detected, the program writes EOF on the output device and terminates by executing an RSUB instruction. We assume that this program was called by the operating system using a JSUB instruction; thus, the RSUB will return control to the operating system.

2.1.1 A Simple SIC Assembler

Figure 2.2 shows the same program as in Fig. 2.1, with the generated object code for each statement. The column headed Loc gives the machine address (in hexadecimal) for each part of the assembled program. We have assumed that the program starts at address 1000. (In an actual assembler listing, of course, the comments would be retained; they have been eliminated here to save space.)

The translation of source program to object code requires us to accomplish the following functions (not necessarily in the order given):

1. Convert mnemonic operation codes to their machine language equivalents—e.g., translate STL to 14 (line 10).
2. Convert symbolic operands to their equivalent machine addresses—e.g., translate RETADR to 1033 (line 10).
3. Build the machine instructions in the proper format.
4. Convert the data constants specified in the source program into their internal machine representations—e.g., translate EOF to 454F46 (line 80).
5. Write the object program and the assembly listing.

All of these functions except number 2 can easily be accomplished by sequential processing of the source program, one line at a time. The translation of addresses, however, presents a problem. Consider the statement

```
10    1000    FIRST    STL    RETADR    141033
```


Line	Loc	Source statement			Object code
5	1000	COPY	START	1000	
10	1000	FIRST	STL	RETADR	141033
15	1003	CLOOP	JSUB	RDREC	482039
20	1006		LDA	LENGTH	001036
25	1009		COMP	ZERO	281030
30	100C		JEQ	ENDFIL	301015
35	100F		JSUB	WRREC	482061
40	1012		J	CLOOP	3C1003
45	1015	ENDFIL	LDA	EOF	00102A
50	1018		STA	BUFFER	0C1039
55	101B		LDA	THREE	00102D
60	101E		STA	LENGTH	0C1036
65	1021		JSUB	WRREC	482061
70	1024		LDL	RETADR	081033
75	1027		RSUB		4C0000
80	102A	EOF	BYTE	C'EOF'	454F46
85	102D	THREE	WORD	3	000003
90	1030	ZERO	WORD	0	000000
95	1033	RETADR	RESW	1	
100	1036	LENGTH	RESW	1	
105	1039	BUFFER	RESB	4096	
110		.			
115		.	SUBROUTINE TO READ RECORD INTO BUFFER		
120		.			
125	2039	RDREC	LDX	ZERO	041030
130	203C		LDA	ZERO	001030
135	203F	RLOOP	TD	INPUT	E0205D
140	2042		JEQ	RLOOP	30203F
145	2045		RD	INPUT	D8205D
150	2048		COMP	ZERO	281030
155	204B		JEQ	EXIT	302057
160	204E		STCH	BUFFER,X	549039
165	2051		TIX	MAXLEN	2C205E
170	2054		JLT	RLOOP	38203F
175	2057	EXIT	STX	LENGTH	101036
180	205A		RSUB		4C0000
185	205D	INPUT	BYTE	X'F1'	F1
190	205E	MAXLEN	WORD	4096	001000
195		.			
200		.	SUBROUTINE TO WRITE RECORD FROM BUFFER		
205		.			
210	2061	WRREC	LDX	ZERO	041030
215	2064	WLOOP	TD	OUTPUT	E02079
220	2067		JEQ	WLOOP	302064
225	206A		LDCH	BUFFER,X	509039
230	206D		WD	OUTPUT	DC2079
235	2070		TIX	LENGTH	2C1036
240	2073		JLT	WLOOP	382064
245	2076		RSUB		4C0000
250	2079	OUTPUT	BYTE	X'05'	05
255			END	FIRST	

Figure 2.2 Program from Fig. 2.1 with object code.