US005883975A

United States Patent [19]

Narita et al.

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[45] Date of Patent: Mar. 16, 1999

[54] **COMPRESSION AND DECOMPRESSION METHODS ON TWO-DIMENSIONAL IMAGE DATA**

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[73] Assignee: **Nippon Steel Corporation**, Tokyo, Japan

[21] Appl. No.: **526,663**

[22] Filed: **Sep. 11, 1995**

[30] **Foreign Application Priority Data**

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Oct. 28, 1994 [JP] Japan 6-289109
Oct. 28, 1994 [JP] Japan 6-289110

[51] **Int. Cl.**[6] **G06K 9/36**

[52] **U.S. Cl.** **382/232**

[58] **Field of Search** 382/232, 233, 382/238, 239, 240, 243, 245, 246; 358/261.1, 261.2, 261.3; 341/51, 55, 79, 106

[56] **References Cited**

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5,003,307 3/1991 Whiting et al. 341/51
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Ziv, Jacob and Lempel, Abraham, "Compression of Individual Sequences via Variable–Rate Coding," *IEEE Transactions of Information Theory*, vol. IT–24, No. 5, Sep. 1978, pp. 530–536.

Primary Examiner—Jose L. Couso
Attorney, Agent, or Firm—Pollock, Vande Sande & Amernick

[57] **ABSTRACT**

A data compression apparatus includes a dictionary buffer for holding data of the immediately preceding line of successively inputted two-dimensional image data, a buffer for extracting a plurality of continuous data strings from the inputted data of the current line to store them as a partial data string to be compressed, a scanning comparison section for detecting whether or not the same data string as the partial data string to be compressed exists in the data stored in the dictionary buffer, and a code generator by which in the case where the presence of the same data string is detected by the scanning comparison section, data of the position and the length of a partial data string on the data of the immediately preceding line stored in the dictionary buffer is outputted as data of that partial data string of the current line.

70 Claims, 48 Drawing Sheets

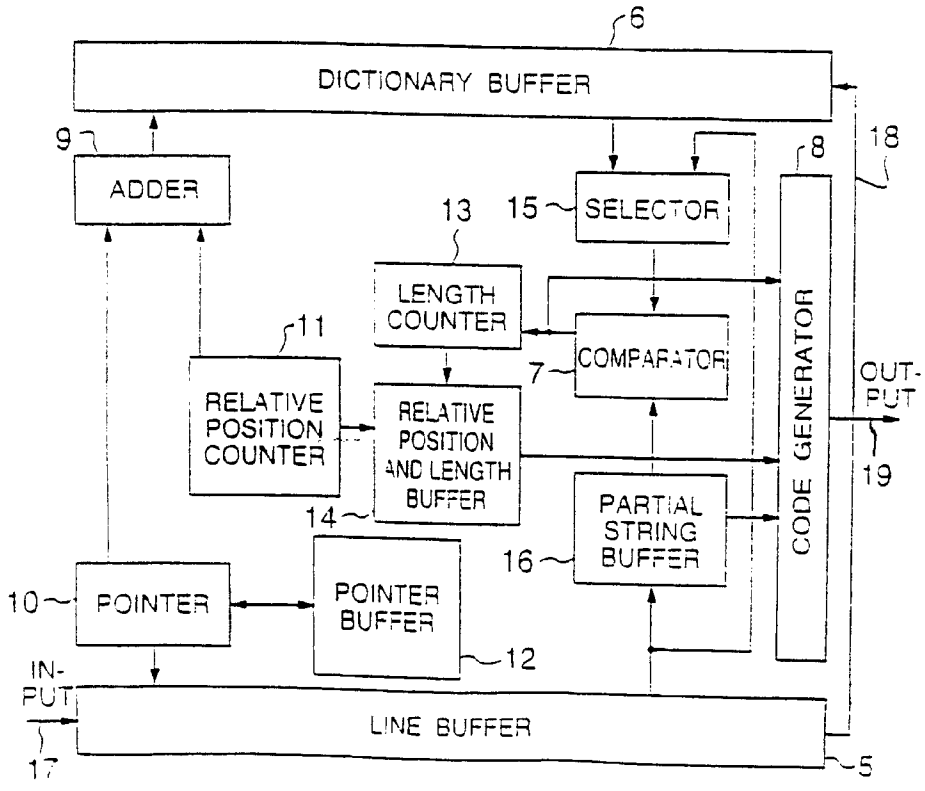


FIG. 1

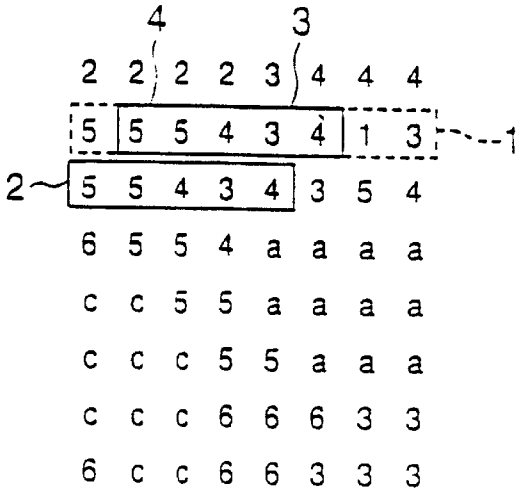

4
3
2 2 2 2 3 4 4 4
5 5 5 4 3 4 1 3
1
2
5 5 4 3 4 3 5 4
6 5 5 4 a a a a
c c 5 5 a a a a
c c c 5 5 a a a
c c c 6 6 6 3 3
6 c c 6 6 3 3 3

FIG. 2

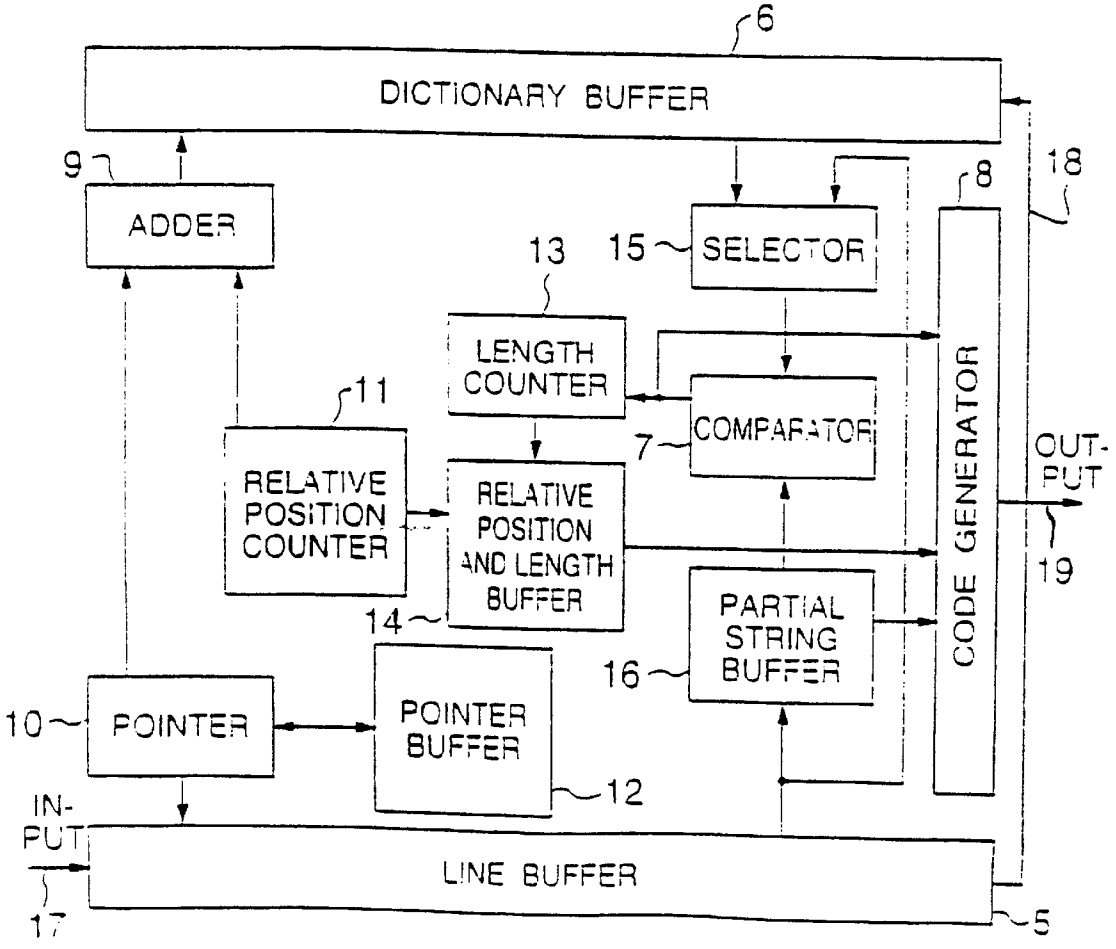

6
DICTIONARY BUFFER
9
ADDER
8
18
13
15
SELECTOR
LENGTH COUNTER
11
COMPARATOR
7
RELATIVE POSITION COUNTER
RELATIVE POSITION AND LENGTH BUFFER
OUT-PUT
19
14
PARTIAL STRING BUFFER
16
CODE GENERATOR
10
POINTER
POINTER BUFFER
12
IN-PUT
17
LINE BUFFER
5

FIG. 3

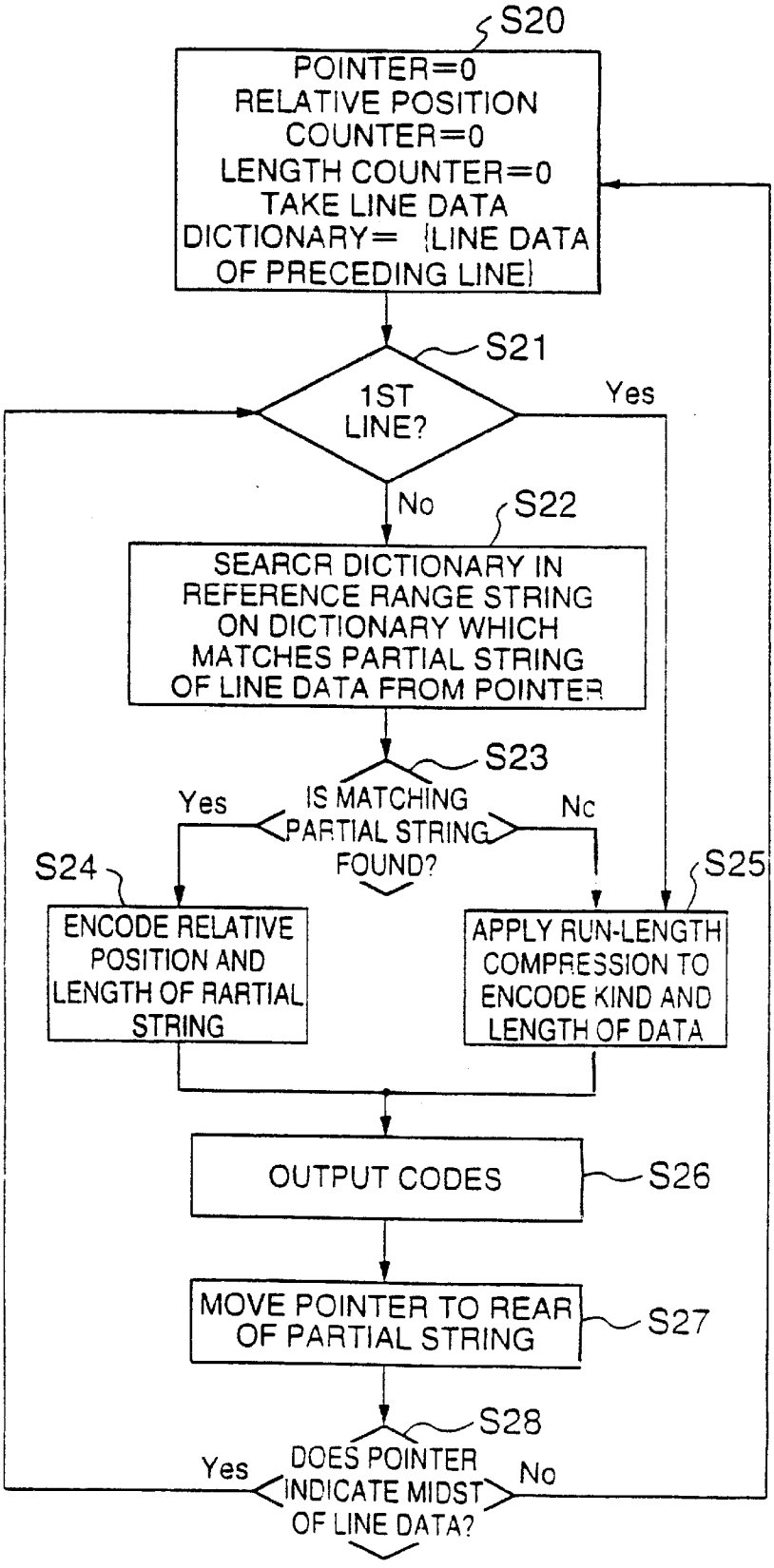

S20
POINTER=0
RELATIVE POSITION COUNTER=0
LENGTH COUNTER=0
TAKE LINE DATA
DICTIONARY= {LINE DATA OF PRECEDING LINE}
S21
1ST LINE?
Yes
No
S22
SEARCR DICTIONARY IN REFERENCE RANGE STRING ON DICTIONARY WHICH MATCHES PARTIAL STRING OF LINE DATA FROM POINTER
S23
IS MATCHING PARTIAL STRING FOUND?
Yes
Nc
S24
ENCODE RELATIVE POSITION AND LENGTH OF RARTIAL STRING
S25
APPLY RUN-LENGTH COMPRESSION TO ENCODE KIND AND LENGTH OF DATA
OUTPUT CODES
S26
MOVE POINTER TO REAR OF PARTIAL STRING
S27
S28
DOES POINTER INDICATE MIDST OF LINE DATA?
Yes
No

FIG. 4A

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 4B

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
a 1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
b 3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

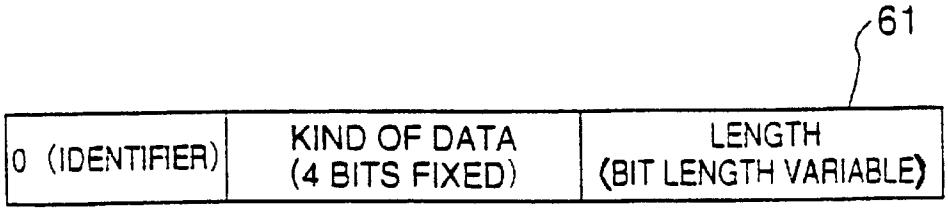
FIG. 4C

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
1	5	5	5	4	3	4	1	3 e
2	5	5	4	3	4	3	5	4
c 3	6	5	5	4	a	a	a	a d
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 5

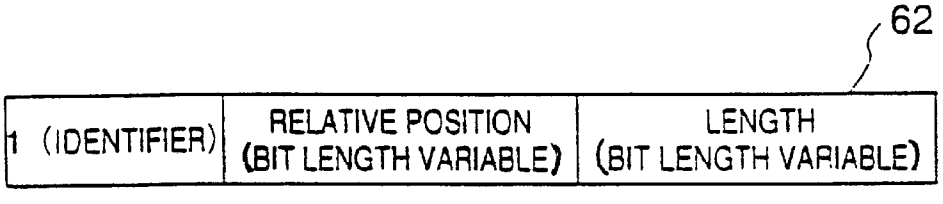
ROW	CODE STRING
0	[2, 4][3. 1][4. 3]
1	[5, 3][4, 1]{0. 2}[1. 1][3, 1]
2	{1, 5} {-1, 1}[5, 1][4. 1]
3	[6, 1]{-1, 3}[a, 4]
4	[c, 2]{-1, 2} {0, 4}
5	{0, 2} {-1, 1} {-1, 5}
6	{0, 3}[6, 3][3. 2]
7	[6, 1]{-1, 2} {0, 2} {1, 2} {0. 1}

FIG. 6A



LENGTH	CODE
1	0
2	10
3	110
4	1110
5	11110
6	111110
7	1111110
8	1111111

FIG. 6B



RELATIVE POSITION	CODE
-1	11
0	0
1	10

LENGTH	CODE
1	00
2	01
3	10
4	1100
5	1101
6	1110
7	11110
8	11111

FIG. 7

ROW	CODE STRING
0	00101110 00110 0100110
1	00101110 001000 1001 000010 000110
2	1101101 11100 001010 001000
3	001100 11110 010101110
4	0110010 11101 101100
5	1001 11100 1111101
6	1010 00110110 0001110
7	001100 11101 1001 11001 1000

FIG. 8

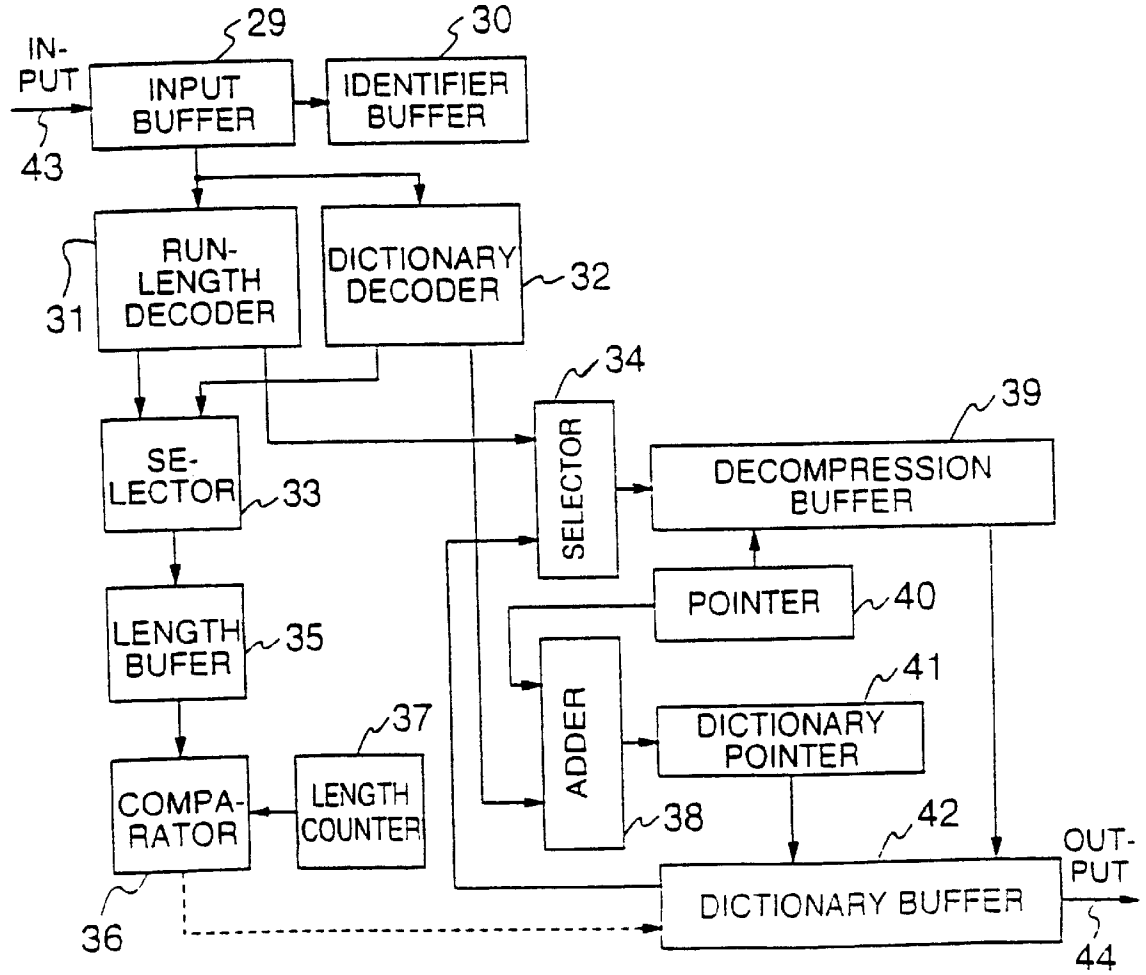


FIG. 9

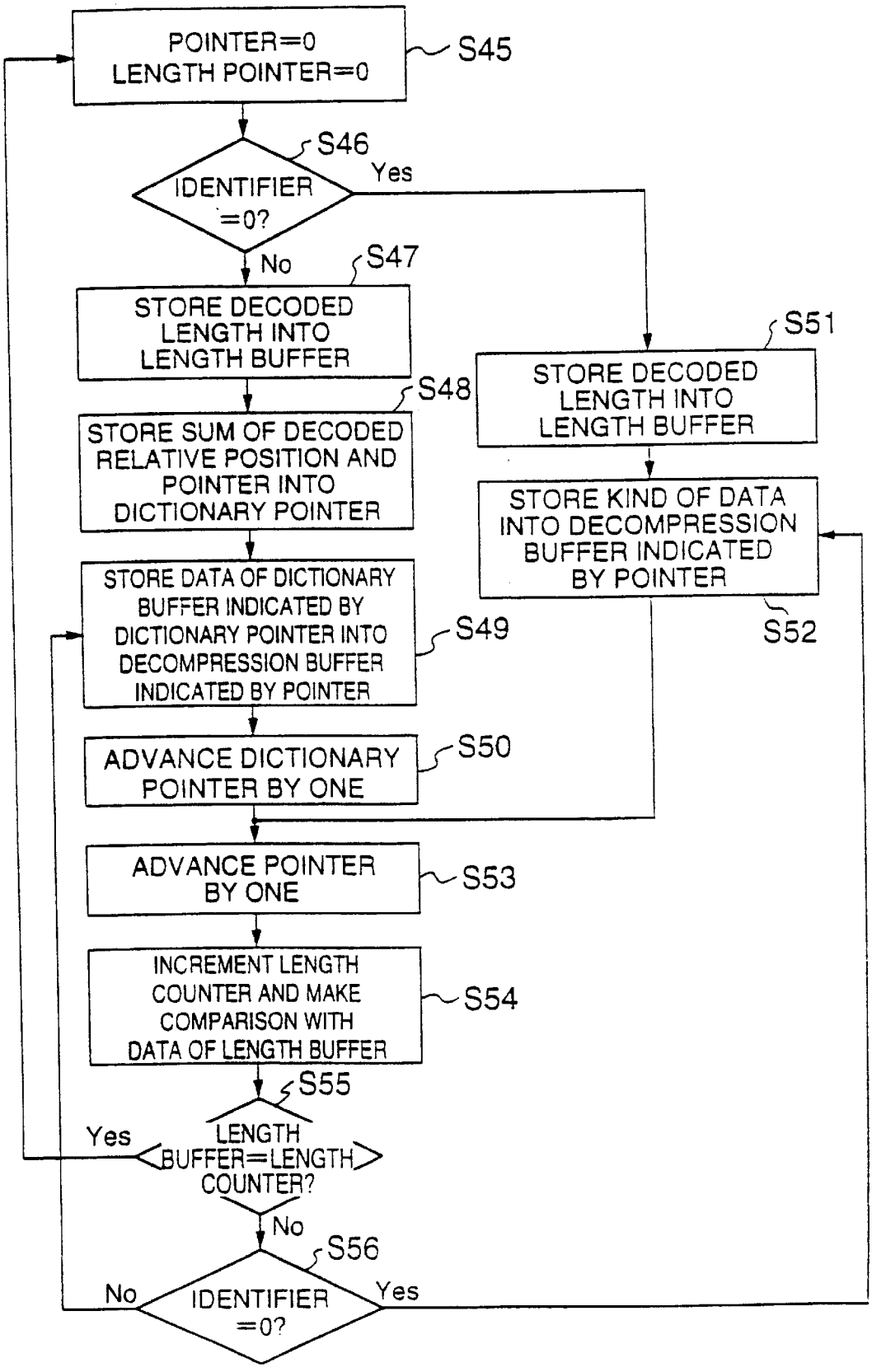

POINTER=0
LENGTH POINTER=0
S45
S46
IDENTIFIER =0?
Yes
No
S47
STORE DECODED LENGTH INTO LENGTH BUFFER
S48
STORE SUM OF DECODED RELATIVE POSITION AND POINTER INTO DICTIONARY POINTER
STORE DATA OF DICTIONARY BUFFER INDICATED BY DICTIONARY POINTER INTO DECOMPRESSION BUFFER INDICATED BY POINTER
S49
ADVANCE DICTIONARY POINTER BY ONE
S50
S51
STORE DECODED LENGTH INTO LENGTH BUFFER
STORE KIND OF DATA INTO DECOMPRESSION BUFFER INDICATED BY POINTER
S52
ADVANCE POINTER BY ONE
S53
INCREMENT LENGTH COUNTER AND MAKE COMPARISON WITH DATA OF LENGTH BUFFER
S54
S55
Yes
LENGTH BUFFER=LENGTH COUNTER?
No
S56
No
IDENTIFIER =0?
Yes

FIG. 10

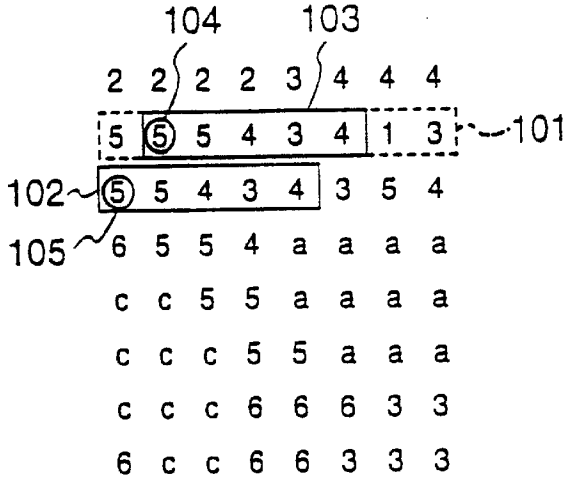

104
103
2 2 2 2 3 4 4 4
5 5 5 4 3 4 1 3
101
102
5 5 4 3 4 3 5 4
105
6 5 5 4 a a a a
c c 5 5 a a a a
c c c 5 5 a a a
c c c 6 6 6 3 3
6 c c 6 6 3 3 3

FIG. 11

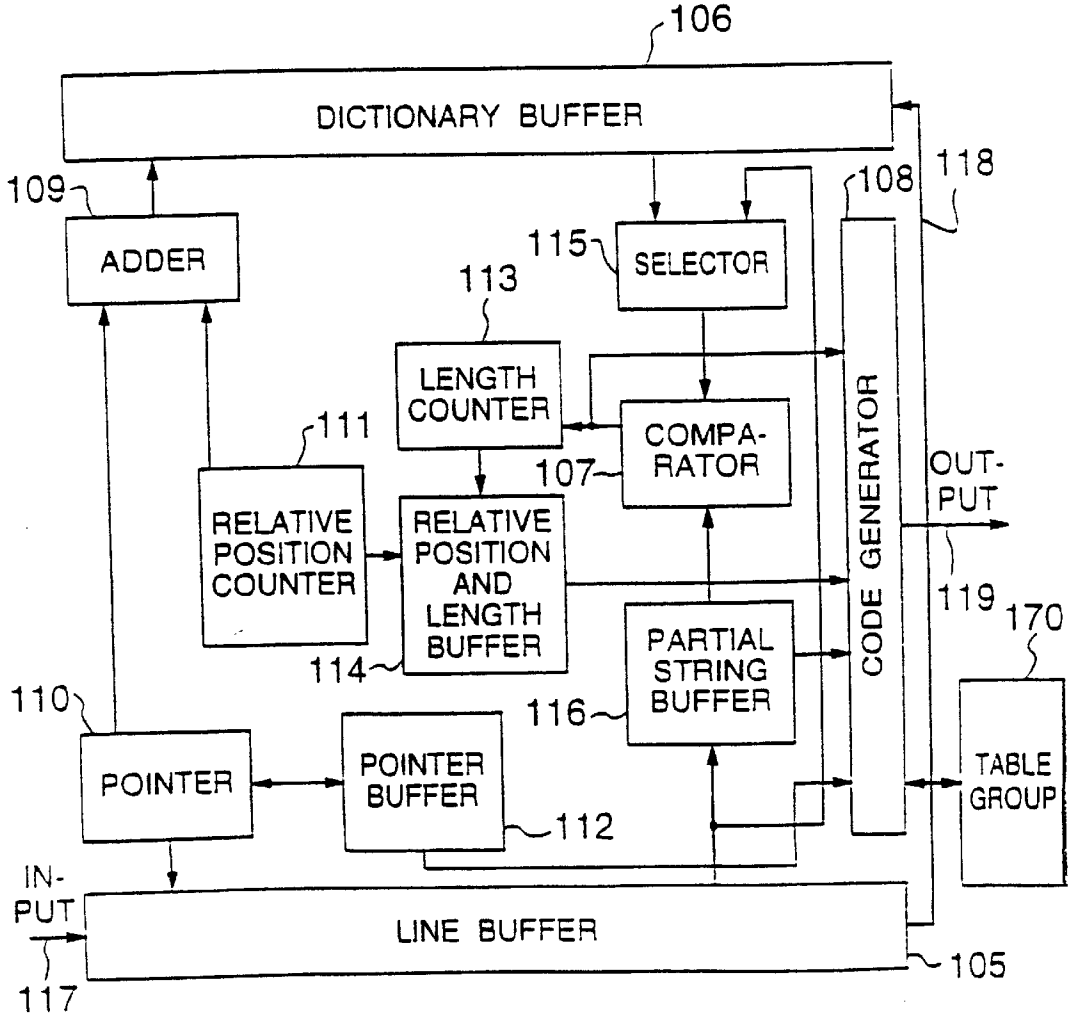

106
DICTIONARY BUFFER
109
ADDER
115
SELECTOR
108
118
113
LENGTH COUNTER
111
COMPA-RATOR
107
RELATIVE POSITION COUNTER
RELATIVE POSITION AND LENGTH BUFFER
114
CODE GENERATOR
OUT-PUT
119
170
PARTIAL STRING BUFFER
116
110
POINTER
POINTER BUFFER
112
TABLE GROUP
IN-PUT
LINE BUFFER
105
117

FIG. 12

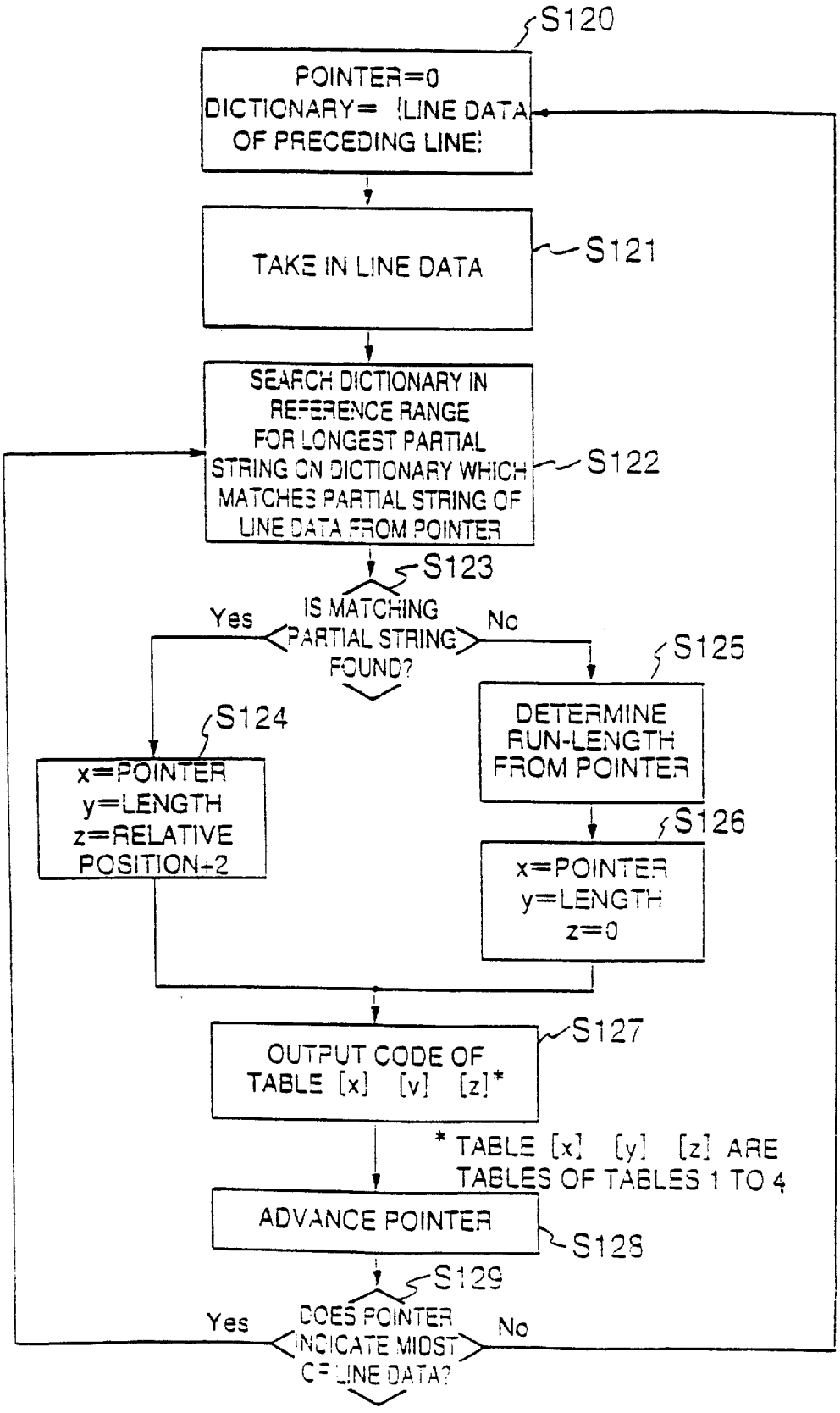

S120
POINTER=0
DICTIONARY= {LINE DATA OF PRECEDING LINE}
TAKE IN LINE DATA
S121
SEARCH DICTIONARY IN REFERENCE RANGE FOR LONGEST PARTIAL STRING ON DICTIONARY WHICH MATCHES PARTIAL STRING OF LINE DATA FROM POINTER
S122
S123
IS MATCHING PARTIAL STRING FOUND?
Yes
No
S124
x=POINTER
y=LENGTH
z=RELATIVE POSITION-2
S125
DETERMINE RUN-LENGTH FROM POINTER
S126
x=POINTER
y=LENGTH
z=0
S127
OUTPUT CODE OF TABLE [x] [y] [z]*
* TABLE [x] [y] [z] ARE TABLES OF TABLES 1 TO 4
ADVANCE POINTER
S128
S129
DOES POINTER INDICATE MIDST OF LINE DATA?
Yes
No

FIG. 13A

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 13B

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
a 1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
b 3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 13C

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
1	5	5	5	4	3	4	1	3 e
2	5	5	4	3	4	3	5	4
c 3	6	5	5	4	a	a	a	a d
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 14

ROW	CODE STRING
0	[0. 2, 4][4, 3, 1][5. 4, 3]
1	[0. 5, 3][3, 4, 1]{4, 0. 2}[6, 1, 1][7, 3. 1]
2	{0. 1, 5} {5. -1, 1}[6. 5, 1][7, 4, 1]
3	[0. 6, 1]{1, -1, 3}[4. a, 4]
4	[0. c, 2]{2, -1, 2} {4, 0, 4}
5	{0. 0, 2} {2. -1, 6}
6	{0, 0, 3}[3. 6, 3][6. 3. 2]
7	[0. 6, 1]{1, 0, 4} {5. 1, 2} {7, 0, 1}

FIG. 15

X=0

z / y	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	110	—	0100	11110
2	1000	—	1010	011110
3	01010	—	01110	111110
4	10110	—	11100	0111110
5	101110	—	10010	0111111
6	101111	—	10011	1111111
7	1111110	—	11101	01011
8	0110	—	00	—

FIG. 16

X=1

y \ z	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	00	0110	1110	010110
2	100	1100	11010	011100
3	1010	11110	011110	0101111
4	10110	011101	0111110	1111101
5	0101110	1111110	01111110	11111111
6	1111100	01111111	11111110	10111
7	11011	01010	0100	—
8	—	—	—	—

FIG. 17

X=2

y \ z	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	10	11010	0001	0101
2	1100	11110	0110	00110
3	0000	111110	01110	1111110
4	110110	001111	011110	011111
5	001110	11111110	11111111	0100
6	0010	110111	1110	—
7	—	—	—	—
8	—	—	—	—

FIG. 18

X=3

y \ z	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	10	0000	0010	11010
2	010	11011	11110	011110
3	0001	01110	111110	011111
4	00111	1111110	1111111	0110
5	1110	00110	1100	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 19

X=4

y \ z	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	10	0010	0011	11010
2	010	11011	01110	01111
3	0110	111110	111111	1100
4	1110	11110	000	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 20

X=5

z / y	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	10	0011	0110	11110
2	010	0111	11111	1110
3	110	0010	000	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 21

X=6

z / y	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	00	1110	1111	100
2	01	101	110	—
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 22

X=7

y \ z	0	1	2	3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	0	11	10	—
2	—	—	—	—
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 23

	CODE STRING
0	101100010 100011 1100100
1	010100101 100100 01110 000001 00011
2	0111111 0011 000101 00100
3	1100110 11110 11100000
4	10000010 11110 000
5	1010 110111
6	01110 00010110 010011
7	1100110 0111110 1110 10

FIG. 24

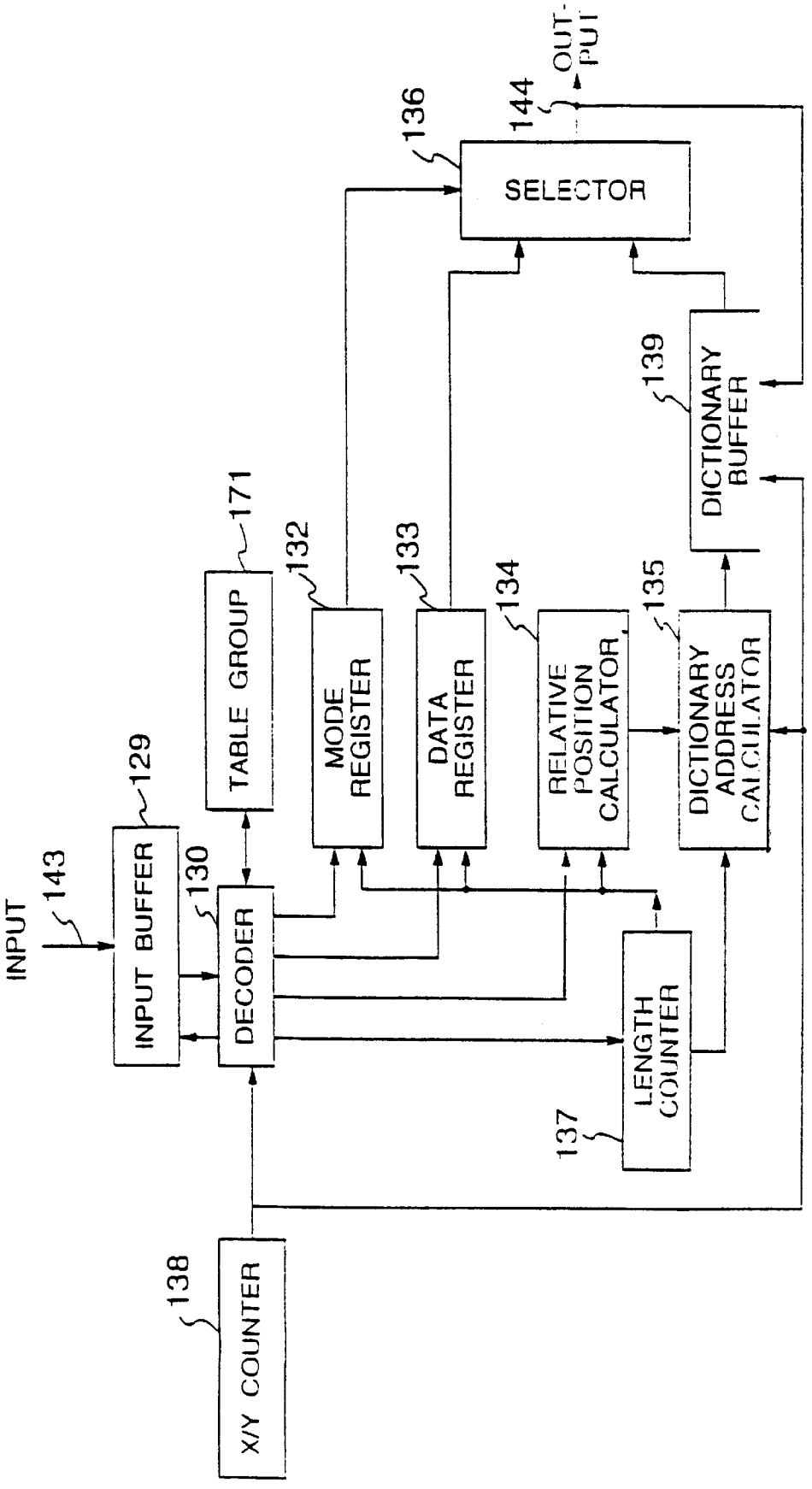

INPUT
143
INPUT BUFFER
129
DECODER
130
TABLE GROUP
171
MODE REGISTER
132
DATA REGISTER
133
RELATIVE POSITION CALCULATOR
134
DICTIONARY ADDRESS CALCULATOR
135
SELECTOR
136
OUT-PUT
144
DICTIONARY BUFFER
139
LENGTH COUNTER
137
X/Y COUNTER
138

FIG. 25

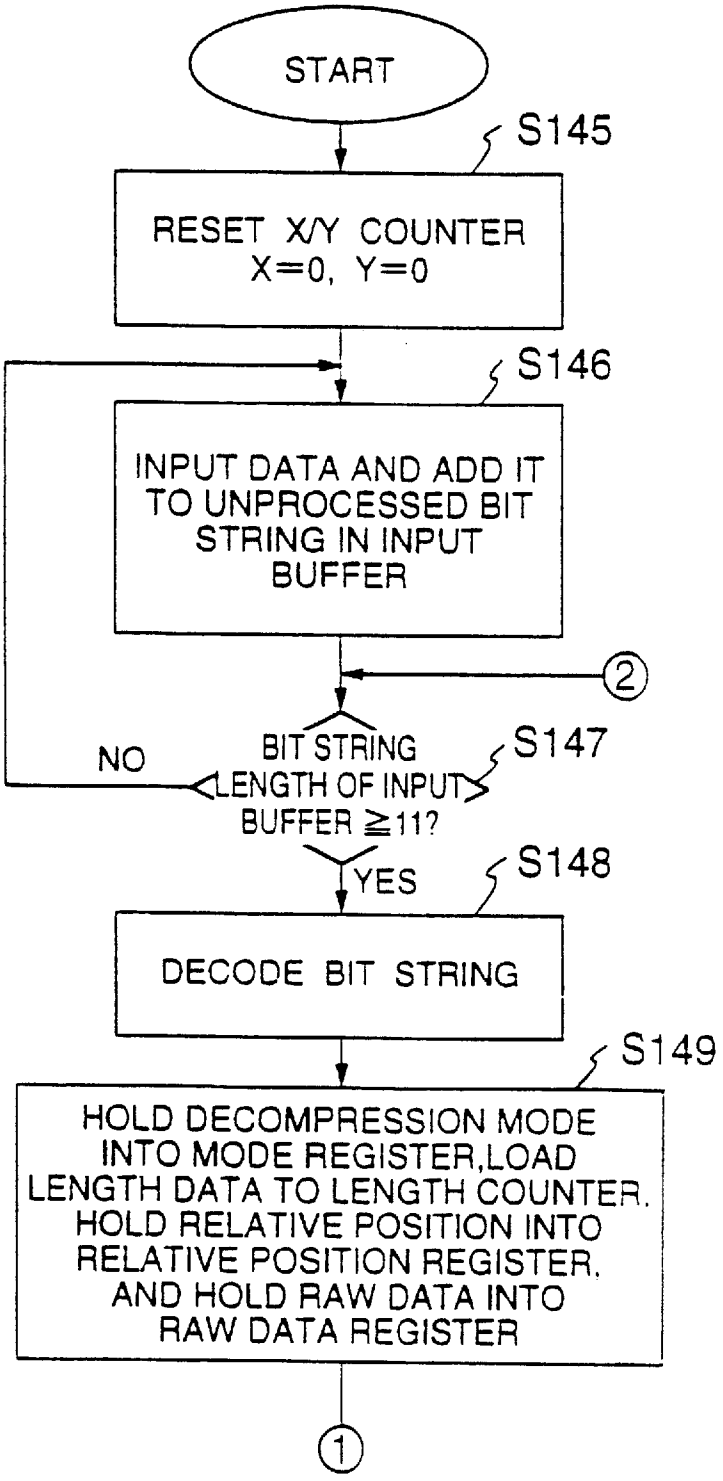

START
S145
RESET X/Y COUNTER
X=0, Y=0
S146
INPUT DATA AND ADD IT TO UNPROCESSED BIT STRING IN INPUT BUFFER
2
BIT STRING LENGTH OF INPUT BUFFER ≧11?
S147
NO
YES
S148
DECODE BIT STRING
S149
HOLD DECOMPRESSION MODE INTO MODE REGISTER,LOAD LENGTH DATA TO LENGTH COUNTER. HOLD RELATIVE POSITION INTO RELATIVE POSITION REGISTER. AND HOLD RAW DATA INTO RAW DATA REGISTER
1

FIG. 26

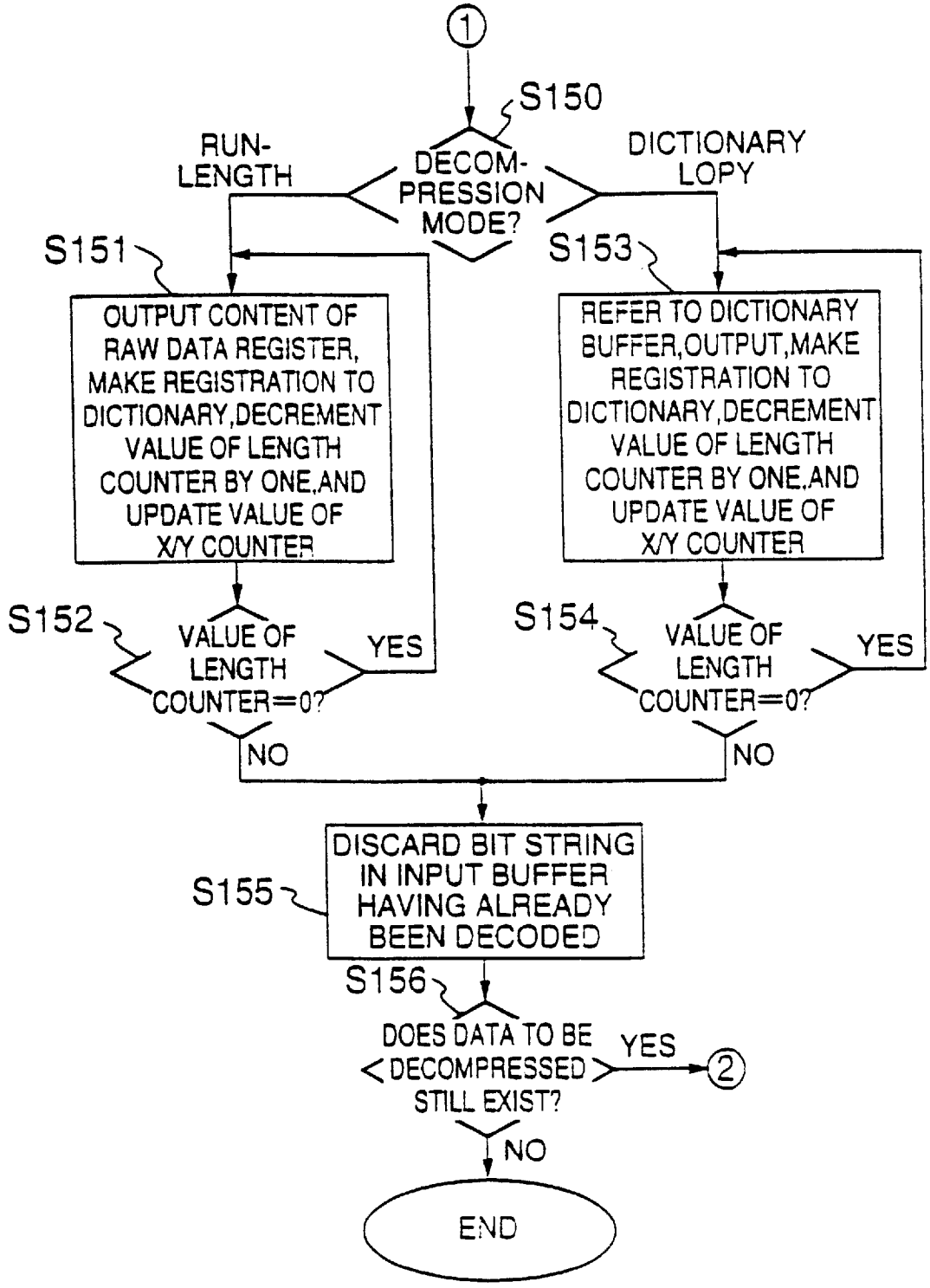

1
S150
DECOM-PRESSION MODE?
RUN-LENGTH
DICTIONARY LOPY
S151
OUTPUT CONTENT OF RAW DATA REGISTER, MAKE REGISTRATION TO DICTIONARY,DECREMENT VALUE OF LENGTH COUNTER BY ONE,AND UPDATE VALUE OF X/Y COUNTER
S153
REFER TO DICTIONARY BUFFER,OUTPUT,MAKE REGISTRATION TO DICTIONARY,DECREMENT VALUE OF LENGTH COUNTER BY ONE,AND UPDATE VALUE OF X/Y COUNTER
S152
VALUE OF LENGTH COUNTER=0?
YES
NO
S154
VALUE OF LENGTH COUNTER=0?
YES
NO
S155
DISCARD BIT STRING IN INPUT BUFFER HAVING ALREADY BEEN DECODED
S156
DOES DATA TO BE DECOMPRESSED STILL EXIST?
YES
2
NO
END

FIG. 27

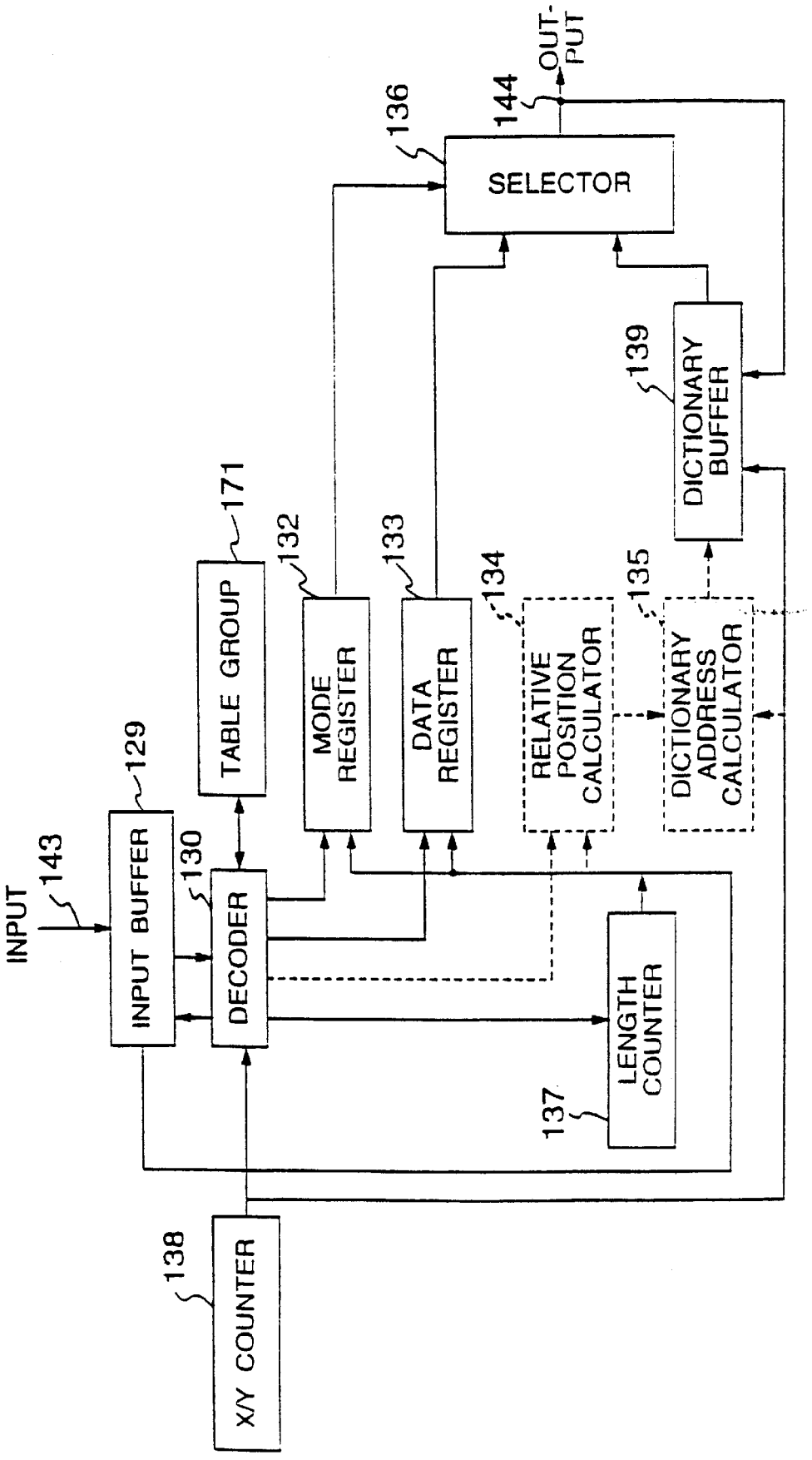

INPUT
143
INPUT BUFFER
129
DECODER
130
TABLE GROUP
171
MODE REGISTER
132
DATA REGISTER
133
RELATIVE POSITION CALCULATOR
134
DICTIONARY ADDRESS CALCULATOR
135
SELECTOR
136
OUT-PUT
144
DICTIONARY BUFFER
139
LENGTH COUNTER
137
X/Y COUNTER
138

FIG. 28

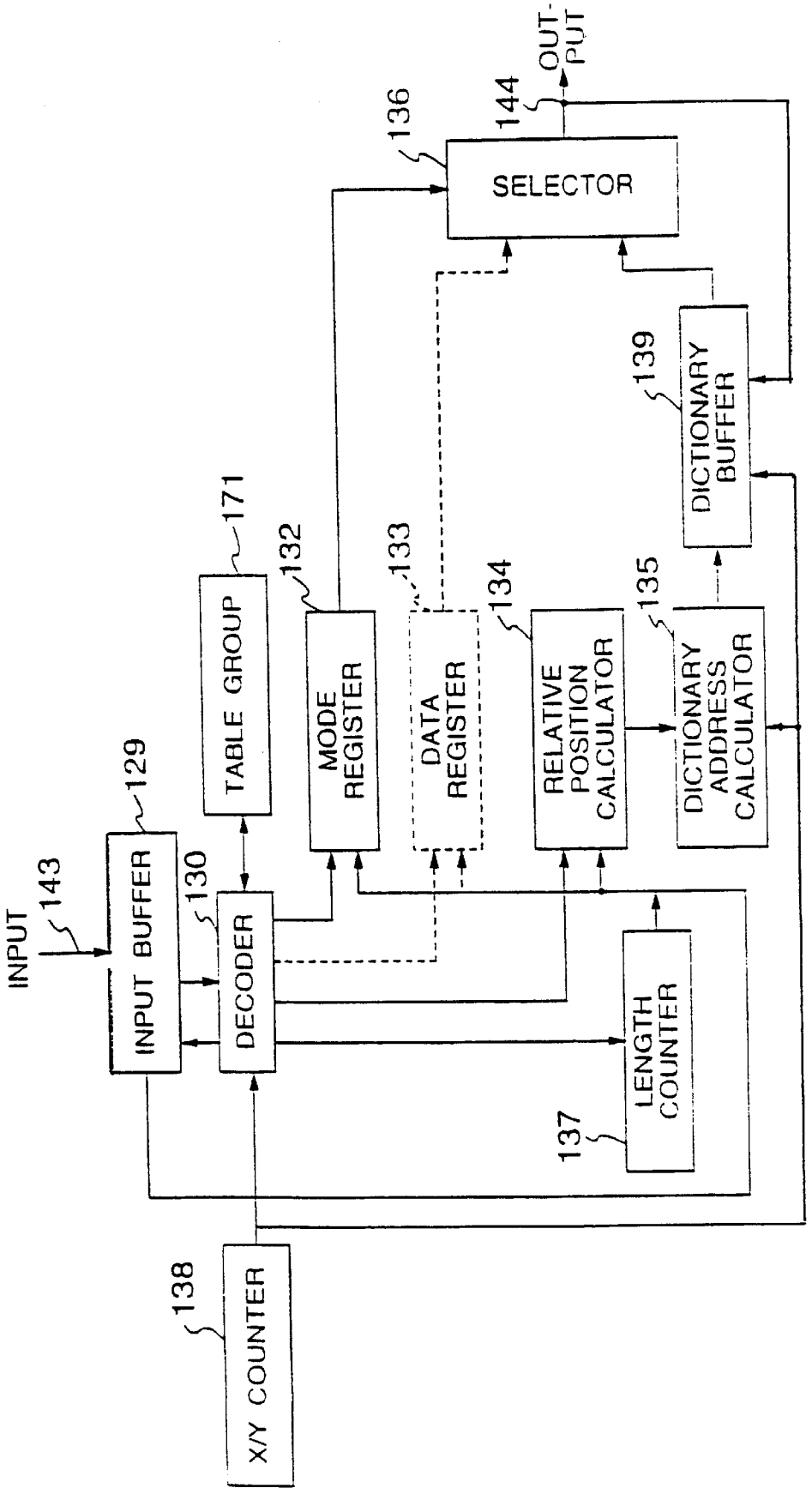

INPUT
143
INPUT BUFFER
129
DECODER
130
TABLE GROUP
171
MODE REGISTER
132
DATA REGISTER
133
RELATIVE POSITION CALCULATOR
134
DICTIONARY ADDRESS CALCULATOR
135
DICTIONARY BUFFER
139
SELECTOR
136
OUT-PUT
144
LENGTH COUNTER
137
X/Y COUNTER
138

FIG. 29

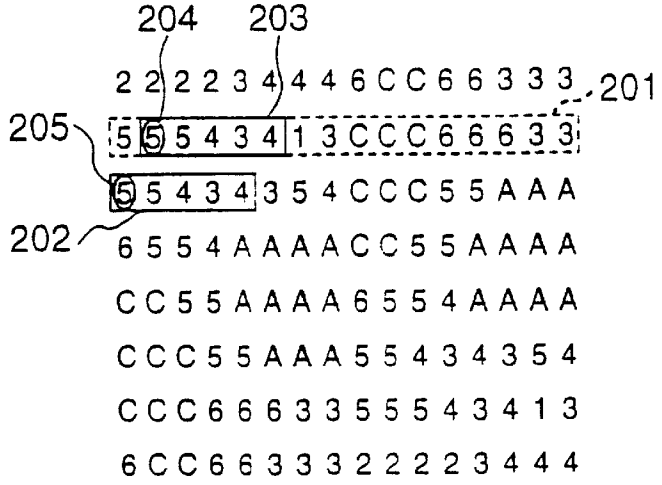

204
203
201
205
202
2 2 2 2 3 4 4 4 6 C C 6 6 3 3 3
5 5 5 4 3 4 1 3 C C C 6 6 6 3 3
5 5 4 3 4 3 5 4 C C C 5 5 A A A
6 5 5 4 A A A A C C 5 5 A A A A
C C 5 5 A A A A 6 5 5 4 A A A A
C C C 5 5 A A A 5 5 4 3 4 3 5 4
C C C 6 6 6 3 3 5 5 5 4 3 4 1 3
6 C C 6 6 3 3 3 2 2 2 2 3 4 4 4

FIG. 30

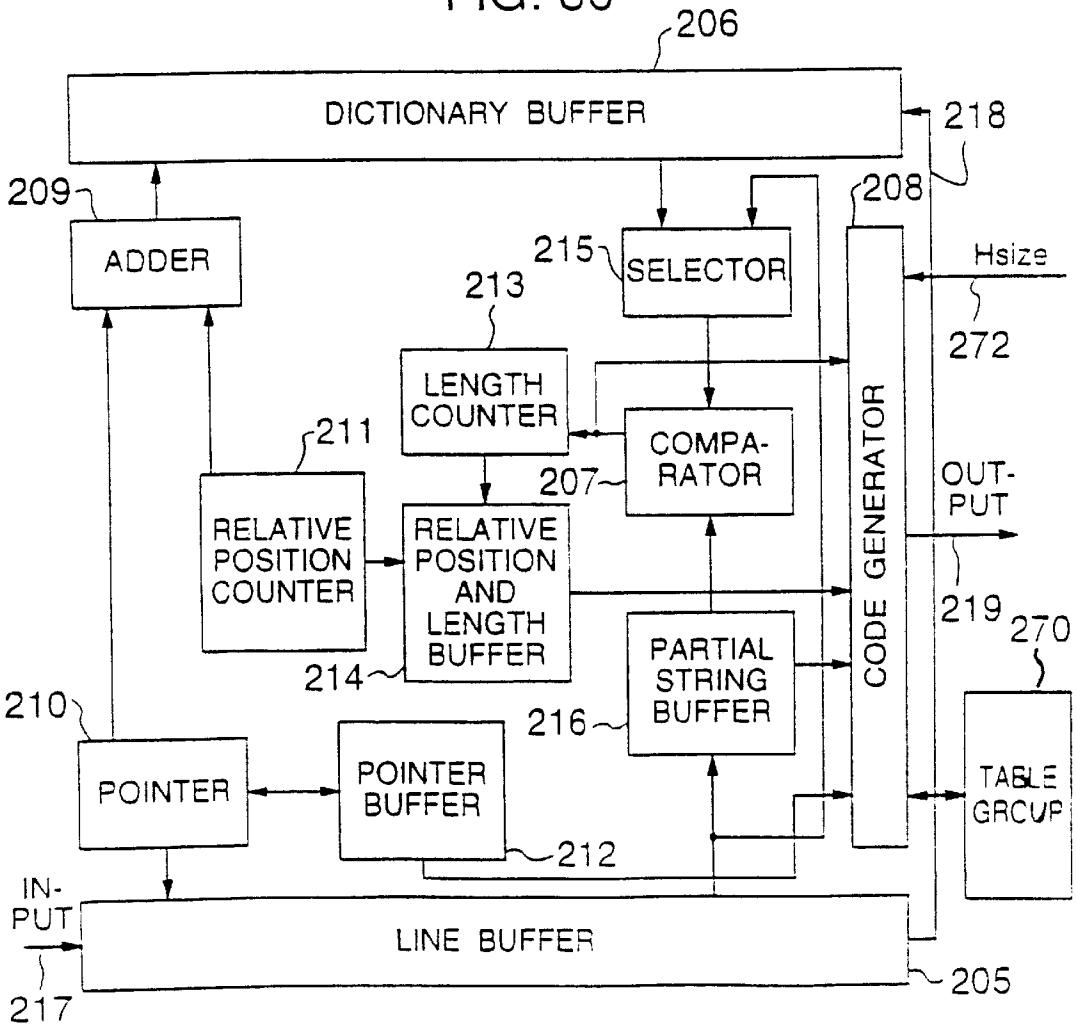

206
DICTIONARY BUFFER
218
209
ADDER
208
215
SELECTOR
Hsize
213
272
LENGTH COUNTER
211
COMPA-RATOR
207
OUT-PUT
RELATIVE POSITION COUNTER
RELATIVE POSITION AND LENGTH BUFFER
CODE GENERATOR
219
270
214
PARTIAL STRING BUFFER
210
216
POINTER
POINTER BUFFER
TABLE GROUP
212
IN-PUT
LINE BUFFER
205
217

FIG. 31

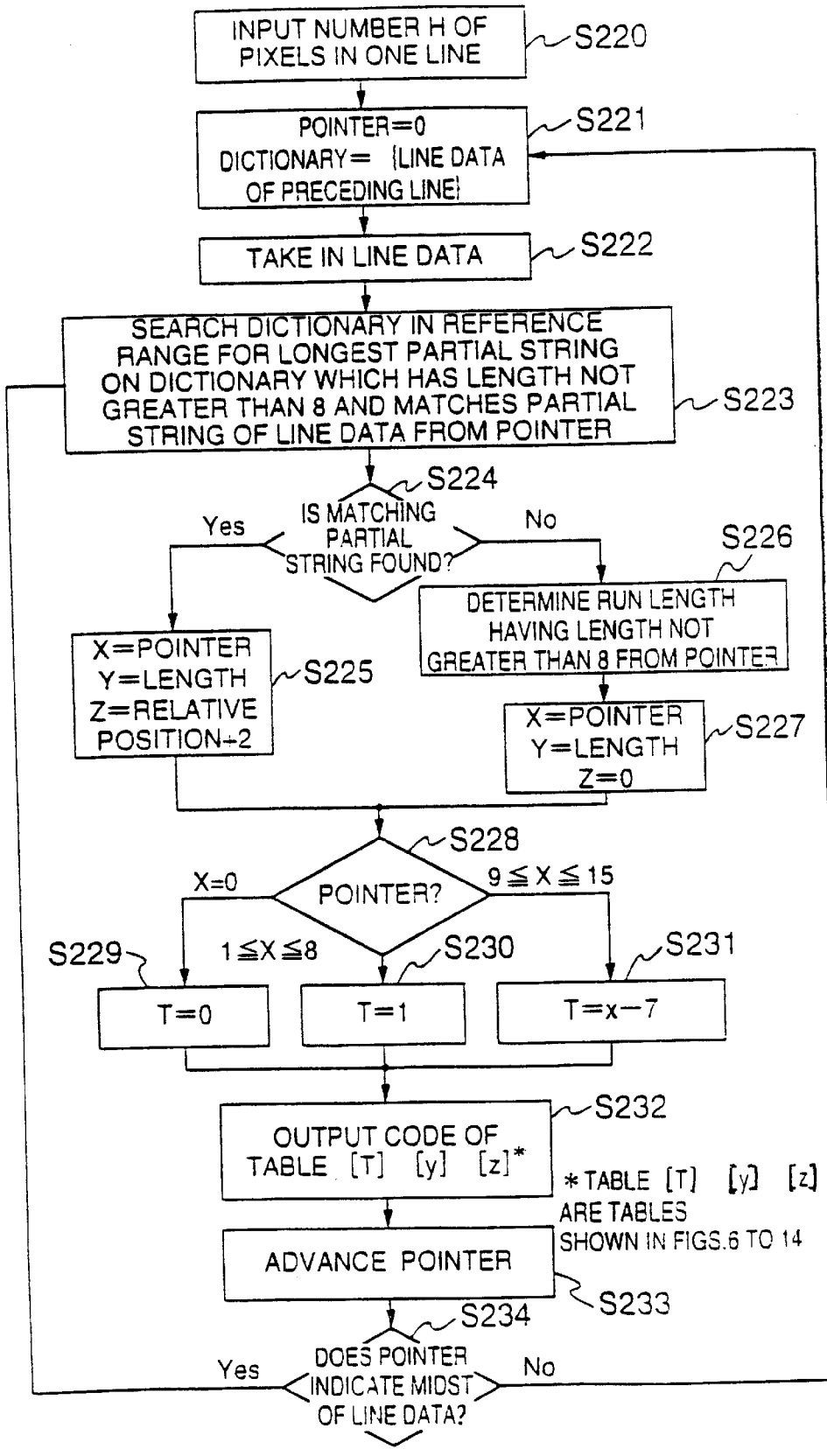

INPUT NUMBER H OF PIXELS IN ONE LINE
S220
POINTER=0
DICTIONARY= {LINE DATA OF PRECEDING LINE}
S221
TAKE IN LINE DATA
S222
SEARCH DICTIONARY IN REFERENCE RANGE FOR LONGEST PARTIAL STRING ON DICTIONARY WHICH HAS LENGTH NOT GREATER THAN 8 AND MATCHES PARTIAL STRING OF LINE DATA FROM POINTER
S223
S224
IS MATCHING PARTIAL STRING FOUND?
Yes
No
X=POINTER
Y=LENGTH
Z=RELATIVE POSITION-2
S225
S226
DETERMINE RUN LENGTH HAVING LENGTH NOT GREATER THAN 8 FROM POINTER
X=POINTER
Y=LENGTH
Z=0
S227
S228
POINTER?
X=0
1≦X≦8
9≦X≦15
S229
S230
S231
T=0
T=1
T=x-7
OUTPUT CODE OF TABLE [T] [y] [z]*
S232
* TABLE [T] [y] [z] ARE TABLES SHOWN IN FIGS.6 TO 14
ADVANCE POINTER
S233
S234
DOES POINTER INDICATE MIDST OF LINE DATA?
Yes
No

FIG. 32A

ROW \ COLUMN	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	2	2	2	2	3	4	4	4	6	C	C	6	6	3	3	3
1	5	5	5	4	3	4	1	3	C	C	C	6	6	6	3	3
2	5	5	4	3	4	3	5	4	C	C	C	5	5	A	A	A
3	6	5	5	4	A	A	A	A	C	C	5	5	A	A	A	A
4	C	C	5	5	A	A	A	A	6	5	5	4	A	A	A	A
5	C	C	C	5	5	A	A	A	5	5	4	3	4	3	5	4
6	C	C	C	6	6	6	3	3	5	5	5	4	3	4	1	3
7	6	C	C	6	6	3	3	3	2	2	2	2	3	4	4	4

FIG. 32B

ROW \ COLUMN	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	2	2	2	2	3	4	4	4	6	C	C	6	6	3	3	3
1	5	5	5	4	3	4	1	3	C	C	C	6	6	6	3	3
2	5	5	4	3	4	3	5	4	C	C	C	5	5	A	A	A
3	6	5	5	4	A	A	A	A	C	C	5	5	A	A	A	A
4	C	C	5	5	A	A	A	A	6	5	5	4	A	A	A	A
5	C	C	C	5	5	A	A	A	5	5	4	3	4	3	5	4
6	C	C	C	6	6	6	3	3	5	5	5	4	3	4	1	3
7	6	C	C	6	6	3	3	3	2	2	2	2	3	4	4	4

FIG. 32C

ROW \ COLUMN	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	2	2	2	2	3	4	4	4	6	C	C	6	6	3	3	3
1	5	5	5	4	3	4	1	3	C	C	C	6	6	6	3	3
2	5	5	4	3	4	3	5	4	C	C	C	5	5	A	A	A
3	6	5	5	4	A	A	A	A	C	C	5	5	A	A	A	A
4	C	C	5	5	A	A	A	A	6	5	5	4	A	A	A	A
5	C	C	C	5	5	A	A	A	5	5	4	3	4	3	5	4
6	C	C	C	6	6	6	3	3	5	5	5	4	3	4	1	3
7	6	C	C	6	6	3	3	3	2	2	2	2	3	4	4	4

FIG. 33

ROW	INTERMMEDIATE CODE STRING
0	[0, 2, 4][1, 3, 1][1, 4, 3][1, 6, 1][2, C, 2][4, 6, 2][6, 3. 3]
1	[0, 5, 3][1, 4, 1]{1, 0, 2}[1, 1, 1][1, 3, 1]{1, 1,2} {3, 0, 3} {6, -1, 3}
2	{0, 1, 5} {1, -1. 1}[1, 5. 1][1, 4. 1]{1, 0. 3}[4, 5, 2][6. A, 3]
3	[0, 6, 1]{1, -1. 3}[1, A. 4]{1, 1. 7} {8, 0. 1}
4	[0, C, 2]{1, -1, 2} {1, 0, 4}[1, 6. 1] {2, 1, 2}[4, 4, 1]{5. 0, 4}
5	{0, 0, 2} {1, -1. 6} {1, 1, 3}[4, 3. 1]{5, -1, 1}[6, 3, 1][7, 5, 1][8, 4, 1]
6	{0, 0, 3}[1, 6. 3][1, 3, 2]{1, 0, 2} {3, -1, 4}[7, 1, 1][8. 3, 1]
7	[0, 6, 1]{1, 0. 4} {1, 1, 2} {1, 0. 1} {1, 2. 4} {5, 0, 2} {7. -1, 1}[8, 4. 1]

FIG. 34

T=0 (x=0)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	01111	—	0101	01100100
2	011011110	—	0000	011011111
3	0110110101	—	0100	01100101
4	0110110111	—	0010	01100111
5	01101101100	—	01110	01101110
6	01101101101	—	0011	01100110
7	0110110100	—	0011	01101100
8	011010	—	1	011000

FIG. 35

T=1 ($1 \leqq x \leqq 8$)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	10	0111	1101	01101
2	0100	01011	11001	00000
3	00110	110000	00111	001010
4	010100	001001	00001	0110011
5	0110001	0110000	010101	11000101
6	01100101	0001110	000110	00011111
7	00011110	01100100	1100011	11000100
8	001000	001011	111	00010

FIG. 36

T=2 (x=9)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	10	11111	11100	111100
2	11011	110000	110011	1111010
3	1101010	110001101	1100010	1100011101
4	1101011	110100001	1101001	1100011111
5	1101000111	110100010	110100000	1100011110
6	1100011100	1101000110	110001100	11101
7	110010	1111011	0	—
8	—	—	—	—

FIG. 37

T=3 (x=10)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	00	01011	01000	010100
2	01101	011100	0110001	01110111
3	0110011	01110101	0110000	0111010000
4	0110010	0111011011	011101001	0111011010
5	0111011000	0111010001	0111011001	01111
6	01001	010101	1	—
7	—	—	—	—
8	—	—	—	—

FIG. 38

T=4 (x=11)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	00	0100	01101	0111011
2	011100	010111	011001	01100001
3	0101101	0110001	011101001	011000000
4	01110101	011101000	011000001	01111
5	01010	0101100	1	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 39

T=5 (x=12)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	01	00100	00101	00001
2	001111	00111000	0011101	0000001
3	0000000	001110010	001110011	0001
4	00110	000001	1	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 40

T=6 (x=13)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	01	00100	00101	00001
2	00000	0011010	0011011	0001
3	00111	001100	1	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 41

T=7 (x=14)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	00	01011	0100	0110
2	0111	01010	1	—
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 42

T=8 (x=15)

y	z=0	z=1	z=2	z=3
LENGTH	RUN LENGTH	RELATIVE POSITION		
		-1	0	+1
1	01	00	1	—
2	—	—	—	—
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—

FIG. 43

ROW	CODE STRING
0	01101101110010 100011 001100100 100110 110111100 0111000110 001110011
1	01101101010101 100100 11001 100001 100011 00000 0110000 001100
2	01101110 0111 100101 100100 00111 0111000101 001111010
3	011110110 110000 0101001010 11000100 1
4	0110111101100 01011 00001 100110 1111010 000100 1
5	0000 0001110 001010 000011 00100 010011 000101 010100
6	0100 001100110 01000011 11001 0111011011 000001 010011
7	011110110 00001 00000 1101 0101000010 0011101 01011 010100

FIG. 44

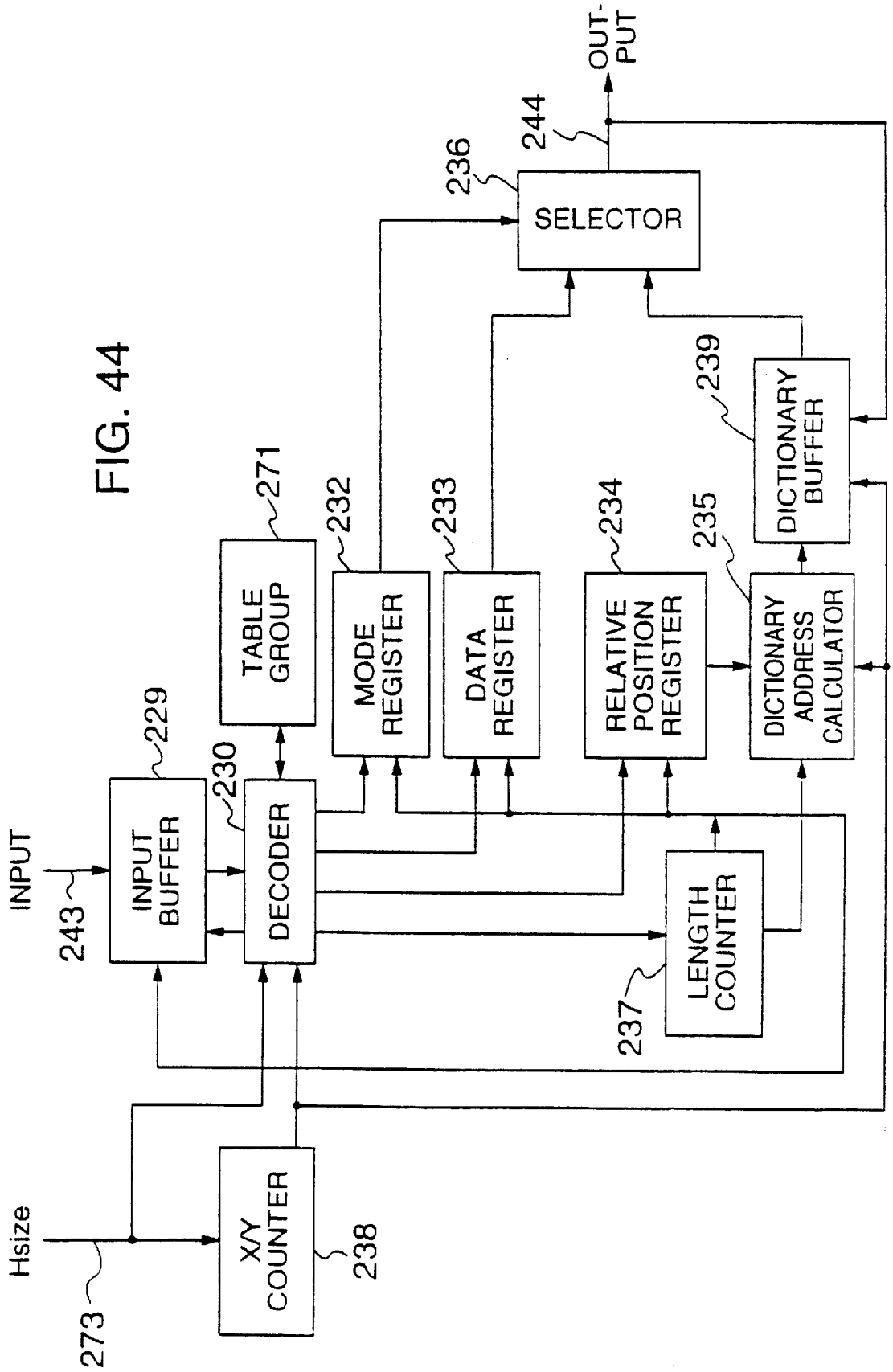

OUT-PUT
244
236
SELECTOR
239
DICTIONARY BUFFER
271
TABLE GROUP
232
MODE REGISTER
233
DATA REGISTER
234
RELATIVE POSITION REGISTER
235
DICTIONARY ADDRESS CALCULATOR
229
INPUT BUFFER
230
DECODER
INPUT
243
LENGTH COUNTER
237
Hsize
273
X/Y COUNTER
238

FIG. 45

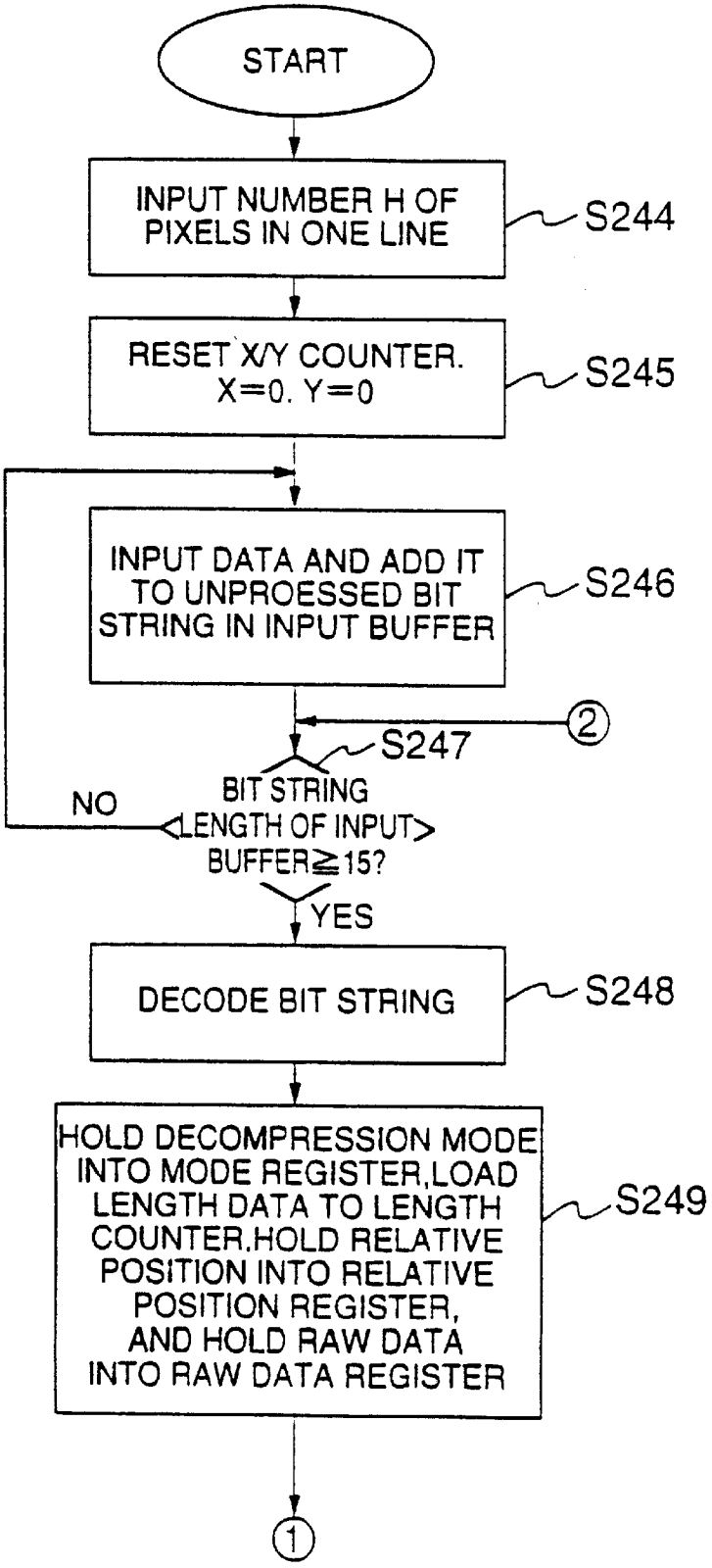

START
INPUT NUMBER H OF PIXELS IN ONE LINE
S244
RESET X/Y COUNTER. X=0. Y=0
S245
INPUT DATA AND ADD IT TO UNPROESSED BIT STRING IN INPUT BUFFER
S246
②
S247
BIT STRING <LENGTH OF INPUT> BUFFER≧15?
NO
YES
DECODE BIT STRING
S248
HOLD DECOMPRESSION MODE INTO MODE REGISTER,LOAD LENGTH DATA TO LENGTH COUNTER,HOLD RELATIVE POSITION INTO RELATIVE POSITION REGISTER, AND HOLD RAW DATA INTO RAW DATA REGISTER
S249
①

FIG. 46

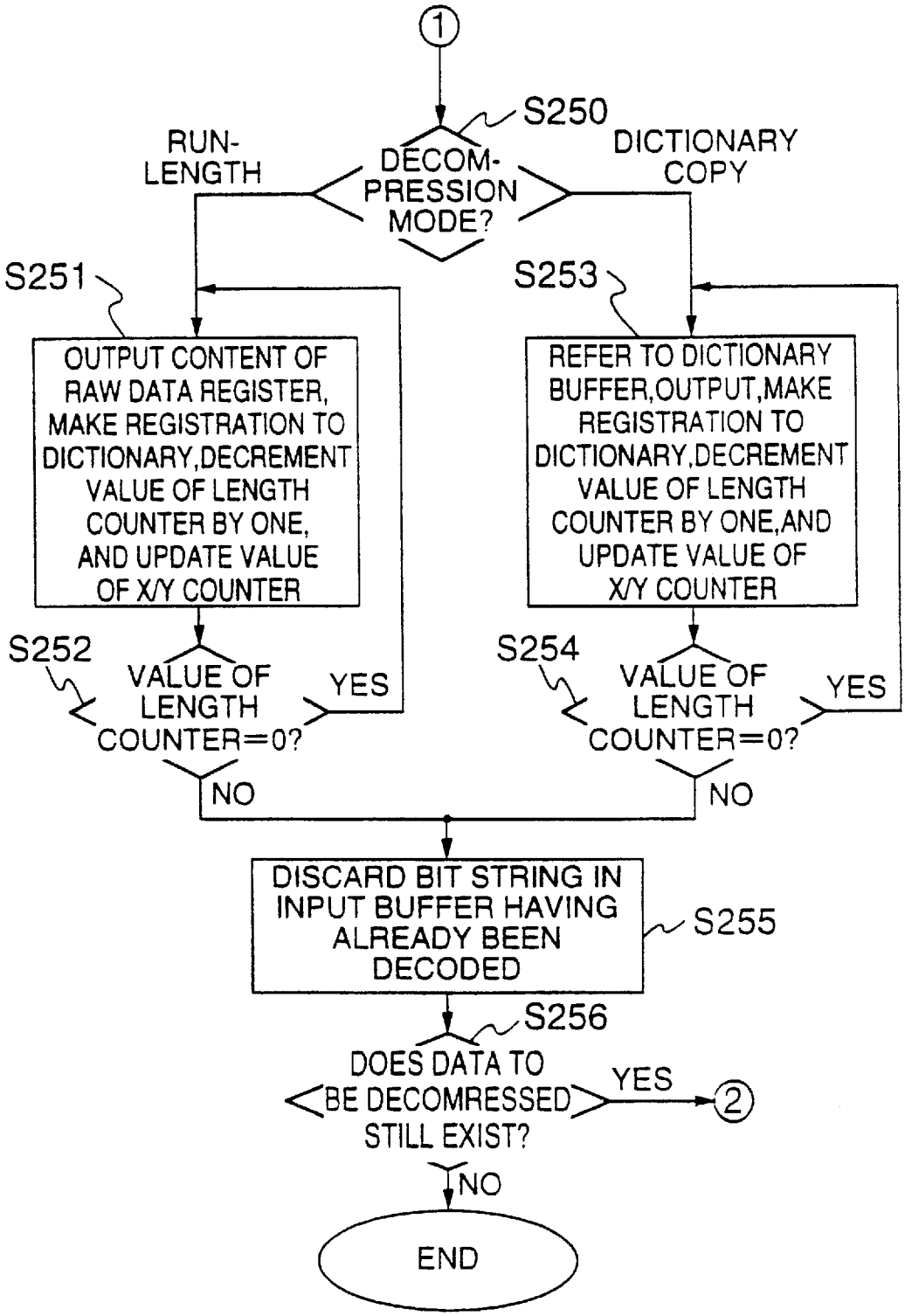

1
S250
DECOM-PRESSION MODE?
RUN-LENGTH
DICTIONARY COPY
S251
OUTPUT CONTENT OF RAW DATA REGISTER, MAKE REGISTRATION TO DICTIONARY,DECREMENT VALUE OF LENGTH COUNTER BY ONE, AND UPDATE VALUE OF X/Y COUNTER
S252
VALUE OF LENGTH COUNTER=0?
YES
NO
S253
REFER TO DICTIONARY BUFFER,OUTPUT,MAKE REGISTRATION TO DICTIONARY,DECREMENT VALUE OF LENGTH COUNTER BY ONE,AND UPDATE VALUE OF X/Y COUNTER
S254
VALUE OF LENGTH COUNTER=0?
YES
NO
DISCARD BIT STRING IN INPUT BUFFER HAVING ALREADY BEEN DECODED
S255
S256
DOES DATA TO BE DECOMRESSED STILL EXIST?
YES
2
NO
END

FIG. 47

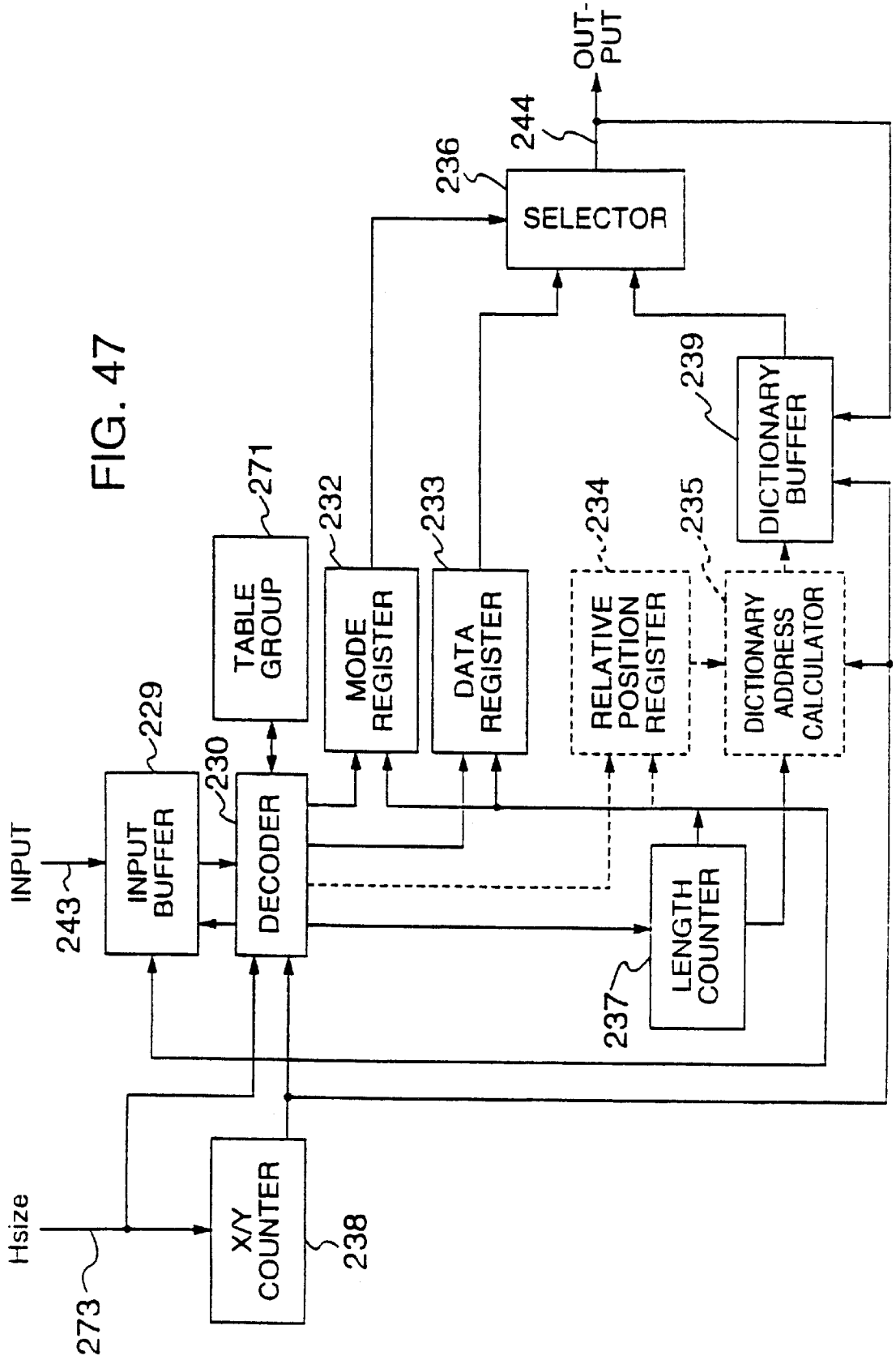

OUT-PUT
244
236
SELECTOR
239
DICTIONARY BUFFER
271
TABLE GROUP
232
MODE REGISTER
233
DATA REGISTER
234
RELATIVE POSITION REGISTER
235
DICTIONARY ADDRESS CALCULATOR
229
INPUT BUFFER
230
DECODER
INPUT
243
LENGTH COUNTER
237
Hsize
273
X/Y COUNTER
238

FIG. 48

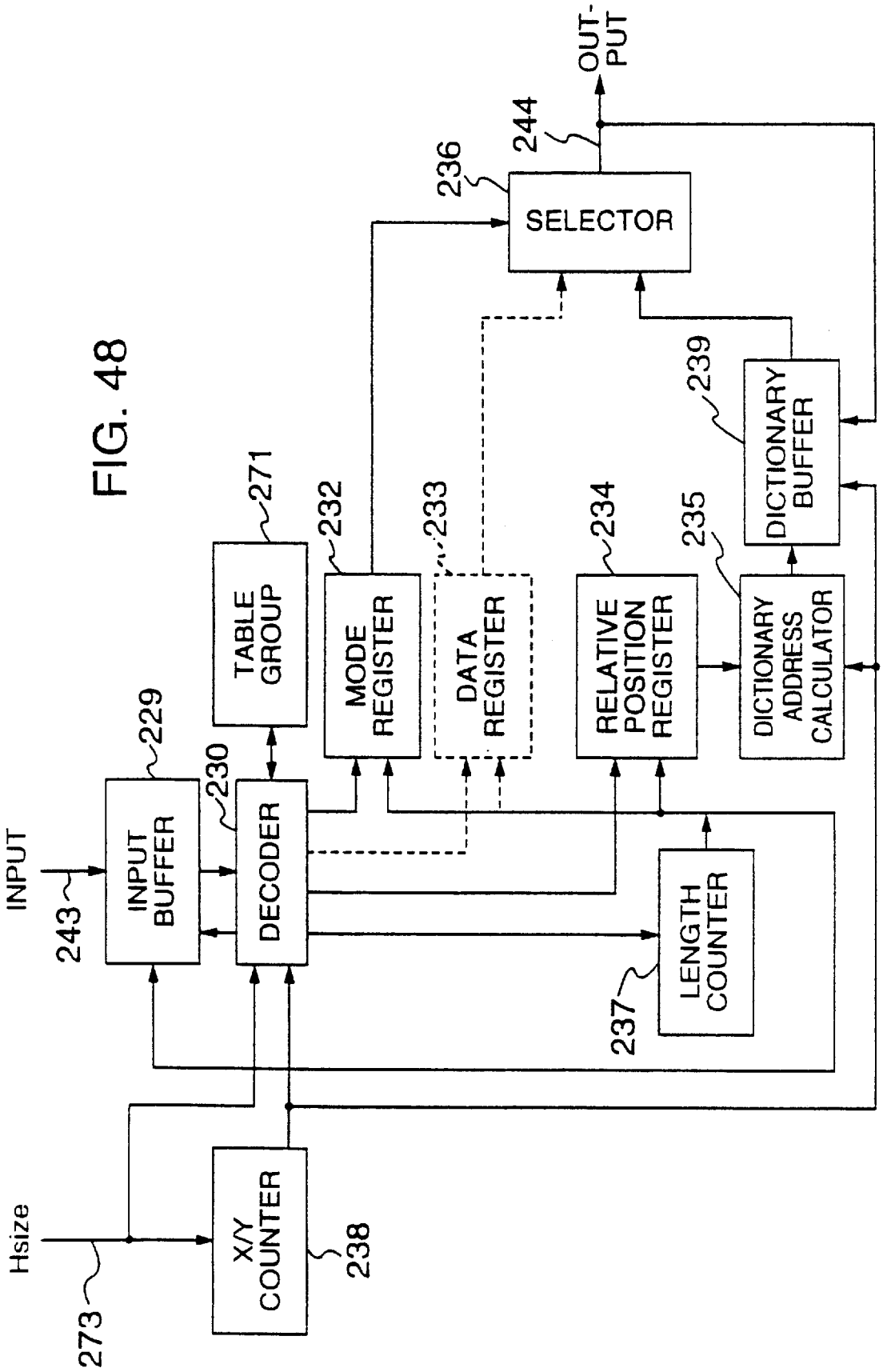

OUT-PUT
244
236
SELECTOR
239
DICTIONARY BUFFER
271
TABLE GROUP
232
MODE REGISTER
233
DATA REGISTER
234
RELATIVE POSITION REGISTER
235
DICTIONARY ADDRESS CALCULATOR
229
INPUT BUFFER
230
DECODER
INPUT
243
LENGTH COUNTER
237
Hsize
273
X/Y COUNTER
238

FIG. 49

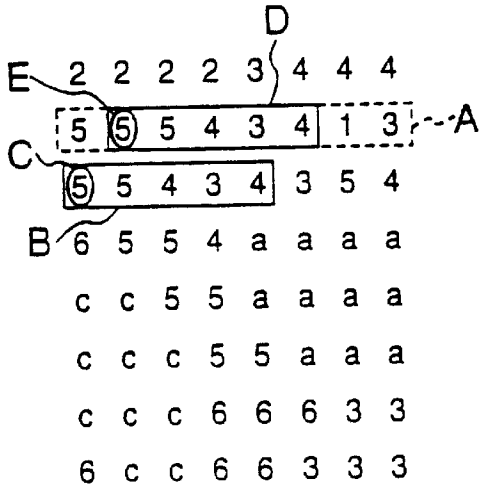

D
E
2 2 2 2 3 4 4 4
5 5 5 4 3 4 1 3
A
C
5 5 4 3 4 3 5 4
B
6 5 5 4 a a a a
c c 5 5 a a a a
c c c 5 5 a a a
c c c 6 6 6 3 3
6 c c 6 6 3 3 3

FIG. 50

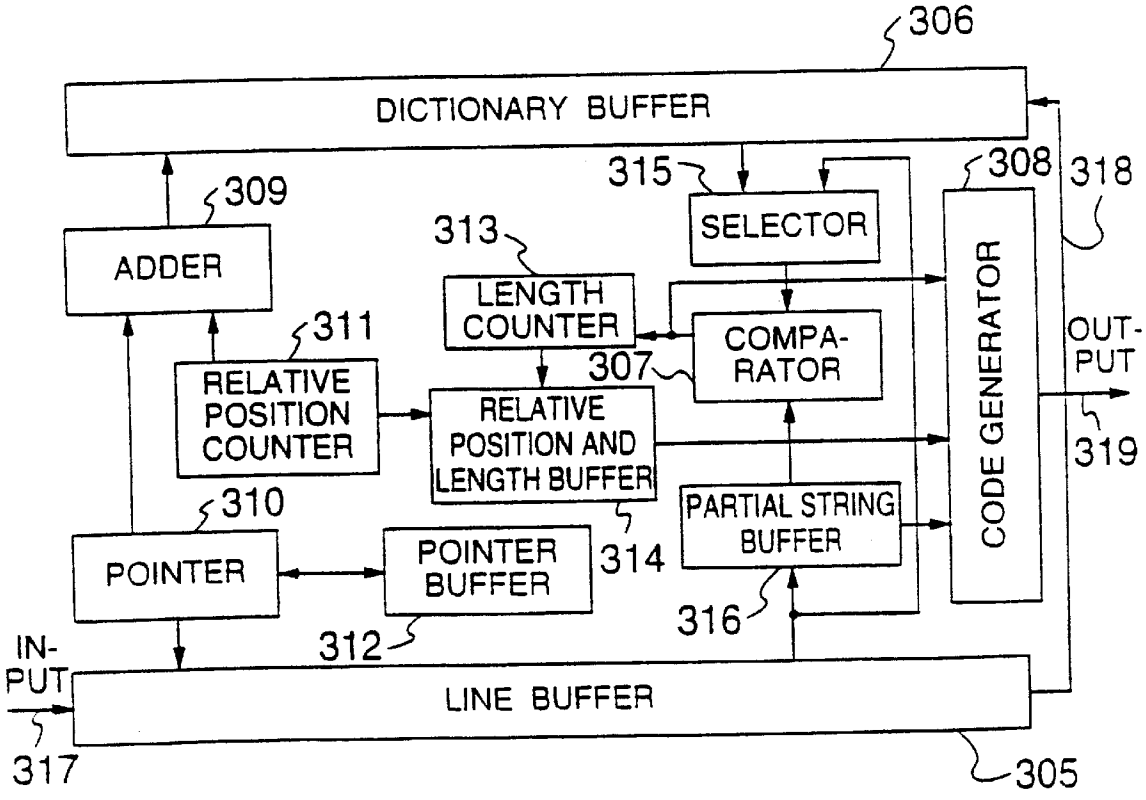

306
DICTIONARY BUFFER
315
308
318
309
SELECTOR
313
ADDER
LENGTH COUNTER
311
COMPA-RATOR
OUT-PUT
307
RELATIVE POSITION COUNTER
RELATIVE POSITION AND LENGTH BUFFER
CODE GENERATOR
319
310
PARTIAL STRING BUFFER
POINTER
POINTER BUFFER
314
316
312
IN-PUT
LINE BUFFER
317
305

FIG. 51

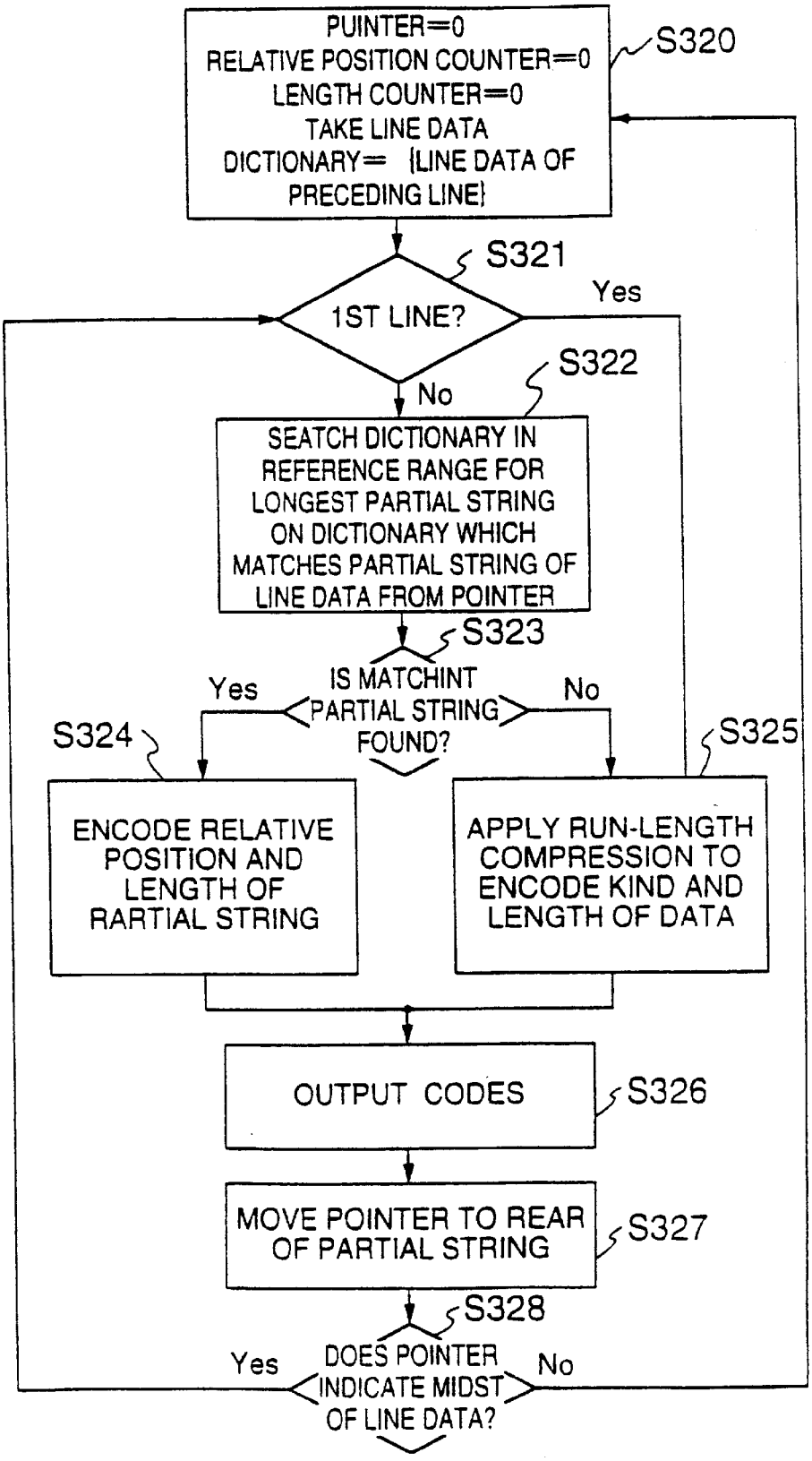

PUINTER=0
RELATIVE POSITION COUNTER=0
LENGTH COUNTER=0
TAKE LINE DATA
DICTIONARY= {LINE DATA OF PRECEDING LINE}
S320
S321
1ST LINE?
Yes
No
S322
SEATCH DICTIONARY IN REFERENCE RANGE FOR LONGEST PARTIAL STRING ON DICTIONARY WHICH MATCHES PARTIAL STRING OF LINE DATA FROM POINTER
S323
IS MATCHINT PARTIAL STRING FOUND?
Yes
No
S324
S325
ENCODE RELATIVE POSITION AND LENGTH OF RARTIAL STRING
APPLY RUN-LENGTH COMPRESSION TO ENCODE KIND AND LENGTH OF DATA
OUTPUT CODES
S326
MOVE POINTER TO REAR OF PARTIAL STRING
S327
S328
DOES POINTER INDICATE MIDST OF LINE DATA?
Yes
No

FIG. 52A

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 52B

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
a 1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
b 3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 52C

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
1	5	5	5	4	3	4	1	3 e
2	5	5	4	3	4	3	5	4
c 3	6	5	5	4	a	a	a	a d
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

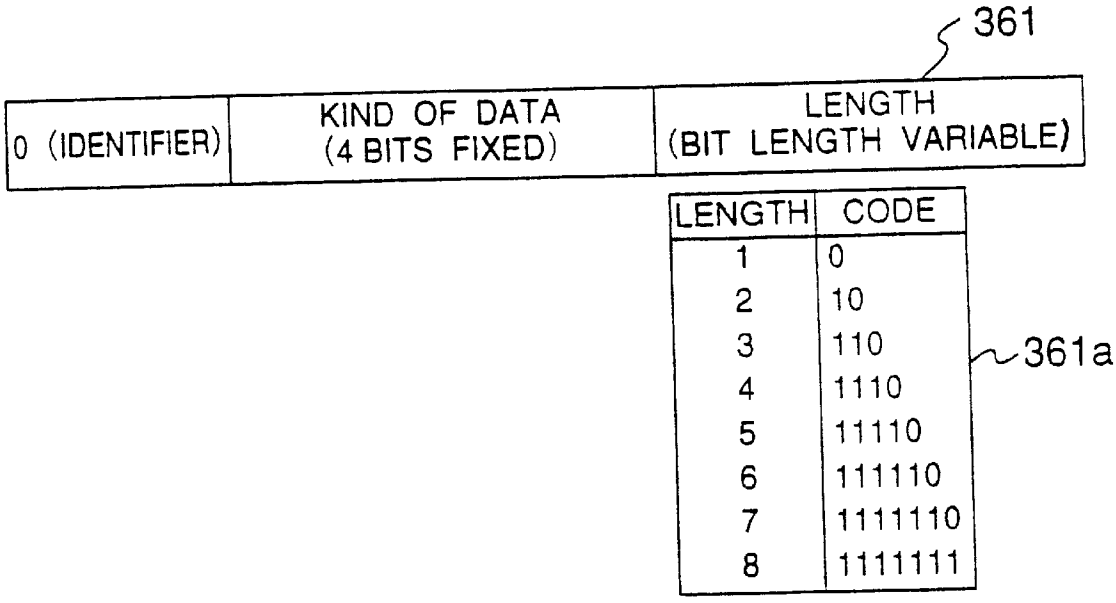
FIG. 53

ROW	CODE STRING
0	[2, 4][3. 1][4, 3]
1	[5, 3][4, 1]{0. 2}[1, 1][3, 1]
2	{1, 5} {-1, 1}[5, 1][4, 1]
3	[6, 1]{-1, 3}[a, 4]
4	[c, 2]{-1, 2} {0, 4}
5	{0, 2} {-1, 6}
6	{0, 3}[6. 3][3. 2]
7	[6, 1]{0. 4} {1, 2} {0. 1}

FIG. 54

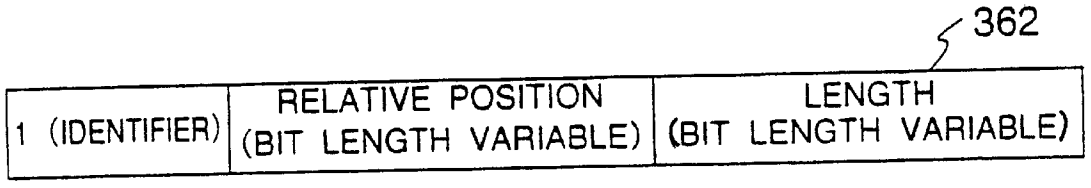
LENGTH	CODE							
	T=0	T=1	T=2	T=3	T=4	T=5	T=6	T=7
1	0	0	0	0	0	0	0	—
2	10	10	10	100	110	10	1	—
3	1100	1100	1100	101	10	11	—	—
4	1101	1101	1101	110	111	—	—	—
5	11110	11110	1110	111	—	—	—	—
6	111110	1110	1111	—	—	—	—	—
7	1110	11111	—	—	—	—	—	—
8	111111	—	—	—	—	—	—	—

FIG. 55A



LENGTH	CODE
1	0
2	10
3	110
4	1110
5	11110
6	111110
7	1111110
8	1111111

FIG. 55B



RELATIVE POSITION	CODE
-1	11
0	0
1	10

362a

FIG. 56

ROW	CODE STRING
0	00101110 00110 0100110
1	00101110 001000 10110 000010 000110
2	1111110 1110 001010 001000
3	001100 1111100 000001110
4	0001010 11110 10111
5	1010 1111111
6	101100 00110110 0001110
7	001100 101101 1101 10

FIG. 57

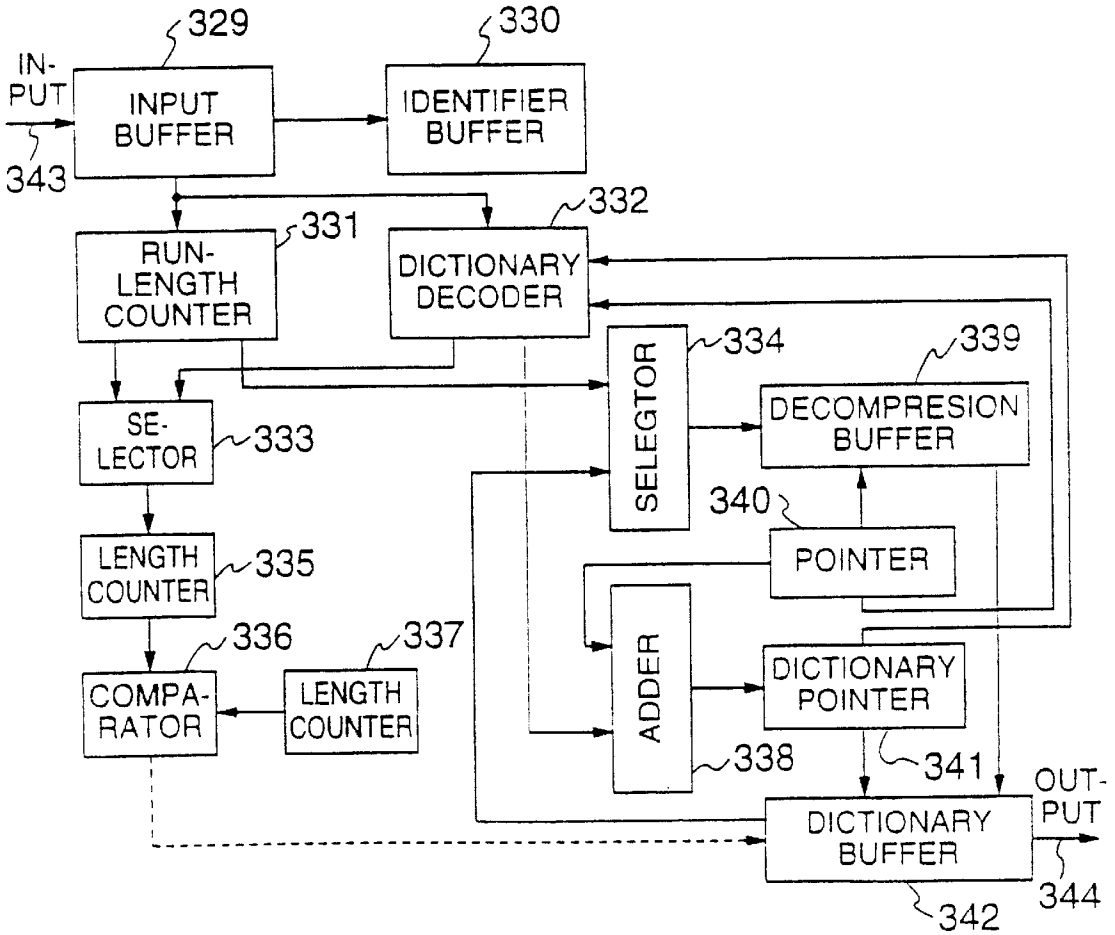


FIG. 58

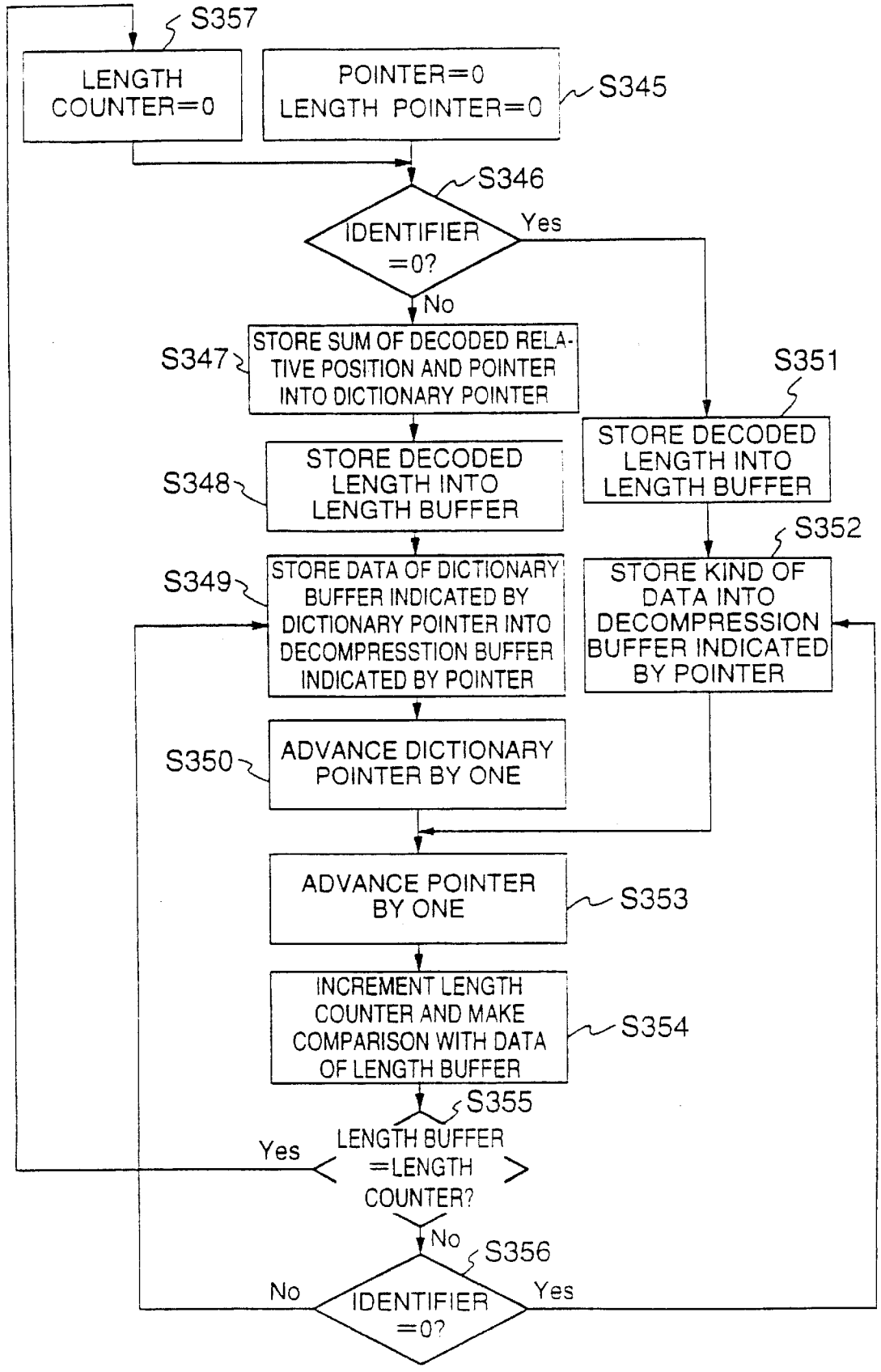

S357
LENGTH COUNTER=0
POINTER=0 LENGTH POINTER=0
S345
S346
IDENTIFIER =0?
Yes
No
S347
STORE SUM OF DECODED RELATIVE POSITION AND POINTER INTO DICTIONARY POINTER
S348
STORE DECODED LENGTH INTO LENGTH BUFFER
S349
STORE DATA OF DICTIONARY BUFFER INDICATED BY DICTIONARY POINTER INTO DECOMPRESSTION BUFFER INDICATED BY POINTER
S350
ADVANCE DICTIONARY POINTER BY ONE
S351
STORE DECODED LENGTH INTO LENGTH BUFFER
S352
STORE KIND OF DATA INTO DECOMPRESSION BUFFER INDICATED BY POINTER
ADVANCE POINTER BY ONE
S353
INCREMENT LENGTH COUNTER AND MAKE COMPARISON WITH DATA OF LENGTH BUFFER
S354
S355
LENGTH BUFFER =LENGTH COUNTER?
Yes
No
S356
IDENTIFIER =0?
No
Yes

FIG. 59

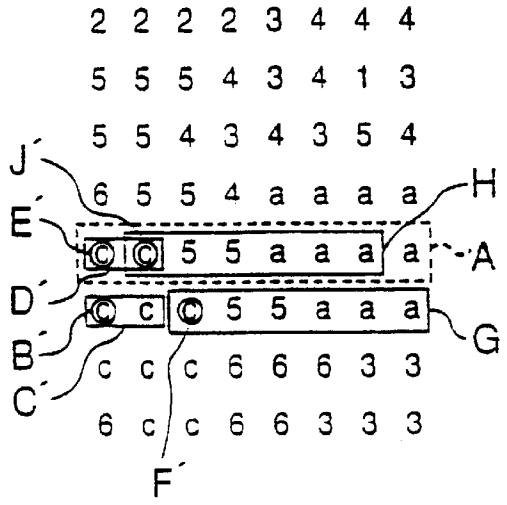

2 2 2 2 3 4 4 4
5 5 5 4 3 4 1 3
5 5 4 3 4 3 5 4
6 5 5 4 a a a a
5 5 a a a a
5 5 a a a
c c c 6 6 6 3 3
6 c c 6 6 3 3 3
J
E
D
B
C
F
H
A
G

FIG. 60

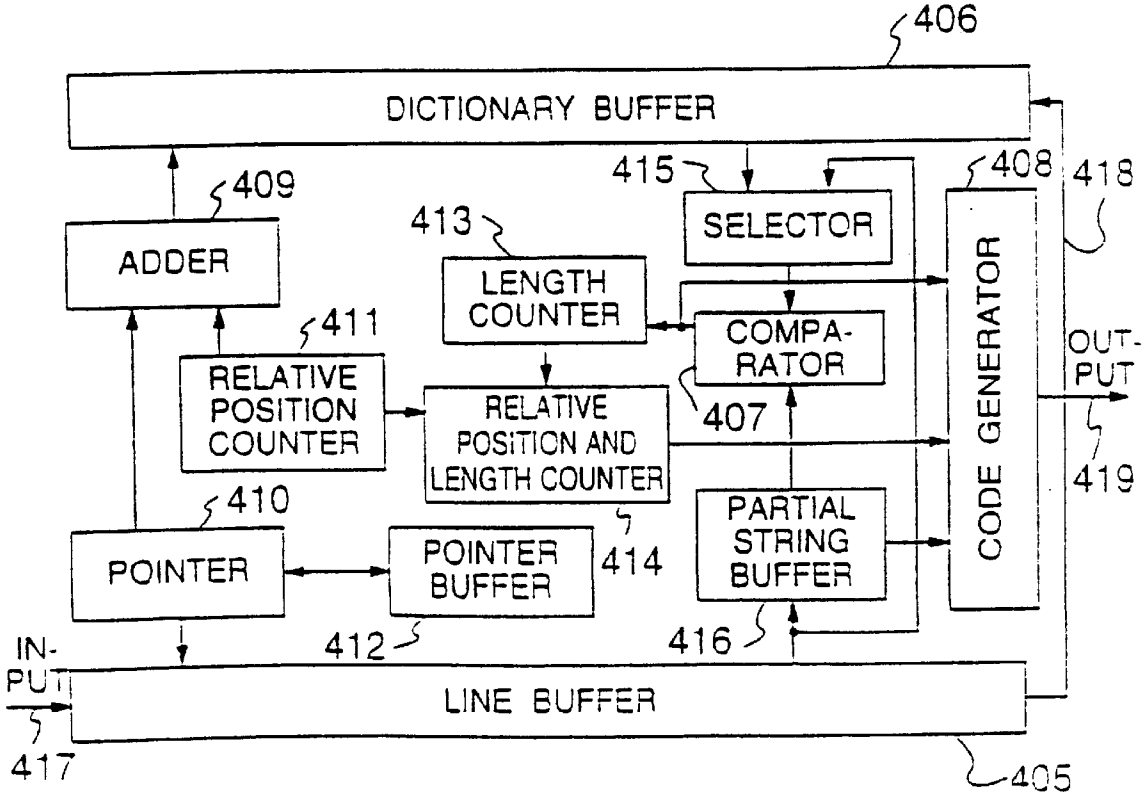

406
DICTIONARY BUFFER
409
ADDER
411
RELATIVE POSITION COUNTER
410
POINTER
POINTER BUFFER
414
412
IN-PUT
417
LINE BUFFER
405
415
SELECTOR
413
LENGTH COUNTER
COMPA-RATOR
407
RELATIVE POSITION AND LENGTH COUNTER
PARTIAL STRING BUFFER
416
408
CODE GENERATOR
418
OUT-PUT
419

FIG. 61

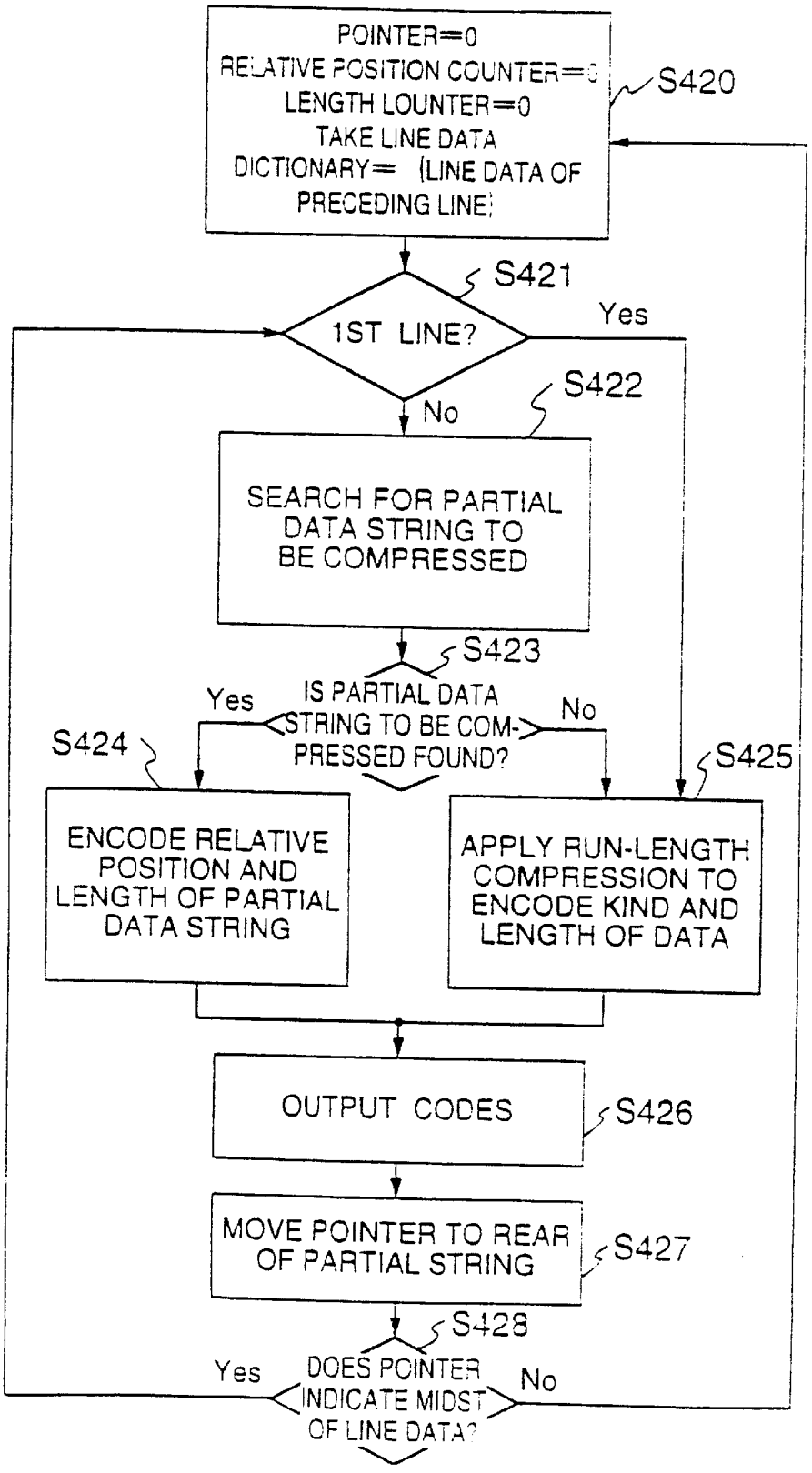

POINTER=0
RELATIVE POSITION COUNTER=0
LENGTH LOUNTER=0
TAKE LINE DATA
DICTIONARY= (LINE DATA OF PRECEDING LINE)
S420
S421
1ST LINE?
Yes
No
S422
SEARCH FOR PARTIAL DATA STRING TO BE COMPRESSED
S423
IS PARTIAL DATA STRING TO BE COMPRESSED FOUND?
Yes
No
S424
ENCODE RELATIVE POSITION AND LENGTH OF PARTIAL DATA STRING
S425
APPLY RUN-LENGTH COMPRESSION TO ENCODE KIND AND LENGTH OF DATA
OUTPUT CODES
S426
MOVE POINTER TO REAR OF PARTIAL STRING
S427
S428
DOES POINTER INDICATE MIDST OF LINE DATA?
Yes
No

FIG. 62A

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 62B

ROW \ COLUMN	0	1	2	3	4	5	6	7
0	2	2	2	2	3	4	4	4
a 1	5	5	5	4	3	4	1	3
2	5	5	4	3	4	3	5	4
b 3	6	5	5	4	a	a	a	a
4	c	c	5	5	a	a	a	a
5	c	c	c	5	5	a	a	a
6	c	c	c	6	6	6	3	3
7	6	c	c	6	6	3	3	3

FIG. 63

ROW	CODE STRING
0	[2, 4][3, 1][4, 3]
1	[5, 3][4, 1]{0, 2}[1, 1][3, 1]
2	{1, 5} {-1, 1}[5, 1][4, 1]
3	[6, 1]{-1, 3}[a, 4]
4	[c, 2]{-1, 2} {0, 4}
5	{0, 2} {-1, 6}
6	{0, 3}[6, 3][3, 2]
7	[6, 1]{0, 4} {1, 2} {0, 1}

FIG. 64A

461

0 (IDENTIFIER)	KIND OF DATA (4 BITS FIXED)	LENGTH (BIT LENGTH VARIABLE)

FIG. 64B

462

1 (IDENTIFIER)	RELATIVE POSITION (BIT LENGTH VARIABLE)	LENGTH (BIT LENGTH VARIABLE)

FIG.65A

RELATIVE POSITION	CODE		
	S´=0	S´=1	S´=2
-1	–	11	1
0	0	0	0
1	1	10	–

FIG. 65B

RELATIVE POSITION	CODE					
	S´=1			S´=2		
	T´=-1	T´=0	T´=1	T´=-1	T´=0	T´=1
-1	–	1	1	–	–	1
0	0	–	0	–	–	0
1	1	0	–	–	–	–

FIG. 66A

LENGTH	CODE
1	0
2	10
3	110
4	1110
5	11110
6	111110
7	1111110
8	1111111

FIG. 66B

LENGTH	CODE							
	U=0	U=1	U=2	U=3	U=4	U=5	U=6	U=7
1	0	0	0	0	0	0	0	–
2	10	10	10	100	110	10	1	–
3	1100	1100	1100	101	10	11	–	–
4	1101	1101	1101	110	111	–	–	–
5	11110	11110	1110	111	–	–	–	–
6	111110	1110	1111	–	–	–	–	–
7	1110	11111	–	–	–	–	–	–
8	111111	–	–	–	–	–	–	–

FIG. 67

ROW	CODE STING
0	00101110 00110 0100110
1	00101110 001000 10110 000010 000110
2	1111110 110 001010 001000
3	001100 1111100 000001110
4	0001010 11110 10111
5	1010 111111
6	101100 00110110 0001110
7	001100 101101 101 10

FIG. 68

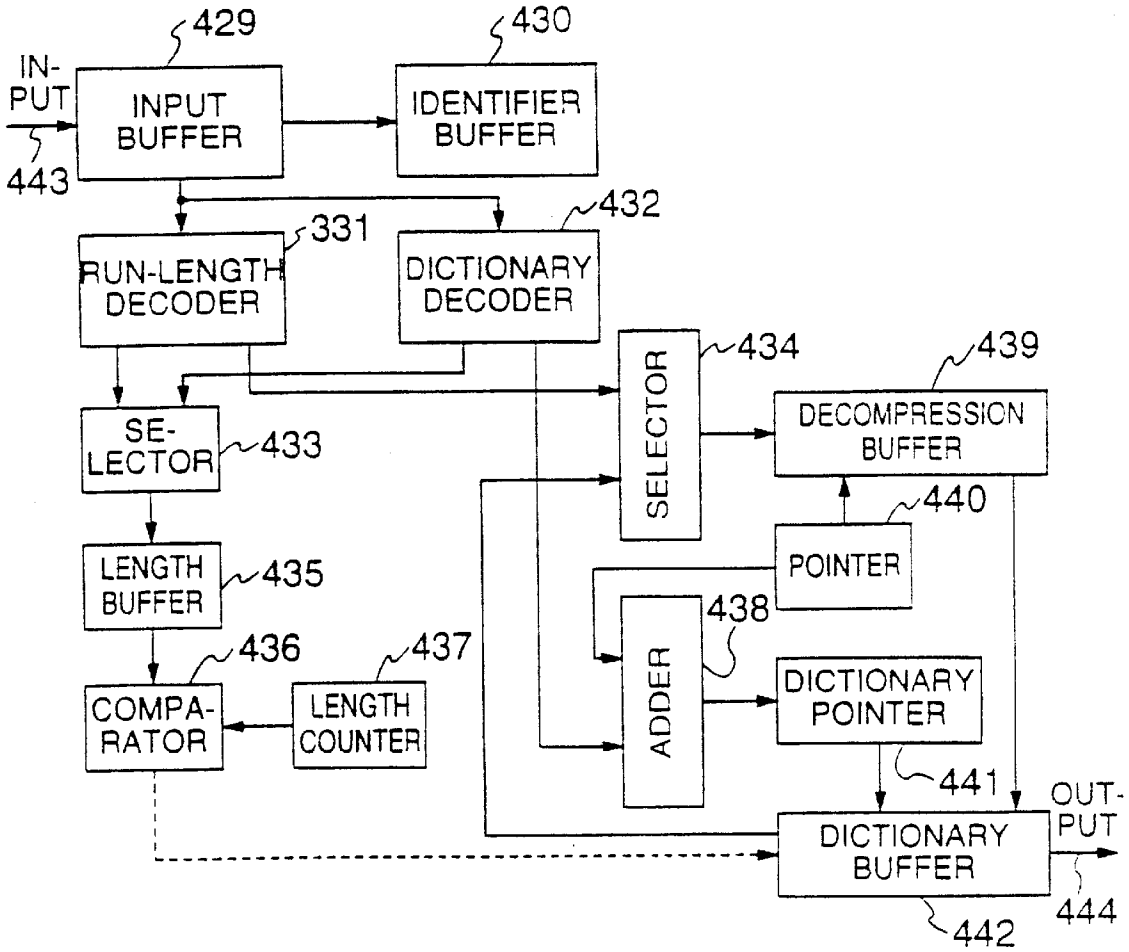
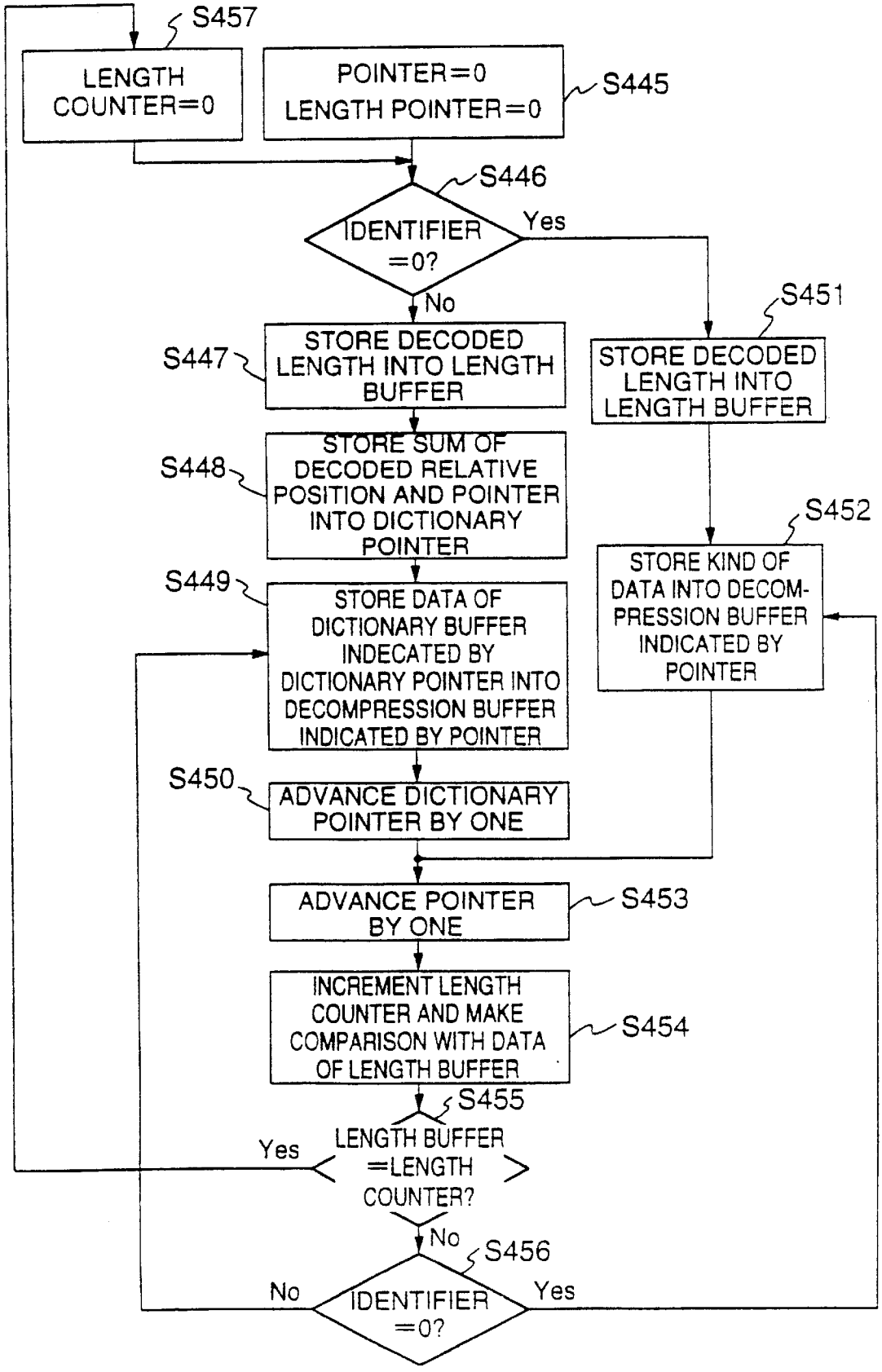


FIG. 69


S457
LENGTH COUNTER=0
POINTER=0 LENGTH POINTER=0
S445
S446
IDENTIFIER =0?
Yes
No
S451
STORE DECODED LENGTH INTO LENGTH BUFFER
S447
STORE DECODED LENGTH INTO LENGTH BUFFER
S448
STORE SUM OF DECODED RELATIVE POSITION AND POINTER INTO DICTIONARY POINTER
S452
S449
STORE KIND OF DATA INTO DECOM-PRESSION BUFFER INDICATED BY POINTER
STORE DATA OF DICTIONARY BUFFER INDECATED BY DICTIONARY POINTER INTO DECOMPRESSION BUFFER INDICATED BY POINTER
S450
ADVANCE DICTIONARY POINTER BY ONE
ADVANCE POINTER BY ONE
S453
INCREMENT LENGTH COUNTER AND MAKE COMPARISON WITH DATA OF LENGTH BUFFER
S454
S455
LENGTH BUFFER =LENGTH COUNTER?
Yes
No
S456
IDENTIFIER =0?
No
Yes

COMPRESSION AND DECOMPRESSION METHODS ON TWO-DIMENSIONAL IMAGE DATA

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to data compression and decompression methods for two-dimensional image data.

2. Description of the Related Art

An irreversible data compression method and a reversible data compression method are known as the conventional image compression method. Examples of the irreversible data compression method include JPEG (Joint Photographic Except Group) or MPEG (Moving Picture Except Group) using discrete cosine transformation (DCT). In the case where image data using color code (or color pallet call code) is to be compressed, such an irreversible data compression method cannot be used since the missing of information may be generated. Typical examples of the reversible data compression method include a method in which data compression is performed using the run length of information (run-length compression method) and a method in which data compression is performed in such a manner that frequently occurring information is registered in a dictionary (dictionary compression method). The latter method or dictionary compression method is disclosed by Ziv and Lempel, "Compression of Individual Sequences via Variable Rate Coding", IEEE Transactions on Information Theory, IT-24, pp. 530–536.

The above compression methods involve problems which will be mentioned in the following.

Though the run-length compression method is effective for image data which abounds with the same continuous information, this method is ineffective for image data which is not so, that is, there may be the case where the effect of compression does not appear at all.

Though the dictionary compression method is effective for image data which has a high hit ratio for the dictionary, this method is ineffective for image data which is not so. Also, since the hit ratio depends on a storage capacity for storing the dictionary, a storage location having a large capacity is needed if it is desired to obtain a high hit ratio. Further, since the large-capacity dictionary is involved, the number of times of reference to the dictionary is increased, thereby lowering the compression speed.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a data compression method which makes compensation for the problems of the above-mentioned conventional compression methods and which can enhance the data compression ratio of image data to reduce the amount of information and can perform the compression at a high speed and to provide a data decompression method in which the compressed data can be expanded (or decompressed) at a high speed.

To achieve the above object, the present invention provides a first data compression method in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there exists a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, data of the position and the length of the partial data string on the immediately preceding line is outputted as data of that partial data string.

A first data decompression method of the present invention provides a decompression method for compressed two-dimensional image data in which in the case where there exists a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, information of the position and the length of the partial data string on the immediately preceding line is successively inputted as data of the overlapping portion,

the method comprising holding at least data of the immediately preceding line, extracting the information concerning the position and the length of said partial data string from the inputted compressed data, and extracting on the basis of the extracted information, that portion of the held data of the immediately preceding line which corresponds to the length of said partial data string from the position of said partial data string, for inputted data of the current line, the extracted data being outputted as decompressed data.

A first data compression apparatus for realizing the first data compression method comprises reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data, buffer means for extracting a plurality of continuous data strings from an inputted signal of the current line to store them as a partial data string to be compressed, scanning comparison means for detecting whether or not the same partial data string as the partial data string to be compressed exists in the data stored in the reference memory means, and code generating means by which in the case where the presence of the same partial data string is detected by the scanning comparison means, data of the position and the length of the partial data string on the data of the immediately line stored in the reference memory means is outputted as data of that partial data string of the current line.

A first data decompression apparatus for realizing the first data decompression method comprises buffer memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data, extracting means for extracting the information concerning the position and the length of the partial data string from inputted compressed data, and decoding means for extracting on the basis of the extracted information, that portion of the data of the immediately preceding line stored in the buffer memory means which corresponds to the length of the partial data string from the position of the partial data string, for inputted data of the current line, and outputting the extracted data as decompressed data.

To achieve the above object, a second data compression method of the present invention provides a compression method for two-dimensional image data in which a compression processing is performed in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there exists a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels,

the method comprising preparing tables which are provided for the respective positions of a pixel of interest on the current line and in which a different code is allotted in accordance with the relative position of a leading pixel of said partial data string and the pixel of interest and the length of said partial data string on the immediately preceding line, and selecting, in the case where there exists a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, said table in accordance with the position of a pixel of interest of input data on the current line to output a code corresponding to the leading position and the length of the partial data string on the immediately preceding line.

A second data decompression method of the present invention provides a decompression method for compressed two-dimensional image data in which in the case where there exists a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, a code differing in accordance with the relative position and the length of the partial data string on the immediately preceding line for each leading position of the compressed data on the current line is allotted and successively inputted as data of the overlapping portion,

the method comprising holding at least data of the immediately preceding line in a buffer, selecting a table corresponding to the position of a pixel of interest to be decompressed on the current line, and extracting said code from the inputted compressed data to refer to the selected table on the basis of the extracted code so that data continuing from a bit corresponding to the relative position of said partial data string to the extent of the length of said partial data string is extracted from said buffer for the inputted data of the current line, the extracted data being outputted as decompressed data.

A second data compression apparatus for realizing the second data compression method comprises reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data, buffer means for extracting a plurality of continuous data strings from an inputted signal of the current line to store them as a partial data string to be compressed, scanning comparison means for detecting whether or not the same data string as a data string continuing from a pixel of interest of said partial data string to be compressed exists in the data stored in said reference memory means, and code generating means by which in the case where the presence of the same data string is detected by said scanning comparison means, data of the position of a leading pixel of said partial data string relative to said pixel of interest and the length of said partial data string on the data of the immediately line stored in said reference memory means is determined and a corresponding code is outputted as data of that partial data string of the current line by referring to a table in which a different code is allotted in accordance with said relative position and the length of said partial data string for each position of the pixel of interest on the current line.

A second data decompression apparatus for realizing the second data decompression method provides a decompression apparatus for compressed two-dimensional image data in which in the case where there exists in two-dimensional image data a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there is successively inputted, as data of the overlapping portion, data encoded by referring to a table in which a different code is allotted in accordance with the relative position and the length of a partial data string on the immediately preceding line for each leading position of the compressed data on the current line,

the apparatus comprising buffer memory means for holding data of the immediately preceding line, inverse transformation tables provided for the respective positions of a pixel of interest on the current line for outputting data of the relative position and the length of a partial data string on the immediately preceding line in accordance with an inputted code, and decoding means for selecting an inverse transformation table corresponding to the position on the current line of a pixel of interest to be subjected to the decoding of the inputted data, extracting said code from the inputted data to refer to the selected table on the basis of said code so that data of the relative position and the length of a partial data string on the immediately preceding line is derived from said inverse transformation table, and extracting, from said buffer memory means, data which continues from a bit corresponding to the relative position of said partial data string to the extent of the length of said partial data string, the extracted data being outputted as decompressed data.

To achieve the above object, a third data compression method of the present invention provides a compression method for two-dimensional image data in which a compression processing is performed in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels,

the method comprising preparing tables which are provided for the respective values of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of a pixel of interest on the current line from a leading pixel thereof ($0 \leqq x \leqq H-1$) and in which a different code is allotted in accordance with the relative position of a leading pixel of said partial data string and said pixel of interest and the length of said partial data string on the immediately preceding line, and determining, in the case where there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, the value of T on the basis of the position x of said pixel of interest on the current line and selecting the corresponding table on the basis of the determined value of T to output a code corresponding to the leading position and the length of the partial data string on the current line.

A third data decompression method of the present invention provides a decompression method for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there is successively inputted as data of the overlapping portion a code which differs in accordance with the relative position of a leading pixel of said partial data string and a pixel of interest and the length of said partial data string on the immediately preceding line for each value of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of said pixel of interest on the current from a leading pixel thereof ($0 \leqq x \leqq H-1$),

the method comprising holding at least decompressed data of the immediately preceding line in a buffer, determining the value of T on the basis of the position x of said pixel of interest to be decompressed on the current line to select a corresponding table on the basis of the determined value of T from tables which are prepared for the respective values of T and in which a different code is allotted in accordance with said relative position and said length, and extracting said code from the inputted compressed data to refer to the

selected table on the basis of the extracted code so that data continuing from a bit corresponding to the leading position of said partial data string to the extent of the length of said partial data string is extracted from said buffer for the inputted data of the current line and the extracted data is outputted as decompressed data.

A third data compression apparatus for realizing the third data compression method comprises reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data, buffer means for extracting a plurality of continuous data strings within the range of a predetermined length from an inputted signal of the current line to store them as a partial data string to be compressed, scanning comparison means for detecting whether or not the same partial data string as a partial data string continuing from a pixel of interest of said partial data string to be compressed exists in the data stored in said reference memory means, and code generating means by which in the case where said scanning comparison means detects the same partial data string, the relative position of a leading pixel of said partial data string and said pixel of interest and the length of said partial data string on the data of the immediately line stored in said reference memory means are determined, and a corresponding code is outputted as data of that partial data string on the current line by referring to tables which are prepared for the respective values of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of a pixel of interest on the current from a leading pixel thereof ($0 \leqq x \leqq H-1$) and in which a different code is allotted in accordance with said relative position and said length of the partial data string.

A third data decompression apparatus for realizing the third data decompression method provides a decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there is successively inputted as data of the overlapping portion a code which differs in accordance with the relative position of a leading pixel of said partial data string and a pixel of interest and the length of said partial data string on the immediately preceding line for each value of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of said pixel of interest on the current from a leading pixel thereof ($0 \leqq x \leqq H-1$),

the apparatus comprising buffer memory means for holding decompressed data of the immediately preceding line, inverse transformation tables which are prepared for the respective values of T and in which the relative position of a leading pixel of said partial data string and said pixel of interest and the length of said partial data string on the immediately preceding line are allotted in accordance with said code, and decoding means for determining the value of T on the basis of the position x of a pixel of interest of the compressed data to be decompressed on the current line from a leading pixel thereof to select the inverse transformation table corresponding to the determined value of T, extracting said code from the inputted data to refer to the selected inverse transformation table on the basis of said code so that data of the leading position and the length of said partial data string on the immediately preceding line is derived from said inverse transformation table, and extracting, from said buffer memory means, data which continues from a bit corresponding to the leading position of said partial data string to the extent of the length of said partial data string, so that the extracted data is outputted as decompressed data.

To achieve the above object, the present invention provides a fourth data compression method in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string to be compressed which is a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the position of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line.

A fourth data decompression method of the present invention provides a decompression method for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string to be compressed which is a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the position of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line,

the method comprising holding at least decompressed data of the immediately preceding line, extracting information concerning the position of said immediately preceding partial data string from the inputted compressed data while determining the position x_2 of the leading pixel of said immediately preceding partial data string from the leading pixel of the immediately preceding line on the basis of the extracted information to extract information concerning the length of said immediately preceding partial string on the basis of the position x_1 of a pixel of interest to be decompressed from a leading pixel of the current line and/or said position x_2, and extracting said immediately preceding partial data string from the held decompressed data of the immediately preceding line on the basis of the

information concerning the position of said immediately preceding partial data string and the information concerning the length of said immediately preceding partial string to output said immediately preceding partial data string as decompressed data of the inputted compressed data.

A fourth data compression apparatus for realizing the fourth data compression method comprises reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data, buffer means for extracting a plurality of continuous data strings from an inputted signal of the current line to store them as a partial data string to be compressed, scanning comparison means for detecting whether or not the same partial data string as said partial data string to be compressed exists in the data stored in said reference memory means, and code generating means by which in the case where said scanning comparison means detects the same partial data string, a code differing in accordance with the position of an immediately preceding partial data string corresponding to said partial data string to be compressed on the data stored in said reference memory means and a code differing in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line are outputted as compressed data of said partial data string to be compressed.

A fourth data decompression apparatus for realizing the fourth data decompression method provides a decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string to be compressed which is a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the position of an immediately preceding partial data string corresponding to said partial data string to be compressed on the immediately preceding line and a code which differs in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line,

the apparatus comprising buffer memory means for holding at least decompressed data of the immediately preceding line, extracting means for extracting information concerning the position of said immediately preceding partial data string from the inputted compressed data while determining the position x_2 of the leading pixel of said immediately preceding partial data string from the leading pixel of the immediately preceding line on the basis of the extracted information to extract information concerning the length of said immediately preceding partial string on the basis of the position x_1 of a pixel of interest to be decompressed from a leading pixel of the current line and/or said position x_2, and decoding means for extracting said immediately preceding partial data string from the decompressed data of the immediately preceding line stored in the buffer memory means on the basis of the information concerning the position of said immediately preceding partial data string and the information concerning the length of said immediately preceding partial data string to output said immediately preceding partial data string as decompressed data of the inputted compressed data.

To achieve the above object, a fifth data compression method of the present invention provides a data compression method in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string,

wherein in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and outputted as compressed data of the partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T which is the relative position of compressed data previously outputted.

A fifth data decompression method of the present invention provides a decompression method for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string, and in which in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and inputted as compressed data of the partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T, T being the relative position of compressed data previously inputted,

the method comprising holding at least decompressed data of the immediately preceding line, extracting information concerning said relative position and the length of said immediately preceding partial data string from the inputted compressed data and extracting, in

the case where the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, information concerning said relative position on the basis of the value of T, and extracting said immediately preceding partial data string from the held compressed data of the immediately preceding line on the basis of the extracted information concerning said relative position and said length of said immediately preceding partial data string to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

A fifth data compression apparatus for realizing the fifth data compression method comprises comprises reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data, buffer means for extracting from an inputted signal of the current line a plurality of partial data strings having a pixel of interest as its leading pixel and a length corresponding to one or more pixels to store them, scanning comparison means for detecting a partial data string to be compressed which is that one of said partial data strings stored in said buffer means which matches data stored in said reference memory means to the longest extent, and code generating means by which in the case where said scanning comparison means detects said partial data string to be compressed, a code differing in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the data stored in said reference memory means and corresponding to said partial data string to be compressed and a code differing in accordance with the length of said immediately preceding partial data string are outputted as compressed data of said partial data string to be compressed, and by which in the case where said partial data string to be compressed is detected by said scanning comparison means on the same line continuously two or more times, a code corresponding to said relative position and outputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T, T being the relative position of compressed data previously outputted.

A fifth data decompression apparatus for realizing the fifth data decompression method provides a decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string, and in which in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and inputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T, T being the relative position of compressed data previously inputted,

the apparatus comprising buffer memory means for holding at least decompressed data of the immediately preceding line, extracting means by which information concerning said relative position and the length of said immediately preceding partial data string is extracted from the inputted compressed data, and by which when the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, information concerning said relative position is extracted on the basis of the value of T, and decoding means for extracting said immediately preceding partial data string from the compressed data of the immediately preceding line stored in said buffer memory means on the basis of the information concerning said relative position and the length of said immediately preceding partial data string extracted by said extracting means to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an explanatory diagram showing two-dimensional image data for explaining the principle of a first data compression and decompression method of the present invention.

FIG. **2** is a block diagram showing a data compression circuit according to an embodiment of a first data compression apparatus for realizing the first data compression method of the present invention.

FIG. **3** is a flow chart showing the operation of data compression in the data compression circuit shown in FIG. **2**.

FIGS. **4**A to **4**C are explanatory diagrams showing image data before data compression.

FIG. **5** is an explanatory diagram showing image data after data compression.

FIGS. **6**A and **6**B are diagrams representing actual codes.

FIG. **7** is an explanatory diagram showing image data after data compression in which the actual codes are allotted.

FIG. **8** is a block diagram showing a data decompression circuit according to an embodiment of a first data decompression apparatus for realizing the first data decompression method of the present invention.

FIG. **9** is a flow chart showing the operation of data decompression in the data decompression circuit shown in FIG. **8**.

FIG. **10** is an explanatory diagram showing two-dimensional image data for explaining the principle of a second data compression and decompression method of the present invention.

FIG. **11** is a block diagram showing a data compression circuit according to an embodiment of a second data compression apparatus for realizing the second data compression method of the present invention.

FIG. **12** is a flow chart showing the operation of data compression in the data compression circuit shown in FIG. **11**.

FIGS. **13**A to **13**C are explanatory diagrams showing image data before data compression.

FIG. **14** is an explanatory diagram showing image data after data compression.

FIG. **15** is a diagram representing a table in the case where the position of a pixel of interest on the current line is the 0th column.

FIG. **16** is a diagram representing a table in the case where the position of the pixel of interest on the current line is the 1st column.

FIG. **17** is a diagram representing a table in the case where the position of the pixel of interest on the current line is the 2nd column.

FIG. **18** is a diagram representing a table in the case where the position of the pixel of interest on the current line is the 3rd column.

FIG. **19** is a diagram representing a table in the case where the position of the pixel of interest on the current line is the 4th column.

FIG. **20** is a diagram representing a table in the case where the position of the pixel of interest on the current line is the 5th column.

FIG. **21** is a diagram representing a table in the case where the position of the pixel of interest on the current line is the 6th column.

FIG. **22** is a diagram representing a table in the case where the position of the pixel of interest on the current line is the 7th column.

FIG. **23** is an explanatory diagram showing image data after data compression in which actual codes are allotted.

FIG. **24** is a block diagram showing a data decompression circuit according to an embodiment of a second data decompression apparatus for realizing the second data decompression method of the present invention.

FIG. **25** is a flow chart showing the operation of data decompression in the data decompression circuit shown in FIG. **24**.

FIG. **26** is a flow chart showing the operation of data decompression in the data decompression circuit shown in FIG. **24**.

FIG. **27** is a diagram for explaining the operation of the data decompression circuit of FIG. **24** in a run-length mode.

FIG. **28** is a diagram for explaining the operation of the data decompression circuit of FIG. **24** in a dictionary copy mode.

FIG. **29** is an explanatory diagram showing two-dimensional image data for explaining the principle of a third data compression and decompression method of the present invention.

FIG. **30** is a block diagram showing a data compression circuit according to an embodiment of a third data compression apparatus for realizing the third data compression method of the present invention.

FIG. **31** is a flow chart showing the operation of data compression in the data compression circuit shown in FIG. **30**.

FIGS. **32**A to **32**C are explanatory diagrams showing image data before data compression.

FIG. **33** is an explanatory diagram showing image data after data compression.

FIG. **34** is a diagram representing a table of T=0.

FIG. **35** is a diagram representing a table of T=1.

FIG. **36** is a diagram representing a table of T=2.

FIG. **37** is a diagram representing a table of T=3.

FIG. **38** is a diagram representing a table of T=4.

FIG. **39** is a diagram representing a table of T=5.

FIG. **40** is a diagram representing a table of T=6.

FIG. **41** is a diagram representing a table of T=7.

FIG. **42** is a diagram representing a table of T=8.

FIG. **43** is an explanatory diagram showing image data after data compression in which actual codes are allotted.

FIG. **44** is a block diagram showing a data decompression circuit according to an embodiment of a third data decompression apparatus for realizing the third data decompression method of the present invention.

FIG. **45** is a flow chart showing the operation of data decompression in the data decompression circuit shown in FIG. **44**.

FIG. **46** is a flow chart showing the operation of data decompression in the data decompression circuit shown in FIG. **44**.

FIG. **47** is a diagram for explaining the operation of the data decompression circuit of FIG. **44** in a run-length mode.

FIG. **48** is a diagram for explaining the operation of the data decompression circuit of FIG. **44** in a dictionary copy mode.

FIG. **49** is an explanatory diagram showing two-dimensional image data for explaining the principle of a fourth data compression and decompression method of the present invention.

FIG. **50** is a block diagram showing a data compression circuit according to an embodiment of a fourth data compression apparatus for realizing the fourth data compression method of the present invention.

FIG. **51** is a flow chart showing the operation of data compression in the data compression circuit shown in FIG. **50**.

FIGS. **52**A to **52**C are explanatory diagrams showing image data before data compression.

FIG. **53** is an explanatory diagram showing image data after data compression.

FIG. **54** is a diagram representing the codes of length in the case of dictionary compression.

FIGS. **55**A and **55**B are diagrams representing actual codes.

FIG. **56** is an explanatory diagram showing image data after data compression in which the actual codes are allotted.

FIG. **57** is a block diagram showing a data decompression circuit according to an embodiment of a fourth data decompression apparatus for realizing the fourth data decompression method of the present invention.

FIG. **58** is a flow chart showing the operation of data decompression in the data decompression circuit shown in FIG. **57**.

FIG. **59** is an explanatory diagram showing two-dimensional image data for explaining the principle of a fifth data compression and decompression method of the present invention.

FIG. **60** is a block diagram showing a data compression circuit according to an embodiment of a fifth data compression apparatus for realizing the fifth data compression method of the present invention.

FIG. **61** is a flow chart showing the operation of data compression in the data compression circuit shown in FIG. **60**.

FIGS. **62**A and **62**B are explanatory diagrams showing image data before data compression.

FIG. **63** is an explanatory diagram showing image data after data compression.

FIGS. **64**A and **64**B are diagrams for explaining the construction of the actual code.

FIGS. **65**A and **65**B are diagrams showing a table of codes of relative position.

FIGS. **66**A and **66**B are diagrams showing a table of codes of length.

FIG. **67** is an explanatory diagram showing image data after data compression in which the actual codes are allotted.

FIG. **68** is a block diagram showing a data decompression circuit according to an embodiment of a fifth data decompression apparatus for realizing the fifth data decompression method of the present invention.

FIG. **69** is a flow chart showing the operation of data decompression in the data decompression circuit shown in FIG. **68**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(First Data Compression/Decompression Method of the Invention)

In order to facilitate the understanding of a first data compression/decompression method of the present invention, the principle of the first data compression/decompression method will be explained using the drawings. In the first data compression/decompression method of the present invention, data of the immediately preceding line in successively scanned two-dimensional image data (shown in FIG. **1**) is held as reference data, using a property that a certain pixel(s) in the image data is similar to a group of pixels in the neighborhood thereof (A buffer for storing the reference data will hereinafter be referred to as "dictionary" **1**.). The reference to the dictionary **1** of the immediately preceding line is made in connection with a partial string **2** of line data to be compressed. When the reference results in that the partial string matches a partial string in the dictionary **1** of the immediately preceding line to the longest possible extent, the position **4** and the length of the partial string **3** on the dictionary **1** are encoded, thereby performing data compression. At this time, the position **4** of the partial string **3** on the dictionary **1** is represented as a relative position on a two-dimensional space from the partial string **2**, and this relative position and the length of the partial string **3** are encoded. Also, the range of reference to the dictionary **1** is limited to fall within a range in which the degree of similarity of the partial string **2** to be compressed to the partial string on the dictionary **1** is high. Further, in the case where the partial string **2** to be compressed does not match the partial string on the dictionary **1**, compression such as run-length compression is applied to the partial string **2** to be compressed.

It is preferable that the above coding is made not with fixed-length codes but with variable-length codes in order to enhance the compression ratio by allotting a short code to data which has a high probability of occurrence.

In the first data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line, as mentioned above. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial string. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. By applying compression such as run-length compression to the first line of the image data and a partial string for which the reference to the dictionary is impossible, a higher compression ratio is obtained.

An embodiment of the first data compression/decompression method of the present invention will now be explained. As shown in FIG. **2**, a data compression circuit according to an embodiment of a first data compression apparatus for realizing the first data compression method of the present invention includes a line buffer **5**, a dictionary buffer **6** for holding data of the immediately preceding line, a comparator **7**, a code generator **8**, an adder **9**, a pointer **10**, a relative position counter **11**, a pointer buffer **12**, a length counter **13**, a relative position and length buffer **14**, a selector **15** and a partial string buffer **16**. In FIG. **2**, reference numeral **17** denotes a line buffer input signal line, reference numeral **18** a dictionary buffer input signal line, and reference numeral **19** a code output line.

Next, the operation of the data compression circuit having the above construction will be explained referring to FIG. **3**. First or in step **S20**, the pointer **10** and so forth are initialized, and successively inputted image data is stored into the line buffer **5** through the line buffer input signal line **17**. At this time, data pushed out of the line buffer **5** is stored into the dictionary buffer **6** through the dictionary buffer input signal line **18**. Next, if line data inputted to the line buffer **5** is data of the first line (step **S21**), the flow goes to step **S25** in which data of the line buffer **5** indicated by the pointer **10** is stored into the partial string buffer **16**. Also, the pointer **10** is advanced by one so that the data of the line buffer **5** is inputted to the comparator **7** through the selector **15** for comparison with data of the partial string buffer **16**. If the result of comparison indicates the matching, the length counter **13** is incremented and the next data indicated by the pointer is inputted to the comparator **7** through the selector **15** for comparison with data of the partial string buffer **16**. The comparison with data of the partial string buffer **16** is repeated with the pointer being advanced one by one until the matching ceases to be obtained. When the matching ceases to be obtained, data of the length counter **13** and data of the partial string buffer **16** are inputted to the code generator **8** which in turn outputs codes through the code output line **19** (step **S26**). Thus, all data of the first line are processed.

If line data inputted to the line buffer **5** is data of the second or subsequent line (step **S21**), the flow goes to step **S22** in which a search for the longest partial string is made. The search for the longest partial string shown as one flow step **S22** in FIG. **3** is made in accordance with the following procedure. The concept of the search for the longest partial string will be explained using 8×8 image data shown in FIGS. **4**A to **4**C by way of example. In the present embodiment, the judgement of whether or not a line preceding by one line to a partial string made the object of search (as which data of continuous pixels selected from data of the current line will be defined) includes the same partial string as the partial string made the object of search, is made by performing a search as to whether or not the same pixel as a leading pixel of the partial string made the object of search exists between a position returned by one from the leading pixel position of the partial string made the object of search (defined as relative position −1) and a position advanced by one therefrom (defined as relative position +1). Namely, the compression in step **S22** is performed in the case where the same pixel string exists in the immediately preceding line within a range shifted by one pixel to the right and left.

Speaking in conjunction with FIG. **4**A, (1) an example of relative position −1 is a partial string "554" continuing from "5" at the 3rd row and 1st column. Since this partial string "554" is the same as a partial string "554" continuing from

"5" at the 2nd row and 0th column, it is determined that the same partial string exists at a position shifted by one pixel to the left. (2) An example of relative position 0 is a partial string "34" continuing from "3" at the 1st row and 4th column. Since this partial string "34" is the same as a partial string "34" continuing from "3" at the 0th row and 4th column, it is determined that the same partial string exists at a position shifted by zero pixel. (3) An example of relative position +1 is a partial string "55434" continuing from "5" at the 2nd row and 0th column. Since this partial string "55434" is the same as a partial string "55434" continuing from "5" at the 1st row and 1st column, it is determined that the same partial string exists at a position shifted by one pixel to the right.

In step S**22**, data of the pointer **10** is first stored into the pointer buffer **12** and the relative position counter **11** is initialized. Next, data of one pixel is taken into the partial string buffer **16** from the line buffer **5** indicated by the pointer **10**. Regarding the data of the one pixel in the current line taken in the partial string buffer **16** from the line buffer **5**, a search is made as to whether or not a matching pixel exists for each of a pixel at the relative position −1, a pixel at the relative position 0 and a pixel at the relative position +1 in the immediately preceding line stored in the dictionary buffer **6**. In the case where there is no matching pixel, the length "0" is written into the relative position and length buffer **14** for each relative position and the flow proceeds to step S**23**. In FIG. **4**A, regarding "4" at the 1st row and 3rd column, the pixels at the 0th row and 2nd column and the 0th row and 3rd column are both "2" and the pixel at the 0th row and 4th column is "3". Accordingly, "0" is written as length data for a point (1, 3) into the relative position and length buffer **14** for all the relative positions −1, 0 and +1.

In the case where there is a matching pixel, the pointer **10** and the length counter **15** are incremented and data of the next pixel is taken into the partial string buffer **16**. At this time, the leading address of the partial string made the object of search under searching in the present search is remained in the pointer buffer **12**.

In the case where the matching for the leading pixel of the partial string made the object of search is found at the relative position −1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position −1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **16**. Also, in the case where the matching is found at the relative position 0, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position 0 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **16**. Further, in the case where the matching is found at the relative position +1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position +1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **16**. In the case where the result of each comparison indicates the matching, the next pixel pointer **10** is incremented to take data of the next pixel into the partial string buffer **16** and the length counter **15** is incremented. This operation is repeated until the matching ceases to be obtained. Thereby, the count value of the length counter **15**, at a point of time when the matching ceases to be obtained, is measured as the length L of a partial data string which has the same data string as data of the immediately preceding line. This length information is counted for each of the relative position −1, the relative position 0 and the relative position +1. Namely, after the length L has been counted for the relative position −1 in a manner mentioned above, the length L is stored as length information of the relative position −1 into the relative position and length buffer **14** at the column of the relative position −1. Subsequently, in order to make a search regarding the relative position 0, the leading address of the partial string made the object of search temporarily stored in the pointer buffer **12** is returned into the pixel pointer **10** and the relative position counter **11** is incremented. With the pixel counter **10** being incremented, the comparison is similarly made for the next data of on the right side of the leading address of the partial string made the object of search until the data matching relevant to the relative position 0 ceases to be obtained. Thereby, the length information L is determined. Subsequently, a similar search is made regarding the relative position +1.

Considering a partial string which has "5" at the 2nd row and 0th column in FIG. **4**A as its leading pixel, this pixel is at the lead of the current line and hence no data exist at the relative position −1 of the preceding line. Therefore, the length L for the relative position −1 is 0. Regarding to the relative position 0, "5" exists at the 1st row and 0th column. Therefore, the length counter **13** is incremented and data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **16** for comparison with "5" of the 1st row and 1st column. Since this comparison too indicates the matching, the length counter **13** is incremented and data "**4**" of the 2nd row and 2nd column next to "5" of the 2nd row and 1st column is taken into the partial string buffer **16** for comparison with "5" of the 1st row and 2nd column. Since this comparison indicates no matching, the number "2" of matching data until this point of time provides L=2 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position 0.

Regarding the partial string having "5" at the 2nd row and 0th column as its leading pixel, "5" exists at the 1st row and 1st column and this data matches the leading pixel. Therefore, the comparison for the next pixel is also made for the relative position +1. Namely, data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **16** and is then compared with "5" of the 1st row and 2nd column which is at the relative position +1. Since this comparison indicates the matching, the comparison is repeated while successively taking in the next pixel on the right side. When the comparison of "3" at the 2nd row and 5th column and "1" at the 1st row and 6th column is made, no matching is found. Accordingly, the value "5" of the length counter **13** at this time provides L=5 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position +1.

With the above, three lengths including L (relative position −1)=0, L (relative position 0)=2 and L (relative position +1)=5 are stored in the relative position and length buffer **14** as the length L of the partial string having "5" at the 2nd row and 0th column as its leading pixel. From thereamong is selected a partial string which has the greatest length L equal to 5. In the case of FIG. **4**A, a partial string a (55) corresponds to the same partial string for the relative position 0 and a partial string b (55434) corresponds to the same partial string for the relative position +1, as shown in FIG. **4**B. Since the length of the partial string a is 2 and the length of the partial string b is 5, the partial string b providing a high efficiency of compression is selected.

Namely, the flow goes to step S**24** in which the longest data among data stored in the relative position and length buffer **14** and the relative position for the longest data are

inputted to the code generator **8** and the code generator **8** outputs codes through the code output line **19**. On the other hand, if the lengths stored in the relative position and length buffer **14** are all 0, that is, if no matching partial string is found in the dictionary (step **S23**), the flow goes to step **S25** in which run-length compression is performed. Since the run-length compression performed herein is not different from the conventional run-length compression method, the detailed explanation thereof will be omitted.

The above operation is repeated up to the last line of the image data to perform the data compression or the encoding.

Next, explanation will be made of the data compression process of the 8×8 image data shown in FIGS. **4**A to **4**C. It is assumed that each data is represented by 4 bits. For convenience' sake, the coordinate of image data will be represented by (column, row) and the encoded code will be represented by {relative position, length} or [kind of data, length]. Namely, a portion enclosed by the brace { } shows a portion subjected to compression based on the first data compression method of the present invention and a portion enclosed by the bracket [ ] shows a portion subjected to compression based on the run-length compression method.

For example, a code corresponding to the relative position equal to 1 and the length equal to 3 results in {1, 3} and a code corresponding to the kind of data equal to 5 and the length equal to 2 results in [5, 2]. Provided that the coordinate of data of interest is (x, y), the range of reference to the dictionary is (x−1, y−1), (x, y−1) and (x+1, y−1) in terms of relative position. First, the first line (or 0th row) is subjected to run-length compression since there is no dictionary to which the reference is to be made. Image data at (0, 0) to (3, 0) are all the same and 2, and hence the resulting code is [2, 4]. Data at (4, 0) is 3 and only one of this data exists. Therefore, the resulting code is [3, 1]. Data at (5, 0) to (7, 0) are all the same and 4, and hence the resulting code is [4, 3]. Accordingly, the resulting codes for the first line are [2, 4] [3, 1] [4, 3], as shown by the first line (or 0th row) in FIG. **5**.

A processing for the second line (or 1st row) is performed handling the first line (or 0th row) as a dictionary. First, data at (0, 1) is compared with data at (0, 0) but this comparison indicates no matching. The data at (0, 1) is thereafter compared with data at (1, 0) but this comparison too indicates no matching. Therefore, on the determination that the dictionary includes no matching partial string, the run-length compression is applied. Data at (0, 1) to (2, 1) are all 5, and hence the resulting code is [5, 3]. Data at (3, 1) is 4 and does not match data at (2, 0), (3, 0) and (4, 0). The run-length compression is applied and the resulting code is [4, 1]. Data at (4, 1) is 3 and matches data at (4, 0) among (3, 0), (4, 0) and (5, 0), and data at (4, 1) to (5, 1) match data of the dictionary at (4, 0) to (5, 0). The resulting code is {0, 2}. Data at (6, 1) and data at (7, 1) do not match data of the dictionary. The resulting codes are [1, 1] and [3, 1], respectively. Accordingly, the resulting codes for the second line (or 1st row) are [5, 3] [4, 1] {0, 2} [1, 1] [3, 1], as shown by the second line (or 1st row) in FIG. **5**.

A processing for the third line (or 2nd row) is performed handling the second line (or 1st row) as a dictionary. Data at (0, 2) matches data of the dictionary at (0, 1) which is the relative position 0 and also matches data of the dictionary at (1, 1) which is the relative position 1. The length of a matching partial string of the dictionary in the case of the relative position 0 is (0, 1) to (1, 1) or 2 whereas the length of a matching partial string of the dictionary in the case of the relative position 1 is (1, 1) to (5, 1) or 5. Namely, the length of the partial string of the dictionary for the relative position 1 is greater than that for the relative position 0. The resulting code is {1, 5}. The above processing is repeated up to the last line. As a result, a code string shown in FIG. **5** is obtained for the image data shown in FIGS. **4**A to **4**C. Next, actual codes are allotted to the code string of FIG. **5** by use of codes shown in FIGS. **6**A and **6**B. A code **61** in the case of the run-length compression is composed of identifier plus kind of data plus length. For example, [2, 4] results in a binary number 000101110. A code **62** in the case of the dictionary compression is composed of identifier plus relative position plus length. For example, {−1, 3} results in a binary number 11110. Regarding the first line, however, only the run-length compression is involved and hence the identifier as a code is omitted.

The result of transformation of the code string of FIG. **5** into the actual codes is shown in FIG. **7**. The capacity of the image data shown in FIGS. **4**A to **4**C is 256 bits whereas the data capacity of the code string shown in FIG. **7** is 171 bits. The use of the algorithm of the first data compression method according to the present invention results in the compression of the original image data to about 67%.

A procedure for decompressing or expanding the code compressed in accordance with the above manner will be shown using FIGS. **8** and **9**. FIG. **8** is a block diagram showing an example of the construction of a decompression circuit. FIG. **9** is a flow chart of a data decompression algorithm. In FIG. **8**, reference numeral **29** denotes an input buffer, numeral **30** an identifier buffer, numeral **31** a run-length decoder, numeral **32** a dictionary decoder, numerals **33** and **34** selectors, numeral **35** a length buffer, numeral **36** a comparator, numeral **37** a length counter, numeral **38** an adder, numeral **39** a decompression buffer, numeral **40** a pointer, numeral **41** a dictionary pointer, numeral **42** a dictionary buffer, numeral **43** an input signal line, and numeral **44** an output signal line.

First, the compressed data is taken into the input buffer **29** through the input signal line **43**. One bit at the beginning is stored into the identifier buffer. In step **S45**, the pointer **40** and the length counter **37** are initialized to 0. Then, the flow goes to step **S46**. If the content of the identifier buffer **30** is 1, the succeeding data is data subjected to dictionary compression. Therefore, the data is passed through the dictionary decoder **32** and information of the decoded length is stored into the length buffer **35** (step **S47**). Information of the decoded relative position and the content of the pointer **40** are inputted to the adder **38**, and the result of addition is stored into the dictionary pointer **41** (step **S48**). The flow goes to step **S49** in which data of the dictionary buffer **42** indicated by the dictionary pointer **41** is stored into the decompression buffer **39** indicated by the pointer **40**. Each of the dictionary pointer **41** and the pointer **40** is advanced by one (steps **S50** and **S53**). The length counter **37** is incremented and the content of the length counter **37** and the content of the length buffer **35** are compared by the comparator **36** (step **S54**). If the content of the length buffer **35** and the content of the length counter **37** do not match (step **S55**), the flow goes to step **S49** through step **S56** so that steps **S49**, **S50**, **S53** and **S54** are successively repeated until the matching is obtained. If the matching is obtained, the flow goes to step **S45** for decompression of a new code.

In the case where it is determined in step **S46** that the identifier is 0, the flow goes to step **S51** in which the decoded length is stored into the length buffer **35**. Next, the kind of data is stored into the decompression buffer **39** indicated by the pointer **40** (step **S52**). The pointer **40** is advanced by one (step **S53**). The length counter **37** is incremented and the content of the length counter **37** and the content of the length

buffer **35** are compared by the comparator **36** (step **S54**). If the content of the length buffer **35** and the content of the length counter **37** do not match (step **S55**), the flow goes to step **S52** through step **S56** so that steps **S52**, **S53** and **S54** are successively repeated until the matching is obtained. Also, if data stored in the decompression buffer **39** reaches data corresponding to one line of the image data, the contents of the decompression buffer **39** are all copied into the dictionary buffer **42** and the content of the dictionary buffer **42** or the restored data is outputted through the output signal line **44**.

In the above-mentioned example of compression, the dictionary is searched in the dictionary reference range for the longest partial string existing on the dictionary and the searched-out partial string is encoded. However, there may also be considered the case where the longest partial string is divided into a plurality of partial strings and the divisional partial string is compressed after composition thereof with another partial string, and the case where partial strings, which are not the longest, are combined and compressed.

The former case is as follows. For example, the partial string b shown in FIG. **4**B is divided into two parts or a partial string c "5543" and a partial string d "4" shown in FIG. **4**C and the partial string d "4" and "3" at the 2nd row and 5th column are composed into a partial string e "43". A code for the partial string c is {1, 4} and a code for the partial string e "43" is {−1, 2} since the partial string e matches "43" continuing from the 1st row and 3rd column of the immediately preceding line. Accordingly, a code for the 2nd row results in {1, 4} {−1, 2} [5, 1] [4, 1]. This code will be referred to as code a'. The latter case is as follows. For example, a partial string "55" for the relative position 0 is selected for the 2nd row and 0th column and a partial string "434" for the relative position +1 is selected for the 2nd row and 2nd column. Thereby, a code for the 2nd row results in {0, 2} {1, 3} {−1, 1} [5, 1] [4, 1]. This code will be referred to as code b'.

Thus, three patterns including the pattern shown in the above-mentioned example of compression may exist as the code for the 2nd row shown in FIG. **4**A. The code for the 2nd row shown in FIG. **5** will be referred to as code c'. When the actual codes shown in FIGS. **6**A and **6**B are allotted to the codes a', b' and c', each of the codes a' and c' spans 24 bits and the code b' spans 26 bits. The codes a' and c' are efficient. However, when codes other than those shown in FIGS. **6**A and **6**B are allotted to the codes a', b' and c', a different result will be obtained and there may be the case where the code b' results in the shortest code. Accordingly, it does not necessarily follow that the best way includes searching for the longest partial string on the dictionary and encoding the longest partial string. It is desirable to select the combination of partial strings on the dictionary which provides the shortest code when the actual codes are allotted.

Even if the combination of partial strings on the dictionary is changed so that the resulting code becomes the shortest, as mentioned above, no influence is given on the data decompression method so long as the encoding rule (using the leading position and the length of the same partial length in the preceding line) is not changed.

(Second Data Compression/Decompression Method of the Invention)

In order to facilitate the understanding of a second data compression/decompression method of the present invention, the principle of the second data compression/decompression method will be explained using the drawings. In the second data compression/decompression method of the present invention, data of the immediately preceding line in successively scanned two-dimensional image data (shown in FIG. **10**) is held as reference data, using a property that a certain pixel(s) in the image data is similar to a group of pixels in the neighborhood thereof. (A buffer for storing the reference data will hereinafter be referred to as "dictionary" **101**.) The reference to the dictionary **101** of the immediately preceding line is made in connection with a partial string **102** of line data to be compressed. When the reference results in that the partial string matches a partial string in the dictionary **101** of the immediately preceding line to the longest possible extent, one table is selected from among tables which are prepared for the respective positions of a pixel of interest (or a leading pixel of a partial string to be compressed) on the current line and in which a different code is allotted in accordance with the relative position of a leading pixel of the partial string on the immediately preceding line and the pixel of interest and the length of the partial string on the immediately preceding line. The selected table corresponds to the position of the pixel **105** of interest on the current line. Referring to the selected table, a code corresponding to the leading position **104** and the length of the partial string **103** on the dictionary **101** is outputted, thereby performing data compression. At this time, the range of reference to the dictionary **101** is limited to fall within a range in which the degree of similarity of the partial string **102** to be compressed to the partial string on the dictionary **101** is high. Also, in the case where the partial string **102** to be compressed does not match the partial string on the dictionary **101**, compression such as run-length compression is applied to the partial string **102** to be compressed. In the case the run-length compression is applied, it is preferable to perform data compression in such a manner that a code corresponding to the length of the same continuous data is outputted by selecting, from among run-length tables which are prepared for the respective positions of a pixel of interest on the current line and in which a different code is allotted in accordance with the length of the same continuous data, a run-length table which corresponds to the position of the pixel of interest on the current line and referring to the selected run-length table. It is required that the code stored in the run-length table should be different from the code stored in the above-mentioned table. Also, it is preferable that the code stored in the table and the run-length table is not a fixed-length code but a variable-length code in order to enhance the compression ratio by allotting a short code to data which has a high probability of occurrence.

In the second data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line, as mentioned above. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial string. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. By applying compression such as run-length compression to the first line of the image data and a partial string for which the reference to the dictionary is impossible, a higher compression ratio is obtained.

An embodiment of the second data compression/decompression method of the present invention will now be explained. As shown in FIG. **11**, a data compression circuit according to an embodiment of a second data compression apparatus for realizing the second data compression method of the present invention includes a line buffer **105**, a dictionary buffer **106** for holding data of the immediately preced-

ing line, a comparator **107**, a code generator **108**, an adder **109**, a pointer **110**, a relative position counter **111**, a pointer buffer **112**, a length counter **113**, a relative position and length buffer **114**, a selector **115**, a partial string buffer **116**, and a group **170** of tables prepared for the respective positions of a pixel of interest (or a leading pixel of a partial string to be compressed) on the current line. Codes for encoding a partial string to be compressed are stored in the group **170** of tables. In FIG. **11**, reference numeral **117** denotes a line buffer input signal line, reference numeral **118** a dictionary buffer input signal line, and reference numeral **119** a code output line.

Next , the operation of the data compression circuit having the above construction will be explained referring to FIG. **12**. First or in step **S120**, the pointer **110** is initialized, and data pushed out of the line buffer **105** is stored into the dictionary buffer **106** through the dictionary buffer input signal line **118**. Next or in step **S121**, successively inputted image data are stored into the line buffer **105** through the line buffer input signal line **117**.

Next or in step **S122**, a search for the longest partial string is made. The search for the longest partial string shown as one flow step **S122** in FIG. **12** is made in accordance with the following procedure. The concept of the search for the longest partial string will be explained using 8×8 image data shown in FIGS. **13**A to **13**C by way of example. In the present embodiment, the judgement of whether or not a line preceding by one line to a partial string made the object of search (as which data of continuous pixels selected from data of the current line will be defined) includes the same partial string as the partial string made the object of search, is made by performing a search as to whether or not the same pixel as the leading pixel of the partial string made the object of search exists between a position returned by one from the leading pixel position of the partial string made the object of search (defined as relative position −1) and a position advanced by one therefrom (defined as relative position +1). The compression in step **S122** is performed in the case where the same pixel string exists in the immediately preceding line within a range shifted by one pixel to the right and left.

Speaking in conjunction with FIG. **13**A, (1) an example of relative position −1 is a partial string "554" continuing from "5" at the 3rd row and 1st column. Since this partial string "554" is the same as a partial string "554" continuing from "5" at the 2nd row and 0th column, it is determined that the same partial string exists at a position shifted by one pixel to the left. (2) An example of relative position 0 is a partial string "34" continuing from "3" at the 1st row and 4th column. Since this partial string "34" is the same as a partial string "34" continuing from "3" at the 0th row and 4th column, it is determined that the same partial string exists at a position shifted by zero pixel. (3) An example of relative position +1 is a partial string "55434" continuing from "5" at the 2nd row and 0th column. Since this partial string "55434" is the same as a partial string "55434" continuing from "5" at the 1st row and 1st column, it is determined that the same partial string exists at a position shifted by one pixel to the right.

In step **S122**, data of the pointer **110** is first stored into the pointer buffer **112** and the relative position counter **111** is initialized. Next, data of one pixel is taken into the partial string buffer **116** from the line buffer **105** indicated by the pointer **110**. Regarding the data of the one pixel in the current line taken in the partial string buffer **116** from the line buffer **105**, a search is made as to whether or not a matching pixel exists for each of a pixel at the relative position −1, a pixel at the relative position 0 and a pixel at the relative position +1 in the immediately preceding line stored in the dictionary buffer **106**. In the case where there is no matching pixel, the length "0" is written into the relative position and length buffer **114** for each relative position and the flow proceeds to step **S123**. In FIG. **13**A, regarding "4" at the 1st row and 3rd column, the pixels at the 0th row and 2nd column and the 0th row and 3rd column are both "2" and the pixel at the 0th row and 4th column is "3". Accordingly, "0" is written as length data for a point (1, 3) into the relative position and length buffer **114** for all the relative positions −1, 0 and +1. In the case where there is a matching pixel, the pointer **110** and the length counter **115** are incremented and data of the next pixel is taken into the partial string buffer **116**. At this time, the leading address of the partial string made the object of search under searching in the present search is remained in the pointer buffer **112**.

In the case where the matching for the leading pixel of the partial string made the object of search is found at the relative position −1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position −1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **116**. Also, in the case where the matching is found at the relative position 0, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position 0 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **116**. Further, in the case where the matching is found at the relative position +1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position +1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **116**. In the case where the result of each comparison indicates the matching, the next pixel pointer **110** is incremented to take data of the next pixel into the partial string buffer **116** and the length counter **115** is incremented. This operation is repeated until the matching ceases to be obtained. Thereby, the count value of the length counter **115**, at a point of time when the matching ceases to be obtained, is measured as the length L of a partial data string which has the same data string as data of the immediately preceding line. This length information is counted for each of the relative position −1, the relative position 0 and the relative position +1. Namely, after the length L has been counted for the relative position −1 in a manner mentioned above, the length L is stored as length information of the relative position −1 into the relative position and length buffer **114** at the column of the relative position −1. Subsequently, in order to make a search regarding the relative position 0, the leading address of the partial string made the object of search temporarily stored in the pointer buffer **112** is returned into the pixel pointer **110** and the relative position counter **111** is incremented. With the pixel counter **110** being incremented, the comparison is similarly made for the next data of on the right side of the leading address of the partial string made the object of search until the data matching relevant to the relative position 0 ceases to be obtained. Thereby, the length information L is determined. Subsequently, a similar search is made regarding the relative position +1.

Considering a partial string which has "5" at the 2nd row and 0th column in FIG. **13**A as its leading pixel, this pixel is at the lead of the current line and hence no data exist at the relative position −1 of the preceding line. Therefore, the length L for the relative position −1 is 0. Regarding to the relative position 0, "5" exists at the 1st row and 0th column. Therefore, the length counter **113** is incremented and data

"5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **116** for comparison with "5" of the 1st row and 1st column. Since this comparison too indicates the matching, the length counter **113** is incremented and data "4" of the 2nd row and 2nd column next to "5" of the 2nd row and 1st column is taken into the partial string buffer **116** for comparison with "5" of the 1st row and 2nd column. Since this comparison indicates no matching, the number "2" of matching data until this point of time provides L=2 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position 0.

Regarding the partial string having "5" at the 2nd row and 0th column as its leading pixel, "5" exists at the 1st row and 1st column and this data matches the leading pixel. Therefore, the comparison for the next pixel is also made for the relative position +1. Namely, data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **116** and is then compared with "5" of the 1st row and 2nd column which is at the relative position +1. Since this comparison indicates the matching, the comparison is repeated while successively taking in the next pixel on the right side. When the comparison of "3" at the 2nd row and 5th column and "1" at the 1st row and 6th column is made, no matching is found. Accordingly, the value "5" of the length counter **113** at this time provides L=5 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position 1.

With the above, three lengths including L (relative position −1)=0, L (relative position 0)=2 and L (relative position +1)=5 are stored in the relative position and length buffer **114** as the length L of the partial string having "5" at the 2nd row and 0th column as its leading pixel. From thereamong is selected a partial string which has the greatest length L equal to 5. In the case of FIG. **13**A, a partial string a (55) corresponds to the same partial string for the relative position 0 and a partial string b (55434) corresponds to the same partial string for the relative position +1, as shown in FIG. **13**B. Since the length of the partial string a is 2 and the length of the partial string b is 5, the partial string b providing a high efficiency of compression is selected.

Namely, the flow goes through step S**123** to step S**124** in which the longest data among data stored in the relative position and length buffer **114**, the relative position for the longest data and the position of the pixel of interest (as which the leading pixel of the partial string to be compressed is defined) on the current line stored in the pointer buffer **112** are inputted to the code generator **108**. In step S**127**, the code generator **108** selects a corresponding table from the table group **170** on the basis of the position of the pixel of interest on the current line and refers to the selected table so that a code corresponding to the length of data and a relative position therefor is outputted from the code generator **108** through the code output line **119**.

On the other hand, if step S**122** determines that the lengths stored in the relative position and length buffer **114** are all 0, that is, if no matching partial string is found in the dictionary, the flow goes through step S**123** to step S**125** in which run-length compression is performed. Namely, a search is made as to whether or not the same pixels continuously exist on the same line. First, data of the line buffer **105** indicated by the pointer **110** is stored into the partial string buffer **116**. Also, the pointer **110** is advanced by one so that the data of the line buffer **105** is inputted to the comparator **107** through the selector **115** for comparison with data of the partial string buffer **116**. If the result of comparison indicates the matching, the length counter **113** is incremented and the next data indicated by the pointer **110** is inputted to the comparator **107** through the selector **115** for comparison with data of the partial string buffer **116**. The comparison with data of the partial string buffer **116** is repeated with the pointer **110** being advanced one by one until the matching ceases to be obtained. When the matching ceases to be obtained, the flow goes to step S**126** in which data of the length counter **113**, data of the partial string buffer **116** and the position of the pixel of interest on line data to be compressed, which is stored in the pointer buffer **112**, are inputted to the code generator **108**. In step S**127**, the code generator **108** selects, on the basis of the position of the pixel of interest on the data line to be compressed, a corresponding table from the table group **170** and refers to the selected table so that a code corresponding to the length of data and the raw data to be repeated are outputted from the code generator **108** through the code output line **119**.

The above operation is repeated up to the last line of the image data to perform the data compression or the encoding.

Next, explanation will be made of the data compression process of the 8×8 image data shown in FIGS. **13**A to **13**C. It is assumed that each data is represented by 4 bits. For convenience' sake, the coordinate of image data will be represented by (column, row) and the encoded code will be represented by {column of pixel of interest, relative position, length} or [column of pixel of interest, kind of data, length]. Namely, a portion enclosed by the brace { } shows a portion subjected to compression based on the second data compression method of the present invention and a portion enclosed by the bracket [ ] shows a portion subjected to compression based on the run-length compression method.

For example, a code corresponding to the column of a pixel of interest equal to 0, the relative position equal to 1 and the length equal to 3 results in {0, 1, 3} and a code corresponding to the column of a pixel of interest equal to 1, the kind of data equal to 5 and the length equal to 2 results in [1, 5, 2]. Provided that the coordinate of the pixel of interest is (x, y), the range of reference to the dictionary is (x−1, y−1), (x, y−1) and (x+1, y−1) in terms of relative position. In the case of FIG. **13**A, the first line (or 0th row) is subjected to run-length compression since there is no dictionary to which the reference is to be made. Image data at (0, 0) to (3, 0) are all the same and 2, and hence the resulting code is [0, 2, 4]. Data at (4, 0) is 3 and only one of this data exists. Therefore, the resulting code is [4, 3, 1]. Data at (5, 0) to (7, 0) are all the same and 4, and hence the resulting code is [5, 4, 3]. Accordingly, the resulting codes for the first line (or 0th row) are [0, 2, 4] [4, 3, 1] [5, 4, 3], as shown by the first line (or 0th row) in FIG. **14**.

A processing for the second line (or 1st row) is performed handling the first line (or 0th row) as a dictionary. Data at (0, 1) is compared with data at (0, 0) but this comparison indicates no matching. The data at (0, 1) is thereafter compared with data at (1, 0) but this comparison too indicates no matching. Therefore, on the determination that the dictionary includes no matching partial string, the run-length compression is applied. Data at (0, 1) to (2, 1) are all 5, and hence the resulting code is [0, 5, 3]. Data at (3, 1) is 4 and does not match data at (2, 0), (3, 0) and (4, 0). The run-length compression is applied and the resulting code is [3, 4, 1]. Data at (4, 1) is 3 and matches data at (4, 0) among (3, 0), (4, 0) and (5, 0), and data at (4, 1) to (5, 1) match data of the dictionary at (4, 0) to (5, 0). The resulting code is {4, 0 2}. Data at (6, 1) and data at (7, 1) do not match data of the dictionary. The resulting codes are [6, 1, 1] and [7, 3, 1], respectively. Accordingly, the resulting codes for the second

line (or 1st row) are [0, 5, 3] [3, 4, 1] {4, 0, 2} [6, 1, 1] [7, 3, 1], as shown by the second line (or 1st row) in FIG. **14**.

A processing for the third line (or 2nd row) is performed handling the second line (or 1st row) as a dictionary. Data at (0, 2) matches data of the dictionary at (0, 1) which is the relative position 0 and also matches data of the dictionary at (1, 1) which is the relative position 1. The length of a matching partial string of the dictionary in the case of the relative position 0 is (0, 1) to (1, 1) or 2 whereas the length of a matching partial string of the dictionary in the case of the relative position 1 is (1, 1) to (5, 1) or 5. Namely, the length of the partial string of the dictionary for the relative position 1 is greater than that for the relative position 0. The resulting code is {0, 1, 5}. The above processing is repeated up to the last line. As a result, a code string shown in FIG. **14** is obtained for the image data shown in FIGS. **13**A to **13**C.

Next, actual codes are allotted to the code string of FIG. **14** by use of tables shown in FIGS. **15** to **22**. FIGS. **15** to **22** show tables which are prepared for the respective values of x and in which a different code is allotted in accordance with the value of y and the value of z. Here, x is the column of a pixel of interest and y is the length of a partial string to be compressed. Also, z is 0 in the case where a code string is enclosed by a bracket [ ], that is, in the case where the run-length compression is made. In the case where the code string is enclosed by a brace { }, that is, in the case where the dictionary compression based on the second data compression method of the present invention is made, z is 1 when the relative position is −1, 2 when the relative position is 0, and 3 when the relative position is +1. The code stored in each table is not a fixed-length code but a variable-length code in order to enhance the compression ratio by allotting a short code to data which has a high probability of occurrence. The maximum value of y in each table is limited to a bit string length between a column at which the pixel of interest is positioned and the maximum value which the column can take (7 in the image data shown in FIGS. **13**A to **13**C). Accordingly, for example, in the table of x=1 shown in FIG. **16**, y is limited to 1 to 7. In the table of x=5 shown in FIG. **20**, y is limited to 1 to 3. Thereby, the redundancy of coding can be improved. Also, in the present embodiment which is directed to the compression of image data, the size of the table is made small in such a manner that in the case of dictionary compression, the dictionary compression is performed for only data which is in a line immediately preceding a line including a pixel of interest and is adjacent to the pixel of interest (or data which is at the relative positions −1, 0 and +1). Thereby, a high compression ratio can be expected. It is preferable that the table prepared in the table group **170** is a table of Huffman codes constructed beforehand in compliance with data to be compressed and decompressed or a table optimized so that the redundancy is reduced with the compression/decompression. In FIGS. **15** to **22**, a hyphen "-" shows that no variable-length code is allotted.

First, one of the tables shown in FIGS. **15** to **22** is selected on the basis of the value of x. For example, the table of x=0 shown in FIG. **15** is selected in the case where [0, 2, 4] is to be encoded, and the table of x=5 shown in FIG. **20** is selected in the case where {5, −1, 1} is to be encoded. Next, a code corresponding to the values y and z is selected from the selected table. For example, in the case where [0, 2, 4] is to be encoded, a code 10110 corresponding to y=4 and z=0 is selected from the table of x=0 shown in FIG. **15**. In the case where {5, −1, 1} is to be encoded, a code 0011 corresponding to y=1 and z=1 is selected from the table of x=5 shown in FIG. **20**. In the case where z=0, that is, in the case where the run-length compression is made, raw data to be repeated (or 4-bit fixed color code information in the present embodiment or luminance data for each color in the case of certain image) is added after a code selected from a table. For example, in the case where [0, 2, 4] is to be encoded, 0010 is added after the code **10110** corresponding to y=4 and z=0 selected from the table of x=0 shown in FIG. **15**. Accordingly, the resulting code for [0, 2, 4] is 101100010.

The result of transformation of the code string of FIG. **14** into the actual codes is shown in FIG. **23**. The capacity of the image data shown in FIGS. **13**A to **13**C is 256 bits whereas the data capacity of the code string shown in FIG. **23** is 160 bits. The use of the algorithm of the second data compression method according to the present invention results in the compression of the original image data to 62.5%.

A procedure for decompressing the code compressed in accordance with the above manner will be shown using FIGS. **24** to **26**. FIG. **24** is a block diagram showing an example of the construction of a decompression circuit. FIGS. **25** and **26** are flow charts of a data decompression algorithm. In FIG. **24**, reference numeral **129** denotes an input buffer, numeral **130** a decoder, numeral **132** a mode register, numeral **133** a data register, numeral **134** a relative position register, numeral **135** a dictionary address calculator, numeral **136** a selector, numeral **137** a length counter, numeral **138** an X/Y counter for specifying the position of data to be decompressed on a two-dimensional space, numeral **139** a dictionary buffer in which data made the object of reference in copying of the dictionary is stored, numeral **171** a group of tables prepared for the respective X coordinate positions of a pixel of interest (or a leading pixel of a partial string to be decompressed) specified by the X/Y counter **138**, numeral **143** an input signal line, and numeral **144** an output signal line. The table group **171** includes eight tables. Each table is a table including variable-length codes in which a decompression mode of run-length/dictionary copy, the relative position and the length are taken as parameters. In the case where the position of the pixel of interest on the X coordinate is x shown in FIGS. **15** to **22**, each table includes the same information as that in a corresponding one of the tables shown in FIGS. **15** to **22**. Though it is not necessary to impose restrictions on a value on the Y coordinate which the X/Y counter **138** can take, it is required that a value on the X coordinate should be limited to a certain range in a relation with the number of prepared tables. In the present embodiment, the value on the X coordinate, which the X/Y counter **138** can take, is limited to the range of 0 to 7 since eight tables are prepared in the table group **171**.

Next, the operation of the decompression circuit having the above construction will be explained referring to FIGS. **25** and **26**. First or in step **S145**, the X/Y counter **138** is initialized. Next, the compressed data is taken into the input buffer **129** through the input signal line **143** (step **S146**). In the second and subsequent decompression processings, the compressed data is taken in after an unprocessed bit string of data stored in the input buffer **129**. The input buffer **129** comprises an FIFO, shift register or the like. In step **147**, the judgement is made of whether or not the length of a bit string stored in the input buffer **129** is not smaller than 11 bits. This is because the bit string length delivered from the input buffer **129** to the decoder **111** must be not smaller than the longest bit string length of data compressed by the data compression circuit. In the compression method according to the present embodiment, when a code selected from the

tables shown in FIGS. **15** to **22** includes 7 bits in the case where the run-length compression is made, raw data (4 bits fixed) is added to the 7 bits and hence the resulting bit length comes to the longest or 11 bits. When the bit string length stored in the input buffer **129** is not smaller than 11 bits, the flow goes to step **S148**. When the bit string length is smaller than 11 bits, the flow returns to step **S146**.

In step **S148**, a portion of 11 bits from the lead of a bit string stored in the input buffer **129** is delivered to the decoder **130**. On the basis of the X coordinate position of a pixel of interest specified by the X/Y counter **138**, the decoder **130** selects a corresponding table from the table group **171**. The selected table is searched for a variable-length code which matches a received bit string to the longest extent of the bit string length from the leading position. For example, in the case where data 01010010110 in the 1st row of the code string of FIG. **23** from the leading position to the 11th bit is delivered from the input buffer **129** to the decoder **130**, a table including the same information as that in the table shown in FIG. **15** is selected from the table group **171** on the basis of the X coordinate position of a pixel of interest specified by the X/Y counter **138** (in this case, the X coordinate position of the pixel of interest is 0). All variable-length codes held in the selected table are compared with the input data 01010010110 one by one from the leading bit. A matching variable-length code, immediately before none of the subsequent variable-length codes match the input data, is regarded as a variable-length which is to be determined and is hidden in the 11-bit input data. Namely, the table is searched for a variable-length code which matches the input data to the longest extent of the bit string length from the leading position of the input data. In this case, a variable-length code 01010 corresponding to the decompression mode of the run-length mode and the length equal to 3 is searched out, as can be conjectured from FIG. **15**. Also, in the case where data 01111110011 in the 2nd row of the code string of FIG. **23** from the leading position to the 11th bit is delivered from the input buffer **129** to the decoder **130**, a table including the same information as that in the table shown in FIG. **15** is selected from the table group **171** on the basis of the X coordinate position of a pixel of interest specified by the X/Y counter **138** (in this case, the X coordinate position of the pixel of interest is 0). The selected table is searched for a variable-length code which matches the data 01111110011 to the longest extent of the bit string length from the leading position. In this case, a variable-length code 0111111 corresponding to the decompression mode of the dictionary copy mode, the relative position equal to 1 and the length equal to 5 is searched out, as can be conjectured from FIG. **15**. In each table, the maximum value of the length parameter is limited to a bit string length from the position of the pixel of interest on the X coordinate to the maximum value of X coordinate values which the X/Y counter **138** can take. Thereby, the redundancy of coding can be improved. Also, in the present embodiment which is directed to the decompression of image data, the size of the table is made small in such a manner that in the case of dictionary copy mode, the dictionary copy is performed for only data which is in a line immediately preceding a line including the pixel of interest and is adjacent to the pixel of interest (or data which is at the relative positions −1, 0 and +1). Thereby, a high compression ratio can be expected. It is preferable that the table prepared in the table group **171** is a table of Huffman codes constructed beforehand in compliance with data to be compressed and decompressed or a table optimized so that the redundancy is reduced with the compression/decompression.

On the basis of the variable-length code for which the selected table is searched, the decoder **130** outputs a mode flag discriminative of a run-length mode or a dictionary copy mode to the mode register **132** and length data to the length counter **137** and outputs relative position data to the relative position register **134** in the case where the mode flag is the dictionary copy mode (step **S149**). Also, the decoder **130** outputs the decoded bit string length to the input buffer **129** and outputs raw data to the data register **133** in the case where the mode flag is the run-length mode. For example, in the case where in the case where data 01010010110 in the 1st row of the code string of FIG. **23** from the leading position to the 11th bit is delivered from the input buffer **129** to the decoder **130**, the parameters of the variable-length code 01010 searched out in step **S148** are such that the decompression mode is the run-length mode and the length is 3. Accordingly, the decoder **130** outputs the run-length mode as the mode flag to the mode register **132**, the value 3 of length data to the length counter **137**, a four-bit portion 0101 (raw data) succeeding the variable-length code 01010 searched out in step **S148** to the data register **133**, and the decoded bit string length or nine bits corresponding to the addition of the bit string length (five bits) of the searched-out variable-length code and the bit string length (four bits fixed) of the raw data to the input buffer **129**. Also, in the case where in the case where data 01111110011 in the 2nd row of the code string of FIG. **23** from the leading position to the 11th bit is delivered from the input buffer **129** to the decoder **130**, the parameters of the variable-length code 0111111 searched out in step **S148** are such that the decompression mode is the dictionary copy mode, the relative position is 1 and the length is 5. Accordingly, the decoder **130** outputs the dictionary copy mode as the mode flag to the mode register **132**, the value 5 of length data to the length counter **137**, the value 1 of relative position data to the relative position register **134**, and or the decoded bit string length or seven bits of the bit string length of the searched-out variable-length code 0111111 to the input buffer **129**. The reason why the decoded bit string length is outputted to the input buffer **129** is that data having the same bit string length as the bit string length decoded by the decoder **130** is added after an unprocessed bit string of data stored in the input buffer **129**.

The flow goes to step **S151** in the case where the mode flag outputted from the decoder **130** is the run-length mode and goes to step **S153** in the case where it is the dictionary copy mode. The mode flag outputted from the decoder **130** is held in the mode register **132** until one decompression operation is completed. When one decompression operation is completed, a new mode flag outputted from the decoder **130** is held in the mode register **132** and the next decompression operation is started.

In step **S151**, a decompression processing in the run-length mode is performed. In the decompression processing in the run-length mode, the relative position register **134** and the dictionary address calculator **135** do not operate, as shown in FIG. **27**. First, the data register **133** holds raw data outputted from the decoder **130** while the length counter **137** loads length data outputted from the decoder **130** as an initial value. Next, the raw data held in the data register **133** is outputted through the selector **136** to the output signal line **144** on the basis of the mode flag of run-length held in the mode register **132** (operation 1). Next, in order to produce a dictionary to which the reference is to be made in performing the decompression processing of the next line data, the same data as the outputted data is registered into the dictionary buffer **139** at an address thereof corresponding to X

and Y coordinate values specified by the X/Y counter **138** (operation 2), the length counter **137** is decremented (operation 3), and the X coordinate value of the X/Y counter **138** is updated by one (operation 4). As mentioned above, the range of possible X coordinate values of the X/Y counter **138** is 0 to 7. Accordingly, in the case where the X coordinate value of the X/Y counter **138** is 7, the updating of the X coordinate value by one results in that the X coordinate value turns to 0 and the Y coordinate value is updated by one. In step **S152**, the above operations 1 to 4 are repeated until the value of the length counter **137** comes to 0. Thereby, there is generated decompressed data in which the raw data outputted from the decoder **130** continues to the extent of a length corresponding to the length data outputted from the decoder **130**.

In step **S153**, a decompression processing in the dictionary copy mode is performed. In the decompression processing in the dictionary copy mode, the data register **133** does not operate, as shown in FIG. **28**. First, the relative position register **153** holds relative position data outputted from the decoder **130** while the length counter **137** loads length data outputted from the decoder **130** as an initial value. Next, on the basis of an X coordinate value specified by the X/Y counter **138** and the relative position data held in the relative position register **134**, the dictionary address calculator **135** determines the address of that data among data stored in the dictionary buffer **139** to which the reference is to be made (operation 5). That data among data stored in the dictionary buffer **139**, which is at the address specified by the dictionary address calculator **135**, is outputted through the selector **136** to the output signal line **144** on the basis of the mode flag of dictionary copy held in the mode register **132** (operation 6). Next, in order to produce a dictionary to which the reference is to be made in performing the decompression processing of the next line data, the same data as the outputted data is registered into the dictionary buffer **139** at an address thereof corresponding to X and Y coordinate values specified by the X/Y counter **138** (operation 7), the length counter **137** is decremented (operation 8), and the X coordinate value of the X/Y counter **138** is updated by one (operation 9). In step **S154**, the above operations 5 to 9 are repeated until the value of the length counter **137** comes to 0. Thereby, there is generated decompressed data in which the data outputted from the dictionary buffer **139** continues to the extent of a length corresponding to the length data outputted from the decoder **130**.

In step **S155**, there is discarded that bit string inclusive of the lead of the bit string stored in the input buffer **129** which has already been decoded by the decoder **130**. The flow returns to step **S147** in the case where data to be decompressed still exists, and the flow is completed in the case where it does not exist (step **S156**).

In the above-mentioned example of compression, the dictionary is searched in the dictionary reference range for the longest partial string existing on the dictionary and the searched-out partial string is encoded. However, there may also be considered the case where the longest partial string is divided into a plurality of partial strings and the divisional partial string is compressed after composition thereof with another partial string, and the case where partial strings, which are not the longest, are combined and compressed.

The former case is as follows. For example, the partial string b shown in FIG. **13**B is divided into two parts or a partial string c "5543" and a partial string d "4" shown in FIG. **13**C and the partial string d "4" and "3" at the 2nd row and 5th column are composed into a partial string e "43". A code for the partial string c is {0, 1, 4} and a code for the partial string e "43" is {4, −1, 2} since the partial string e matches "43" continuing from the 1st row and 4th column of the immediately preceding line. Accordingly, a code for the 2nd row results in ({0, 1, 4} {4, −1, 2} [6, 5, 1] [7, 4, 1]. This code will be referred to as code a'. The latter case is as follows. For example, a partial string "55" for the relative position 0 is selected for the 2nd row and 0th column and a partial string "434" for the relative position +1 is selected for the 2nd row and 2nd column. Thereby, a code for the 2nd row results in {0, 0, 2} {2, 1, 3} {5, −1, 1} [6, 5, 1] [7, 4, 1]. This code will be referred to as code b'.

Thus, three patterns including the pattern shown in the above-mentioned example of compression may exist as the code for the 2nd row shown in FIG. **13**A. The code for the 2nd row shown in FIG. **14** will be referred to as code c'. When the actual codes shown in FIGS. **15** to **22** are allotted to the codes a', b' and c', the codes a' spans 23 bits, the code b' spans 26 bits and the code c' spans 22 bits. The code c' are efficient. However, when codes other than those shown in FIG. **15** are allotted to the codes a', b' and c', a different result will be obtained and there may be the case where the code a' or the code b' results in the shortest code. Accordingly, it does not necessarily follow that the best way includes searching for the longest partial string on the dictionary and encoding the longest partial string. It is desirable to select the combination of partial strings on the dictionary which provides the shortest code when the actual codes are allotted.

Even if the combination of partial strings on the dictionary is changed so that the resulting code becomes the shortest, as mentioned above, no influence is given on the data decompression method so long as the encoding rule (using the position of a pixel of interest on the current line, and the leading position and the length of the same partial length in the immediately preceding line) is not changed.

As explained in detail in the foregoing, according to the second data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial string. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. Further, data compression is performed in such a manner that tables in which a different code is allotted in accordance with the relative position of a leading pixel of a partial string on the immediately preceding line and a pixel of interest and the length of the partial string on the immediately preceding line are prepared for the respective positions of the pixel of interest on the current line, and a code corresponding to the relative position and the length of the partial string is outputted from a table selected in accordance with the position of the pixel of interest on the current line. Each table is a table of Huffman codes constructed beforehand in compliance with data to be compressed and decompressed or a table optimized so that the redundancy is reduced with the compression/decompression. Thereby, a higher compression ratio is obtained. Furthermore, compression such as run-length compression is applied to the first line of the image data and a partial string for which the reference to the dictionary is impossible. Thereby, a still higher compression ratio is obtained.

(Third Data Compression/Decompression Method of the Invention)

In order to facilitate the understanding of a third data compression/decompression method of the present

invention, the principle of the third data compression/decompression method will be explained using the drawings. In the third data compression/decompression method of the present invention, data of the immediately preceding in successively scanned two-dimensional image data (shown in FIG. **29**) is held as reference data, using a property that a certain pixel(s) in the image data is similar to a group of pixels in the neighborhood thereof. (A buffer for storing the reference data will hereinafter be referred to as "dictionary" **201**.) The reference to the dictionary **201** of the immediately preceding line is made to detect whether or not the dictionary includes a partial string which is the same as a partial string **202** on line data to be compressed to the extent of at least one or more pixels.

In the case where it is detected that the dictionary **201** includes a partial string which matches the partial string **202** to be compressed, a partial string **203** is detected which matches the partial string **202** to be compressed to the longest possible extent within the range of the preset maximum detection string length N. (In the present example, it is assumed that N=8.) Next, assume that the number of pixels in one line of the two-dimensional image data is H and the position of a pixel of interest (or a leading pixel of the partial string to be compressed) on the current line is x ($0 \leqq x \leqq H-1$). Then, one table is selected from among tables which are prepared for the respective values of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H−N+1 when $H-N+1 \leqq x \leqq H-1$ and in which a different code is allotted in accordance with the relative position of a leading pixel of the partial string on the immediately preceding line and the pixel of interest and the length of the partial string on the immediately preceding line. The selected table corresponds to the value of T (T=0 in the shown example) determined on the basis of the position x (x=0 in the shown example) of the pixel **205** of interest on the current line from a leading pixel thereof. The reference to the selected table is made, and a code corresponding to the leading position **204** of the partial string **203** on the dictionary **201** and the length of the partial string **203** (five dots in the shown example) is outputted, thereby performing data compression. At this time, it is preferable that the range of reference to the dictionary **201** is limited to fall within a range in which the degree of similarity of the partial string **202** to be compressed to the partial string on the dictionary **201** is high. In order to improve the compression/decompression speed, it is also preferable that the maximum detection string length N is set to be greater when the same partial string existing on adjacent lines in the two-dimensional image data is relatively long and to be smaller when it is short. However, if N is set to an extremely great value, the number of tables is increased so that the compression/decompression speed is lowered on the contrary. On the other hand, if N is set to an extremely small value, the number of tables is reduced but the compression ratio is deteriorated since the length of a partial string made the object of reference is small. Though FIG. **29** shows the two-dimensional image data in which the number H of pixels in one line is 16 bits, the range of values which T can take is constant irrespective of the value of the number H of pixels in one line so long as the maximum detection string length N is smaller than the number H of pixels in one line. Namely, the possible values of T are $0 \leqq T \leqq x-H+N+1$ but there ultimately results in $0 \leqq T \leqq N$ since the maximum possible value of the position x of the pixel of interest on the current line is H−1. Accordingly, even when the number H of pixels in one line of the two-dimensional image data is increased, the number of tables always comes to N+1 (always 9 in the present example in which N=8 is assumed).

In the case where a partial string matching the partial string **202** to be compressed is not detected in the dictionary **201**, compression such as run-length compression is applied to the partial string **202** to be compressed. In the case the run-length compression is applied, it is preferable to perform data compression in such a manner that a corresponding code is outputted by selecting, from among run-length tables which are prepared for the respective values of T mentioned above and in which a different code is allotted in accordance with the length of the same continuous data, a run-length table which corresponds to the value of T determined on the basis of the position x of the pixel **205** of interest on the current line from the leading pixel thereof and referring to the selected run-length table. It is required that the codes stored in the run-length table should be different from the codes stored in the above-mentioned table. Also, it is preferable that the code stored in the table and the run-length table is not a fixed-length code but a variable-length code in order to enhance the compression ratio by allotting a short code to data which has a high probability of occurrence.

In the third data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line, as mentioned above. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial string within the range of the maximum detection string length N. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. Further, the number of tables to be prepared is always N (the maximum detection string length) plus 1 irrespective of the number of pixels in one line of the two-dimensional image data. Therefore, when the number of pixels in one line of the two-dimensional image data is increased, it is possible to prevent the lowering of the processing speed which may occur due to the increase of the capacity of the table. By applying compression such as run-length compression to the first line of the image data and a partial string for which the reference to the dictionary is impossible, a higher compression ratio is obtained.

An embodiment of the third data compression/decompression method of the present invention will now be explained. As shown in FIG. **30**, a data compression circuit according to an embodiment of a third data compression apparatus for realizing the third data compression method of the present invention includes a line buffer **205**, a dictionary buffer **206** for holding data of the immediately preceding line, a comparator **207**, a code generator **208**, an adder **209**, a pointer **210**, a relative position counter **211**, a pointer buffer **212**, a length counter **213**, a relative position and length buffer **214**, a selector **215**, a partial string buffer **216**, and a table group **270** including tables shown in FIGS. **34** to **42**. In FIG. **30**, reference numeral **217** denotes a line buffer input signal line, reference numeral **218** a dictionary buffer input signal line, reference numeral **219** a code output line, and reference numeral **272** an input signal line for the number Hsize of pixels in one line of the two-dimensional image data.

The tables shown in FIGS. **34** to **42** are prepared for the respective values of T (which will be mentioned later on) determined on the basis of the position of a pixel of interest (or a leading pixel of a partial string to be compressed) on the current line from a leading pixel thereof. In each table, a different code is allotted and stored in accordance with the relative position of a leading pixel of the same partial string as the partial string to be compressed in the two-dimensional

image data successively inputted through the line buffer input signal line **217** and the pixel of interest on the immediately preceding line and the length of the partial string to be compressed on the immediately preceding line.

Next, the outline of the operation of the data compression circuit having the above construction will be shown on the basis of a flow shown in FIG. **31**. First or in step **S220**, the number H (Hsize) of pixels in one line of two-dimensional image data is inputted to the code generator **208**. Next or in step **S221**, the pointer **210** is initialized, and data pushed out of the line buffer **205** is stored into the dictionary buffer **206** through the dictionary buffer input signal line **218**. Thereafter, the two-dimensional image data successively inputted image data are stored into the line buffer **205** through the line buffer input signal line **217** (step **S222**).

Next, a search is made for the longest partial string on the dictionary which matches a partial string to be compressed (as which data of continuous pixels selected from data of the current line stored in the line buffer **205** will be defined) to the longest possible extent within the range of the preset maximum detection string length N ($1 \leqq N \leqq H$) (step **S223**). In order to improve the compression/decompression speed, it is preferable that the maximum detection string length N is set to be greater when the same partial string existing on adjacent lines in the two-dimensional image data successively inputted through the line buffer input line **217** is relatively long and to be smaller when it is short. However, if N is set to an extremely great value, the number of tables is increased so that the compression/decompression speed is lowered on the contrary. On the other hand, if N is set to an extremely small value, the number of tables is reduced but the compression ratio is deteriorated since the length of a partial string made the object of reference is small. In the present embodiment, N is selected to be 8. A search for the longest partial string shown as one flow step **S223** in FIG. **31** is made in accordance with the following procedure. The concept of the search for the longest partial string will be explained using 16×8 image data shown in FIGS. **32**A to **32**C by way of example. In the present embodiment, the judgement of whether or not a line preceding by one line to the partial string made the object of search includes the same partial string as the partial string made the object of search, is made by performing a search as to whether or not the same pixel as the leading pixel of the partial string made the object of search exists between a position returned by one from the leading pixel position of the partial string made the object of search (defined as relative position −1) and a position advanced by one therefrom (defined as relative position +1). The compression in step **S223** is performed in the case where the same pixel string exists in the immediately preceding line within a range shifted by one pixel to the right and left.

Speaking in conjunction with FIG. **32**A, (1) an example of relative position −1 is a partial string "554" continuing from "5" at the 3rd row and 1st column. Since this partial string "554" is the same as a partial string "554" continuing from "5" at the 2nd row and 0th column, it is determined that the same partial string exists at a position shifted by one pixel to the left. (2) An example of relative position 0 is a partial string "34" continuing from "3" at the 1st row and 4th column. Since this partial string "34" is the same as a partial string "34" continuing from "3" at the 0th row and 4th column, it is determined that the same partial string exists at a position shifted by zero pixel. (3) An example of relative position +1 is a partial string "55434" continuing from "5" at the 2nd row and 0th column. Since this partial string "55434" is the same as a partial string "55434" continuing from "5" at the 1st row and 1st column, it is determined that the same partial string exists at a position shifted by one pixel to the right.

In step **S223**, data of the pointer **210** is first stored into the pointer buffer **212** and the relative position counter **211** is initialized. Next, data of one pixel is taken into the partial string buffer **216** from the line buffer **205** indicated by the pointer **210**. Regarding the data of the one pixel in the current line taken in the partial string buffer **216** from the line buffer **205**, a search is made as to whether or not a matching pixel exists for each of a pixel at the relative position −1, a pixel at the relative position 0 and a pixel at the relative position +1 in the immediately preceding line stored in the dictionary buffer **206**. In the case where there is no matching pixel, the length "0" is written into the relative position and length buffer **214** for each relative position and the flow proceeds to step **S224**. In FIG. **32**A, regarding "4" at the 1st row and 3rd column, the pixels at the 0th row and 2nd column and the 0th row and 3rd column are both "2" and the pixel at the 0th row and 4th column is "3". Accordingly, "0" is written as length data for a point (1, 3) into the relative position and length buffer **114** for all the relative positions −1, 0 and +1. In the case where there is a matching pixel, the pointer **210** and the length counter **215** are incremented and data of the next pixel is taken into the partial string buffer **216**. At this time, the leading address of the partial string made the object of search under searching in the present search is remained in the pointer buffer **212**.

In the case where the matching for the leading pixel of the partial string made the object of search is found at the relative position −1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position −1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **216**. Also, in the case where the matching is found at the relative position 0, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position 0 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **216**. Further, in the case where the matching is found at the relative position +1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position +1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **216**. In the case where the result of each comparison indicates the matching, the next pixel pointer **210** is incremented to take data of the next pixel into the partial string buffer **216** and the length counter **215** is incremented. This operation is repeated until the result of each comparison indicates no matching or the count value of the length counter **215** becomes the maximum detection string length N (N=8 in the present embodiment). Thereby, in the case where the result of comparison indicates no matching, the count value of the length counter **215**, at a point of time when the matching ceases to be obtained, is measured as the length L of a partial data string which has the same data string as data of the immediately preceding line. In the case where the count value of the length counter **215** becomes the maximum detection string length N, the maximum detection string length N is measured as the length L of a partial data string which has the same data string as data of the immediately preceding line. This length information is counted for each of the relative position −1, the relative position 0 and the relative position +1. Namely, after the length L has been counted for the relative position −1 in a manner mentioned above, the length L is stored as length information of the relative position −1 into the relative position and length buffer **214** at the column of the

relative position −1. Subsequently, in order to make a search regarding the relative position 0, the leading address of the partial string as the object of search temporarily stored in the pointer buffer **212** is returned into the pixel pointer **210** and the relative position counter **211** is incremented. With the pixel counter **210** being incremented, the comparison is similarly made for the next data of on the right side of the leading address of the partial string made the object of search until the data matching relevant to the relative position 0 ceases to be obtained or the count value of the length counter **215** becomes the maximum detection string length N. Thereby, the length information L is determined. Subsequently, a similar search is made regarding the relative position +1.

Considering a partial string which has "5" at the 2nd row and 0th column in FIG. **32**A as its leading pixel, this pixel is at the lead of the current line and hence no data exist at the relative position −1 of the preceding line. Accordingly, the length L for the relative position −1 is 0. Regarding to the relative position 0, "5" exists at the 1st row and 0th column. Therefore, the length counter **213** is incremented and data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **216** for comparison with "5" of the 1st row and 1st column. Since this comparison too indicates the matching, the length counter **213** is incremented and data "4" of the 2nd row and 2nd column next to "5" of the 2nd row and 1st column is taken into the partial string buffer **216** for comparison with "5" of the 1st row and 2nd column. This comparison indicates no matching. The value of the length counter **213** at this time is "2" and does not reach the maximum partial string length N=8. Accordingly, the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position 0 comes to 2.

Regarding the partial string having "5" at the 2nd row and 0th column as its leading pixel, "5" exists at the 1st row and 1st column and this data matches the leading pixel. Therefore, the comparison for the next pixel is also made for the relative position +1. Namely, data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **216** and is then compared with "5" of the 1st row and 2nd column which is at the relative position +1. Since this comparison indicates the matching, the comparison is repeated while successively taking in the next pixel on the right side. When the comparison of "3" at the 2nd row and 5th column and "1" at the 1st row and 6th column is made, no matching is found. The value of the length counter **213** at this time is "5" and does not reach the maximum partial string length N=8. Accordingly, the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position 1 comes to 5.

With the above, three lengths including L (relative position −1)=0, L (relative position 0)=2 and L (relative position +1)=5 are stored in the relative position and length buffer **214** as the length L of the partial string having "5" at the 2nd row and 0th column as its leading pixel. From thereamong is selected a partial string which has the greatest length L equal to 5. In the case of FIG. **32**A, a partial string a (55) corresponds to the same partial string for the relative position 0 and a partial string b (55434) corresponds to the same partial string for the relative position +1, as shown in FIG. **32**B. Since the length of the partial string a is 2 and the length of the partial string b is 5, the partial string b providing a high efficiency of compression is selected.

Namely, the flow goes through step S**224** to step S**225** in which x, y and z are inputted to the code generator **208**, where x is the position of a pixel of interest on the current line stored in the pointer buffer **212**, y is the length of the longest data among data stored in the relative position and length buffer **214**, and z is a value corresponding to the addition of 2 to the relative position of the longest data.

In step S**228**, the code generator **208** determines the value of T from the position x of the pixel of interest on the current line. The value of T is T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$, where H is the number of pixels in one line of the two-dimensional image data inputted to the code generator **208** at step S**220** and N is the preset maximum detection string length. In the present embodiment, H is 16 and N is set to 8 beforehand, as mentioned above. Accordingly, the value of T is T=0 when x=0 (step S**229**), T=1 when $1 \leqq x \leqq 8$ (step S**230**), and T=x−7 when $9 \leqq x \leqq 15$ (step S**231**).

In step S**232**, the code generator **208** selects a corresponding table from the table group **270** on the basis of the value of T determined from the position x of the pixel of interest on the current line and refers to the selected table so that a code corresponding to the length y of data and the value z of addition of 2 to the relative position of that data is outputted from the code generator **208** through the code output line **219**.

On the other hand, if step S**224** determines that the lengths stored in the relative position and length buffer **214** are all 0, that is, if no matching partial string is found in the dictionary, the flow goes through step S**224** to step S**226** in which run-length compression is performed. Namely, a search is made for a partial string on the current line including the same pixels which continue to the longest possible extent within the range of the maximum detection string length N (N=8 in the present embodiment). First, data of the line buffer **205** indicated by the pointer **210** is stored into the partial string buffer **216**. Also, the pointer **210** is advanced by one so that the data of the line buffer **205** is inputted to the comparator **207** through the selector **215** for comparison with data of the partial string buffer **216**. If the result of comparison indicates the matching, the length counter **213** is incremented and the next data indicated by the pointer **210** is inputted to the comparator **207** through the selector **215** for comparison with data of the partial string buffer **216**. The comparison with data of the partial string buffer **216** is repeated with the pointer **210** being advanced one by one until the result of comparison indicates no matching or the count value of the length counter **215** becomes the maximum detection string length N. In the case where the result of comparison indicates no matching, the count value of the length counter **215**, at the point of time when the matching ceases to be obtained, is measured as the length L of the partial data string on the current line including the same continuous pixels. In the case where the count value of the length counter **215** becomes the maximum detection string length N, the maximum detection string length N is measured as the length L of the partial data string on the current line including the same continuous pixels.

Next or in step **227**, data stored in the partial string buffer **216** is inputted together with the values of x, y and z to the code generator **208**, where x is the position of a pixel of interest on the current line stored in the pointer buffer **212**, y is the length of the partial data string with the same continuous pixels counted by the length counter **213**, and z is 0.

Next, a corresponding table is selected from the table group **270** on the basis of the value of T determined from the position x of the pixel of interest on the current line and

refers to the selected table so that a code corresponding to the length y of data and z=0 and raw data to be repeated is outputted through the code output line **219** (step S**232**).

The above operation is repeated through step S**233** and step S**234** up to the last line of the two-dimensional image data to perform the data compression or the encoding.

Next, explanation will be made of the data compression process of the 16×8 image data shown in FIGS. **32**A to **32**C. It is assumed that each data is represented by 4 bits. For convenience' sake, the coordinate of image data will be represented by (column, row) and the encoded code will be represented by {T, relative position, length} or [T, kind of data, length]. Namely, a portion enclosed by the brace { } shows a portion subjected to compression based on the third data compression method of the present invention and a portion enclosed by the bracket [ ] shows a portion subjected to compression based on the run-length compression method. Here, T is the value determined from the position x of the pixel of interest on the current line in step S**228**. Namely, in the present embodiment, T is 0 in the case where the pixel of interest is positioned at the 0th column, 1 in the case where it is positioned at the 1st to 8th columns, 2 in the case where it is positioned at the 9th column, 3 in the case where it is positioned at the A-th column, 4 in the case where it is positioned at the B-th column, 5 in the case where it is positioned at the C-th column, 6 in the case where it is positioned at the D-th column, 7 in the case where it is positioned at the E-th column, and 8 in the case where it is positioned at the F-th column.

For example, a code corresponding to the column of the pixel of interest equal to 0, the relative position equal to 1 and the length equal to 3 results in {0, 1, 3} and a code corresponding to the column of the pixel of interest equal to 1, the kind of data equal to and the length equal to 2 results in [1, 5, 2]. Provided that the coordinate of the pixel of interest is (x, y), the range of reference to the dictionary is (x−1, y−1), (x, y−1) and (x+1, y−1) in terms of relative position. In the case of FIG. **32**A, the 0th row is subjected to run-length compression since there is no dictionary to which the reference is to be made. Image data at (0, 0) to (3, 0) are all the same and 2, and hence the resulting code is [0, 2, 4]. Data at (4, 0) is 3 and only one of this data exists. Therefore, the resulting code is [1, 3, 1]. Data at (5, 0) to (7, 0) are all the same and 4, and hence the resulting code is [1, 4, 3]. Data at (8, 0) is 6 and only one of this data exists. Therefore, the resulting code is [1, 6, 1]. Data at (9, 0) and (A, 0) are both the same and C, and hence the resulting code is [2, C, 2]. Data at (B, 0) and (C, 0) are both the same and 6, and hence the resulting code is [4, 6, 2]. Data at (D, 0) to (F, 0) are all the same and 3, and hence the resulting code is [6, 3, 3]. Accordingly, the resulting codes for the 0th row are [0, 2, 4] [1, 3, 1] [1, 4, 3] [1, 6, 1] [2, C, 2] [4, 6, 2] [6, 3, 3], as shown by the 0th row in FIG. **33**.

A processing for the 1st row shown in FIG. **32**A is performed handling the 0th row as a dictionary. Data at (0, 1) is compared with data at (0, 0) but this comparison indicates no matching. The data at (0, 1) is thereafter compared with data at (1, 0) but this comparison too indicates no matching. Therefore, on the determination that the dictionary includes no matching partial string, the run-length compression is applied. Data at (0, 1) to (2, 1) are all 5, and hence the resulting code is [0, 5, 3]. Data at (3, 1) is 4 and does not match data at (2, 0), (3, 0) and (4, 0). The run-length compression is applied and the resulting code is [1, 4, 1]. Data at (4, 1) is 3 and matches data at (4, 0) among (3, 0), (4, 0) and (5, 0), and data at (4, 1) to (5, 1) match data of the dictionary at (4, 0) to (5, 0). The resulting code is {1, 0, 2}. Data at (6, 1) and data at (7, 1) do not match data of the dictionary. The resulting codes are [1, 1, 1] and [1, 3, 1], respectively. Data at (8, 1) is C and matches data at (9, 0) among (7, 0), (8, 0) and (9, 0), and data at (8, 1) to (9, 1) match data of the dictionary at (9, 0) to (A, 0). The resulting code is {1, 1, 2}. Data at (A, 1) is C and matches data at (9, 0) and (A, 0) among (9, 0), (A, 0) and (B, 0). Here, data at (B, 1) and data at (A, 0) do not match but data at (A, 1) to (C, 1) match data of the dictionary at (A, 0) to (C, 0). The resulting code is {3, 0, 3}. Data at (D, 1) is 6 and matches data at (C, 0) among (C, 0), (D, 0) and (E, 0), and data at (D, 1) to (F, 1) match data of the dictionary at (C, 0) to (E, 0). The resulting code is {6, −1, 3}. Accordingly, the resulting codes for the 1st row are [0, 5, 3] [1, 4, 1] {1, 0, 2} [1, 1, 1] [1, 3, 1] {1, 1, 2} {3, 0, 3} {6, −1, 3}, as shown by the 1st row in FIG. **33**.

A processing for the 2nd row shown in FIG. **32**A is performed handling the 1st row as a dictionary. Data at (0, 2) matches data of the dictionary at (0, 1) which is the relative position 0 and also matches data of the dictionary at (1, 1) which is the relative position 1. The length of a matching partial string of the dictionary in the case of the relative position 0 is (0, 1) to (1, 1) or 2 whereas the length of a matching partial string of the dictionary in the case of the relative position 1 is (1, 1) to (5, 1) or 5. Namely, the length of the partial string of the dictionary for the relative position 1 is greater than that for the relative position 0. The resulting code is {0, 1, 5}. The above processing is repeated up to the last line. As a result, a code string shown in FIG. **33** is obtained for the image data shown in FIGS. **32**A to **32**C.

Next, actual codes are allotted to the code string of FIG. **33** by use of tables shown in FIGS. **34** to **42**. FIGS. **34** to **42** show tables which are prepared for the respective values of T and in which a different code is allotted in accordance with the value of y and the value of z. Here, T is the value determined in step S**228** from the position x of a pixel of interest on the current line and y and z are the values inputted to the code generator **208** in step S**225** or step S**227**. The value y is the length of a partial string to be compressed. Also, the value z is 0 in the case where a code string is enclosed by a bracket [ ], that is, in the case where the run-length compression is made and is equal to the addition of 2 to the relative position in the case where the code string is enclosed by a brace { }, that is, in the case where the dictionary compression based on the third data compression method of the present invention is made.

The code stored in each table is not a fixed-length code but a variable-length code in order to enhance the compression ratio by allotting a short code to data which has a high probability of occurrence. The reason why the tables are prepared for the respective values of T is as follows. In principle, the number of tables to be prepared may be one. However, when the tables are united into one, different codes must be allotted in accordance with all values which y and z can take. By the way, the possible values of y and z differ depending on the position x of the pixel of interest on the current line from the leading pixel thereof. For example, the maximum value of y in each table comes to a bit string length from the pixel of interest to a pixel positioned at the last of the current line. Also, in the case of x=0, it is not necessary to allot codes for z=1 (or the case where the relative position is −1). Accordingly, if the tables are united into one, the redundancy of coding is increased. On the other hand, in the case where the tables are prepared for the respective values x of the pixel of interest on the current line from the leading pixel thereof, the redundancy of coding

can be improved by limiting the maximum value of y in each table to a bit string length from the pixel of interest to a pixel positioned at the last of the current line. However, in the case where the number H of pixels in one line of the two-dimensional image is increased, new tables must be added and hence the table capacity is increased, thereby lowering the compression/decompression speed. Thus, in the present embodiment, the maximum detection string length N of a partial string to be compressed is set beforehand. In the case of x=0, an exclusive table is prepared since it is not necessary to allot codes for z=1. In the case of $1 \leqq x \leqq H-N$, tables are united to one or one table is prepared since the maximum possible values of y are all N and the possible values of z are all 0 to 3. In the case of $H-N+1 \leqq x \leqq H-1$, tables for the exclusive use for the respective values of x are prepared since the possible values of z are all 0 to 3 but the maximum possible value of y is a bit string length from the pixel of interest to a pixel positioned at the last of the current line. Namely, the tables are prepared for the respective values of T, T being set to T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H−N+1 when $H-N+1 \leqq x \leqq H-1$. With such setting of the value of T, the range of possible values of T is constant irrespective of the value of the number H of pixels in one line so long as the maximum detection string length N is smaller than the number H of pixels in one line. Namely, the possible values of T are $0 \leqq T \leqq x-H+N+1$ but there ultimately results in $0 \leqq T \leqq N$ since the maximum possible value of the position x of the pixel of interest on the current line is H−1. Accordingly, even when the number H of pixels in one line of the two-dimensional image data is increased, the number of tables is always N+1 and it is therefore possible to prevent the table capacity from increasing with the lowering of the compression/decompression speed.

Also, in the present embodiment which is directed to the compression of image data, the size of the table is made small in such a manner that in the case of dictionary compression, the dictionary compression is performed for only data which is in a line immediately preceding a line including a pixel of interest and is adjacent to the pixel of interest (or data which is at the relative positions −1, 0 and +1). Thereby, a high compression ratio can be expected. It is preferable that the table prepared in the table group **270** is a table of Huffman codes constructed beforehand in compliance with data to be compressed and decompressed or a table optimized so that the redundancy is reduced with the compression/decompression. In FIGS. **34** to **42**, a hyphen "-" shows that no variable-length code is allotted.

First, one of the tables shown in FIGS. **34** to **42** is selected on the basis of the value of T. For example, the table of T=0 shown in FIG. **34** is selected in the case where [0, 2, 4] is to be encoded, and the table of T=1 shown in FIG. **35** is selected in the case where {1, −1, 1} is to be encoded. Next, a code corresponding to the values y and z is selected from the selected table. For example, in the case where [0, 2, 4] is to be encoded, a code 0110110111 corresponding to y=4 and z=0 is selected from the table of T=0 shown in FIG. **34**. In the case where {1, −1, 1} is to be encoded, a code 0111 corresponding to y=1 and z=1 is selected from the table of T=1 shown in FIG. **35**. In the case where z=0, that is, in the case where the run-length compression is made, raw data to be repeated (or 4-bit fixed color code information in the present embodiment or luminance data for each color in the case of certain image) is added after a code selected from a table. For example, in the case where [0, 2, 4] is to be encoded, 0010 is added after the code 0110110111 corresponding to y=4 and z=0 selected from the table of T=0 shown in FIG. **34**. Accordingly, the resulting code for [0, 2, 4] is 01101101110010.

The result of transformation of the code string of FIG. **33** into the actual codes is shown in FIG. **43**. The capacity of the image data shown in FIGS. **32**A to **32**C is 512 bits whereas the data capacity the code string shown in FIG. **43** is 404 bits. The use of the algorithm of the third data compression method according to the present invention results in the compression of the original image data to 78.9%.

A procedure for decompressing the code compressed in accordance with the above manner will be shown using FIGS. **44** to **46**. FIG. **44** is a block diagram showing an example of the construction of a decompression circuit. FIGS. **45** and **46** are flow charts of a data decompression algorithm. In FIG. **44**, reference numeral **229** denotes an input buffer, numeral **230** a decoder, numeral **232** a mode register, numeral **233** a data register, numeral **234** a relative position register, numeral **235** a dictionary address calculator, numeral **236** a selector, numeral **237** a length counter, numeral **238** an X/Y counter for specifying the position of data to be decompressed on a two-dimensional space, numeral **239** a dictionary buffer in which data made the object of reference in copying of the dictionary is stored, numeral **271** a group of tables prepared for the respective values of T, numeral **243** an input signal line to the input buffer **229**, numeral **244** an output signal line, and numeral **273** an input signal line for the number Hsize of pixels in one line of two-dimensional image data. The value of T in the table group **217** is determined in the same manner as that in step S**228** shown in FIG. **31**, when the position of a pixel of interest (or a leading pixel of a partial string to be decompressed) on the X coordinate specified by the X/Y counter **238** is x. In each table is stored the same information as that in the table of FIGS. **34** to **42** for each value of T determined on the basis of the value of x of the pixel of interest on the X coordinate. Though it is not necessary to impose restrictions on a value on the Y coordinate which the X/Y counter **238** can take, a value on the X coordinate is limited 0 to H−1 in the case where the number of pixels in one line of the two-dimensional image data is H. In the present embodiment, the value on the X coordinate, which the X/Y counter **238** can take, is limited to 0 to 15 since the number H of pixels in one line of the two-dimensional image data is 16.

Next, the outline of the operation of the decompression circuit having the above construction will be shown. First or in step S**244**, the number H (Hsize) of pixels in one line of two-dimensional image data to be decompressed is inputted to the X/Y counter **238** and the decoder **230**. Next or in step S**245**, the X/Y counter **238** is initialized. Thereafter, the compressed data is taken into the input buffer **229** through the input signal line **243** (step S**246**). In the second and subsequent decompression processings, the compressed data is taken in after an unprocessed bit string of data stored in the input buffer **229**. The input buffer **229** comprises an FIFO, shift register or the like. In step S**247**, the judgement is made of whether or not the length of a bit string stored in the input buffer **229** is not smaller than 15 bits. This is because the bit string length delivered from the input buffer **229** to the decoder **211** must be not smaller than the longest bit string length of data compressed by the data compression circuit. In the compression method according to the present embodiment, when a code selected from the tables shown in FIGS. **34** to **42** includes 11 bits in the case where the run-length compression is made, raw data (4 bits fixed) is added to the 11 bits and hence the resulting bit length comes to the longest or 15 bits. When the bit string length stored in

the input buffer **229** is not smaller than 15 bits, the flow goes to step S**248**. When the bit string length is smaller than 15 bits, the flow returns to step S**246**.

In step S**248**, a portion of 15 bits from the lead of a bit string stored in the input buffer **229** is delivered to the decoder **230**. On the basis of the position x of a pixel of interest on the X coordinate which is specified by the X/Y counter **238**, the number H of pixels in one line of the two-dimensional image data to be decompressed which is inputted in step S**244** (H=16 in the present embodiment) and the maximum detection string length N which is used in the compression circuit (N=8 in the present embodiment), the decoder **230** determines the value of T in the same manner as that in step S**228** shown in FIG. **31** and thereafter selects a table corresponding to the value of T from the table group **271**. The selected table is searched for a variable-length code which matches a received bit string to the longest extent of the bit string length from the leading position. For example, in the case where data 011011011100101 in the 0th row of the code string of FIG. **43** from the leading position to the 15th bit is delivered from the input buffer **229** to the decoder **230**, a table including the same information as that in the table shown in FIG. **34** is selected from the table group **271** on the basis of the value of T determined from the position x of a pixel of interest on the X coordinate specified by the X/Y counter **238** (in this case, T=0 since x=0). All variable-length codes held in the selected table are compared with the input data 011011011100101 one by one from the leading bit. A matching variable-length code, immediately before none of the subsequent variable-length codes match the input data, is regarded as a variable-length which is to be determined and is hidden in the 15-bit input data. Namely, the table is searched for a variable-length code which matches the input data to the longest extent of the bit string length from the leading position of the input data. In this case, a variable-length code 0110110111 corresponding to the decompression mode of the run-length mode and the length equal to 4 is searched out, as can be conjectured from FIG. **34**. Also, in the case where data 011011100111100 in the 2nd row of the code string of FIG. **43** from the leading position to the 15th bit is delivered from the input buffer **229** to the decoder **230**, a table including the same information as that in the table shown in FIG. **34** is selected from the table group **271** on the basis of the value of T determined from the position x of a pixel of interest on the X coordinate specified by the X/Y counter **238** (in this case, T=0 since x=0). The selected table is searched for a variable-length code which matches the data 011011100111100 to the longest extent of the bit string length from the leading position. In this case, a variable-length code 01101110 corresponding to the decompression mode of the dictionary copy mode, the relative position equal to 1 and the length equal to 5 is searched out, as can be conjectured from FIG. **34**.

On the basis of the variable-length code for which the selected table is searched, the decoder **230** outputs a mode flag discriminative of a run-length mode or a dictionary copy mode to the mode register **232** and length data to the length counter **237** and outputs relative position data to the relative position register **234** in the case where the mode flag is the dictionary copy mode (step S**249**). Also, the decoder **230** outputs the decoded bit string length to the input buffer **229** and outputs raw data to the data register **233** in the case where the mode flag is the run-length mode. For example, in the case where in the case where data 011011011100101 in the 0th row of the code string of FIG. **43** from the leading position to the 15th bit is delivered from the input buffer **229** to the decoder **230**, the parameters of the variable-length code 0110110111 searched out in step S**248** are such that the decompression mode is the run-length mode and the length is 4. Accordingly, the decoder **230** outputs the run-length mode as the mode flag to the mode register **232**, the value 4 of length data to the length counter **237**, a four-bit portion 0010 (raw data) succeeding the variable-length code 0110110111 searched out in step S**248** to the data register **233**, and the decoded bit string length or fourteen bits corresponding to the addition of the bit string length (ten bits) of the searched-out variable-length code and the bit string length (four bits fixed) of the raw data to the input buffer **229**. Also, in the case where in the case where data 011011100111100 in the 2nd row of the code string of FIG. **43** from the leading position to the 15th bit is delivered from the input buffer **229** to the decoder **230**, the parameters of the variable-length code 01101110 searched out in step S**248** are such that the decompression mode is the dictionary copy mode, the relative position is 1 and the length is 5. Accordingly, the decoder **230** outputs the dictionary copy mode as the mode flag to the mode register **232**, the value 5 of length data to the length counter **237**, the value 1 of relative position data to the relative position register **234**, and the decoded bit string length or seven bits of the bit string length of the searched-out variable-length code 01101110 to the input buffer **229**. The reason why the decoded bit string length is outputted to the input buffer **229** is that data having the same bit string length as the bit string length decoded by the decoder **230** is added after an unprocessed bit string of data stored in the input buffer **229**.

The flow goes to step S**251** through step S**250** in the case where the mode flag outputted from the decoder **230** is the run-length mode and goes to step S**253** through step S**250** in the case where it is the dictionary copy mode. The mode flag outputted from the decoder **230** is held in the mode register **232** until one decompression operation is completed. When one decompression operation is completed, a new mode flag outputted from the decoder **230** is held in the mode register **232** and the next decompression operation is started.

In step S**251**, a decompression processing in the run-length mode is performed. In the decompression processing in the run-length mode, the relative position register **234** and the dictionary address calculator **235** do not operate, as shown in FIG. **47**. First, the data register **233** holds raw data outputted from the decoder **230** while the length counter **237** loads length data outputted from the decoder **230** as an initial value. Next, the raw data held in the data register **233** is outputted through the selector **236** to the output signal line **244** on the basis of the mode flag of run-length held in the mode register **232** (operation 1). Next, in order to produce a dictionary to which the reference is to be made in performing the decompression processing of the next line data, the same data as the outputted data is registered into the dictionary buffer **239** at an address thereof corresponding to X and Y coordinate values specified by the X/Y counter **238** (operation 2), the length counter **237** is decremented (operation 3), and the X coordinate value of the X/Y counter **238** is updated by one (operation 4). In the case of the present embodiment, the range of possible X coordinate values of the X/Y counter **238** is 0 to 15, as mentioned above. Accordingly, in the case where the X coordinate value of the X/Y counter **238** is 15, the updating of the X coordinate value by one results in that the X coordinate value turns to 0 and the Y coordinate value is updated by one. In step S**252**, the above operations 1 to 4 are repeated until the value of the length counter **237** comes to 0. Thereby, there is generated decompressed data in which the raw data outputted from the decoder **230** continues to the

extent of a length corresponding to the length data outputted from the decoder **230**.

In step S**253**, a decompression processing in the dictionary copy mode is performed. In the decompression processing in the dictionary copy mode, the data register **233** does not operate, as shown in FIG. **48**. First, the relative position register **253** holds relative position data outputted from the decoder **230** while the length counter **237** loads length data outputted from the decoder **230** as an initial value. Next, on the basis of an X coordinate value specified by the X/Y counter **238** and the relative position data held in the relative position register **253**, the dictionary address calculator **235** determines the address of that data, to which the reference is to be made (operation 5), among data stored in the dictionary buffer **239**. That data among data stored in the dictionary buffer **239**, which is at the address specified by the dictionary address calculator **235**, is outputted through the selector **236** to the output signal line **244** on the basis of the mode flag of dictionary copy held in the mode register **232** (operation 6). Next, in order to produce a dictionary to which the reference is to be made in performing the decompression processing of the next line data, the same data as the outputted data is registered into the dictionary buffer **239** at an address thereof corresponding to X and Y coordinate values specified by the X/Y counter **238** (operation 7), the length counter **237** is decremented (operation 8), and the X coordinate value of the X/Y counter **238** is updated by one (operation 9). In step S**254**, the above operations 5 to 9 are repeated until the value of the length counter **237** comes to 0. Thereby, there is generated decompressed data in which the data outputted from the dictionary buffer **239** continues to the extent of a length corresponding to the length data outputted from the decoder **230**.

In step S**255**, there is discarded that bit string inclusive of the lead of the bit string stored in the input buffer **229** which has already been decoded by the decoder **230**. The flow returns to step S**247** in the case where data to be decompressed still exists, and the flow is completed in the case where it does not exist (step S**256**).

In the above-mentioned embodiment of compression, the dictionary is searched in the dictionary reference range for the longest partial string existing on the dictionary within the range of the maximum detection string length N and the searched-out partial string is encoded. However, there may also be considered the case where the longest partial string existing on the dictionary is divided into a plurality of partial strings, the divisional partial string is composed with another partial string to produce a partial string within the range of the maximum detection string length N, and the produced partial string is in turn compressed, and the case where partial strings, which are not the longest, are combined to produce a partial string within the range of the maximum detection string length N and the produced partial string is compressed.

The former case is as follows. For example, the partial string b shown in FIG. **32**B is divided into two parts or a partial string c "5543" and a partial string d "4" shown in FIG. **32**C and the partial string d "4" and "3" at the 2nd row and 5th column are composed into a partial string e "43". A code for the partial string c is {0, 1, 4} and a code for the partial string e "43" is {1, −1, 2} since the partial string e matches "43" continuing from the 1st row and 4th column of the immediately preceding line. Accordingly, a code for the 2nd row results in {0, 1, 4} {1, −1, 2} [1, 5, 1] [1, 4, 1] {1, 0, 3} [4, 5, 2] [6, A, 3]. This code will be referred to as code a'. The latter case is as follows. For example, a partial string "55" for the relative position 0 is selected for the 2nd row and 0th column and a partial string "434" for the relative position +1 is selected for the 2nd row and 2nd column. Thereby, a code for the 2nd row results in {0, 0, 2} {1, 1, 3} {1, −1, 1} [1, 5, 1] [1, 4, 1] {1, 0, 3} [4, 5, 2] [6, A, 3]. This code will be referred to as code b'.

Thus, three patterns including the pattern shown in the above-mentioned example of compression may exist as the code for the 2nd row shown in FIG. **32**A. The code for the 2nd row shown in FIG. **33** will be referred to as code c'. When the actual codes shown in FIGS. **34** to **42** are allotted to the codes a', b' and c', the codes a' spans 49 bits, the code b' spans 50 bits and the code c' spans 48 bits. The code c' are efficient. However, when codes other than those shown in FIGS. **34** to **42** are allotted to the codes a', b' and c', a different result will be obtained and there may be the case where the code a' or the code b' results in the shortest code. Accordingly, it does not necessarily follow that the best way includes searching for the longest partial string within the range of the maximum detection string length N and encoding the longest partial string. It is desirable to produce and select, within the range of the maximum detection string length N, the combination of partial strings on the dictionary which provides the shortest code when the actual codes are allotted.

Even if the combination of partial strings on the dictionary is changed so that the resulting code becomes the shortest, as mentioned above, no influence is given on the data decompression method so long as the encoding rule (using the value of T determined the position x of a pixel of interest on the current line, and the leading position and the length of the same partial length in the immediately preceding line) is not changed.

As explained in detail in the foregoing, according to the third data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial string within the range of the maximum detection string length. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. Further, data compression is performed in such a manner that tables in which a different code is allotted in accordance with the relative position of a leading pixel of a partial string on the immediately preceding line and a pixel of interest and the length of the partial string on the immediately preceding line, are prepared for the respective values of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of two-dimensional image data, N is the maximum detection string length ($1 \leqq N \leqq H$) and x is the position of the pixel of interest on the current line from a leading pixel ($0 \leqq x \leqq H-1$), the value of T is determined on the basis of the position x of the pixel of interest on the current line from the leading pixel, and a code corresponding to the relative position and the length of the partial string is outputted from a table selected in accordance with the determined value of T. Each table is a table of Huffman codes constructed beforehand in compliance with data to be compressed and decompressed or a table optimized so that the redundancy is reduced with the compression/decompression. Thereby, a higher compression ratio is obtained. Furthermore, compression such as run-length compression is applied to the first line of the image data and a partial string for which the reference to the dictionary is impossible. Thereby, a still higher compression

ratio is obtained. In addition, the possible value of T is always $0 \leqq T \leqq$ maximum detection string length N. Therefore, when the number H of pixels in one line of the two-dimensional image data is increased, it is possible to prevent the table capacity from increasing with the lowering of the compression/decompression speed.

(Fourth Data Compression/Decompression Method of the Invention)

In order to facilitate the understanding of a fourth data compression/decompression method of the present invention, the principle of the fourth data compression/decompression method will be explained using the drawings. In the fourth data compression/decompression method of the present invention, data of the immediately preceding in successively scanned two-dimensional image data (shown in FIG. **49**) is held as reference data, using a property that a certain pixel(s) in the image data is similar to a group of pixels in the neighborhood thereof. (A buffer for storing the reference data will hereinafter be referred to as "dictionary" A.) The reference to the dictionary A is made to detect a partial data string B (defined as a partial data string to be compressed) on the current line which matches data on the dictionary A to the longest possible extent. Next, there are outputted a code which differs in accordance with the relative position on a two-dimensional space of a pixel of interest C (as which a leading pixel of the partial data string B to be compressed will be defined) and a leading pixel E of a partial data string D (defined as an immediately preceding partial data string) on the dictionary A which matches the partial data string B to be compressed, and a code which differs in accordance with the length of the immediately preceding partial data string D (five dots in the shown example) for each value of a position x_1 and/or a position x_2 where x_1 is the position of the pixel of interest C from a leading pixel of the current line (x_1=0 in the shown example) and x_2 is the position of the leading pixel E from a leading pixel of the dictionary A (x_2=1 in the shown example). Thereby, the data compression of the partial data string B to be compressed is performed. It is preferable that the code is not a fixed-length code but a variable-length code in order to enhance the compression ratio by allotting a short code to data which has a high probability of occurrence. Regarding the code according to the length of the immediately preceding partial data string, the reason why a different code is allotted in accordance with the length of the immediately preceding partial data string for each value of the position x_1 and/or the position x_2 is as follows. In principle, if a different code is allotted in accordance with the length of the immediately preceding partial data string, it is not necessary to allot the code for each value of the position x_1 and/or the position x_2. However, the maximum value which the length of the immediately preceding partial data string can take never exceeds a dot length from the pixel of interest to a pixel positioned at the last of the current line. Namely, the maximum possible value of the length of the immediately preceding partial data string differs depending on the value of x_1. Also, the maximum value which the length of the immediately preceding partial data string can take never exceeds a dot length from a pixel on the immediately preceding line corresponding to the pixel of interest to a pixel positioned at the last of the immediately preceding line. Namely, the maximum possible value of the length of the immediately preceding partial data string also differs depending on the value of x_2. In the fourth data compression/decompression method of the present invention, therefore, the code representing to the length of the immediately preceding partial data string is prepared for each value of the position x_1 and/or the position x_2, so that the uselessness of the allotment of codes for values outside of the range of values which the length can take is reduced, thereby improving the redundancy of coding to enhance the compression ratio. In particular, a different code is allotted in accordance with the length of the immediately preceding partial data string for each value of T which is a larger one of the position x_1 and the position x_2, so that the uselessness of the allotment of codes for values outside of the range of values which the length can take is completely eliminated, thereby further improving the redundancy of coding to enhance the compression ratio.

It is preferable that the range of reference to the dictionary is limited to fall within a range in which the degree of similarity of a partial data string on the current line to a partial data string on the dictionary is high. Also, in the case where a partial data string to be compressed does not a partial data string on the dictionary, compression such as run-length compression is applied to the partial data string to be compressed.

In the fourth data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line, as mentioned above. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial data string. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. Further, a different code is allotted in accordance with the length of the immediately preceding partial data string for each value of the position x_1 and/or the position x_2. Therefore, it is possible to improve the redundancy of the code representing the length of the immediately preceding partial data string, thereby enhancing the compression ratio. Furthermore, by applying compression such as run-length compression to the first line of the image data and a partial string for which the reference to the dictionary is impossible, a higher compression ratio is obtained.

An embodiment of the fourth data compression/decompression method of the present invention will now be explained. As shown in FIG. **50**, a data compression circuit according to an embodiment of a fourth data compression apparatus for realizing the fourth data compression method of the present invention includes a line buffer **305**, a dictionary buffer **306** for holding data of the immediately preceding line, a comparator **307**, a code generator **308**, an adder **309**, a pointer **310**, a relative position counter **311**, a pointer buffer **312**, a length counter **313**, a relative position and length buffer **314**, a selector **315**, and a partial string buffer **316**. In FIG. **50**, reference numeral **317** denotes a line buffer input signal line, reference numeral **318** a dictionary buffer input signal line, and reference numeral **319** a code output line.

Next, the outline of the operation of the data compression circuit having the above construction will be shown on the basis of a flow shown in FIG. **51**. First or in step S**320**, the pointer **310** and so forth are initialized, and successively inputted image data is stored into the line buffer **305** through the line buffer input signal line **317**. At this time, data pushed out of the line buffer **305** is stored into the dictionary buffer **306** through the dictionary buffer input signal line **318**. Next or in step S**321**, the judgement is made of whether or not line data inputted to the line buffer **305** is data of the first line. In the case where the line data inputted to the line buffer **305** is data of the first line, run-length compression is performed (step S**325**) since data to which the reference is to be made

is not still stored in the dictionary buffer **306**. Namely, a search is made for a partial data string on the current line which continues to the longest possible extent. First, data of the line buffer **305** indicated by the pointer **310** is stored into the partial string buffer **316**. Also, the pointer **310** is advanced by one so that the data of the line buffer **305** is inputted to the comparator **307** through the selector **315** for comparison with data of the partial string buffer **316**. If the result of comparison indicates the matching, the length counter **313** is incremented and the next data indicated by the pointer **310** is inputted to the comparator **307** through the selector **315** for comparison with data of the partial string buffer **316**. The comparison with data of the partial string buffer **316** is repeated with the pointer **310** being advanced one by one until the matching ceases to be obtained. Thereby, the count value of the length counter **313**, at the point of time when the result of comparison indicates no matching, is measured as the length L of a partial data string on the current line which includes the same continuous pixels. Next, data of the length L of the partial data string counted by the length counter **313** and raw data stored in the partial string buffer **316** are inputted to the code generator **308**. The code generator **308** encodes the data of the length L of the partial data string and the raw data and outputs the resulting code through the code output line **319** (step S**326**). Thus, all data of the first line are processed.

If line data inputted to the line buffer **305** is data of the second or subsequent line (step S**321**), a search is made for the longest partial data string on the dictionary which matches a partial data string made the object of search (as which data of continuous pixels selected from data of the current line stored in the line buffer **305** will be defined) to the longest possible extent (step S**322**). The search for the longest partial data string shown as one flow step S**322** in FIG. **51** is made in accordance with the following procedure. The concept of the search for the longest partial data string will be explained using 8×8 image data shown in FIGS. **52**A to **52**C by way of example. In the present embodiment, the judgement of whether or not a line preceding by one line to the partial data string made the object of search includes the same partial data string as the partial data string made the object of search, is made by performing a search as to whether or not the same pixel as a leading pixel of the partial data string made the object of search exists between a position returned by one from the leading pixel position of the partial data string made the object of search (defined as relative position −1) and a position advanced by one therefrom (defined as relative position +1). Namely, the compression in step S**324** is performed in the case where the same pixel string exists in the immediately preceding line within a range shifted by one pixel to the right and left.

Speaking in conjunction with FIG. **52**A, (1) an example of relative position −1 is a partial data string "554" continuing from "5" at the 3rd row and 1st column. Since this partial data string "554" is the same as a partial data string "554" continuing from "5" at the 2nd row and 0th column, it is determined that the same partial data string exists at a position shifted by one pixel to the left. (2) An example of relative position 0 is a partial data string "34" continuing from "3" at the 1st row and 4th column. Since this partial data string "34" is the same as a partial data string "34" continuing from "3" at the 0th row and 4th column, it is determined that the same partial data string exists at a position shifted by zero pixel. (3) An example of relative position +1 is a partial data string "55434" continuing from "5" at the 2nd row and 0th column. Since this partial data string "55434" is the same as a partial data string "55434" continuing from "5" at the 1st row and 1st column, it is determined that the same partial data string exists at a position shifted by one pixel to the right.

In step S**322**, data of the pointer **310** is first stored into the pointer buffer **312** and the relative position counter **311** is initialized. Next, data of one pixel is taken into the partial string buffer **316** from the line buffer **305** indicated by the pointer **310**. Regarding the data of the one pixel in the current line taken in the partial string buffer **316** from the line buffer **305**, a search is made as to whether or not a matching pixel exists for each of a pixel at the relative position −1, a pixel at the relative position 0 and a pixel at the relative position +1 in the immediately preceding line stored in the dictionary buffer **306**. In the case where there is no matching pixel, the length "0" is written into the relative position and length buffer **314** for each relative position and the flow proceeds to step S**323**. In FIG. **52**A, regarding "4" at the 1st row and 3rd column, the pixels at the 0th row and 2nd column and the 0th row and 3rd column are both "2" and the pixel at the 0th row and 4th column is "3". Accordingly, "0" is written as length data for a point (1, 3) into the relative position and length buffer **314** for all the relative positions −1, 0 and +1. In the case where there is a matching pixel, the pointer **310** and the length counter **315** are incremented and data of the next pixel is taken into the partial string buffer **316**. At this time, the leading address of the partial data string made the object of search under searching in the present search is remained in the pointer buffer **312**.

In the case where the matching for the leading pixel of the partial data string made the object of search is found at the relative position −1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position −1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **316**. Also, in the case where the matching is found at the relative position 0, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position 0 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **316**. Further, in the case where the matching is found at the relative position +1, a search regarding the next pixel is made in such a manner that data of a pixel at the relative position +1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **316**. In the case where the result of each comparison indicates the matching, the next pixel pointer **310** is incremented to take data of the next pixel into the partial string buffer **316** and the length counter **315** is incremented. This operation is repeated until the result of each comparison indicates no matching. Thereby, the count value of the length counter **315**, at a point of time when the result of comparison indicates no matching, is measured as the length L of a partial data string which has the same data string as data of the immediately preceding line. This length information L is counted for each of the relative position −1, the relative position 0 and the relative position +1. Namely, after the length L has been counted for the relative position −1 in a manner mentioned above, the length L is stored as length information of the relative position −1 into the relative position and length buffer **314** at the column of the relative position −1. Subsequently, in order to make a search regarding the relative position 0, the leading address of the partial data string made the object of search temporarily stored in the pointer buffer **312** is returned into the pixel pointer **310** and the relative position counter **311** is incremented. With the pixel counter **310** being incremented, the comparison is similarly made for the next

data of on the right side of the leading address of the partial data string made the object of search until the data matching relevant to the relative position 0 ceases to be obtained. Thereby, the length information L is determined. Subsequently, a similar search is made regarding the relative position +1.

Considering a partial data string which has "5" at the 2nd row and 0th column in FIG. **52**A as its leading pixel, this pixel is at the lead of the current line and hence no data exist at the relative position −1 of the preceding line. Therefore, the length L for the relative position −1 is 0. Regarding to the relative position 0, "5" exists at the 1st row and 0th column. Therefore, the length counter **313** is incremented and data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **316** for comparison with "5" of the 1st row and 1st column. Since this comparison too indicates the matching, the length counter **313** is incremented and data "4" of the 2nd row and 2nd column next to "5" of the 2nd row and 1st column is taken into the partial string buffer **316** for comparison with "5" of the 1st row and 2nd column. Since this comparison indicates no matching, the number "2" of matching data until this point of time provides L=2 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position 0.

Regarding the partial data string having "5" at the 2nd row and 0th column as its leading pixel, "5" exists at the 1st row and 1st column and this data matches the leading pixel. Therefore, the comparison for the next pixel is also made for the relative position +1. Namely, data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **316** and is then compared with "5" of the 1st row and 2nd column which is at the relative position +1. Since this comparison indicates the matching, the comparison is repeated while successively taking in the next pixel on the right side. When the comparison of "3" at the 2nd row and 5th column and "1" at the 1st row and 6th column is made, no matching is found. Accordingly, the value "5" of the length counter **313** at this time provides L=5 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position +1.

With the above, three lengths including L (relative position −1)=0, L (relative position 0)=2 and L (relative position +1)=5 are stored in the relative position and length buffer **314** as the length L of the partial data string having "5" at the 2nd row and 0th column as its leading pixel. From thereamong is selected a partial data string which has the greatest length L equal to 5. In the case of FIG. **52**A, a partial data string a (55) corresponds to the same partial data string for the relative position 0 and a partial data string b (55434) corresponds to the same partial data string for the relative position +1, as shown in FIG. **52**B. Since the length of the partial data string a is 2 and the length of the partial data string b is 5, the partial data string b providing a high efficiency of compression is selected.

Namely, the flow goes through step S**323** to step S**324** in which the longest data among data stored in the relative position and length buffer **314** and data of the relative position for the longest data are inputted to the code generator **308**. The code generator **308** encodes the data of the relative position and the data of the length L of the partial data string to output the code through the code output line **319** (step S**326**).

On the other hand, if the lengths stored in the relative position and length buffer **314** are all 0, that is, if no matching partial data string is found in the dictionary, the flow goes through step S**323** to step S**325** in which the above-mentioned run-length compression is performed.

The above operation is repeated through steps S**327** and S**328** up to the last line of the two-dimensional image data to perform the data compression or the encoding.

Next, explanation will be made of the data compression process of the 8×8 image data shown in FIGS. **52**A to **52**C. It is assumed that each data is represented by 4 bits. For convenience' sake, the coordinate of image data will be represented by (column, row) and the encoded code will be represented by {relative position, length} or [kind of data, length]. Namely, a portion enclosed by the brace { } shows a portion subjected to compression based on the fourth data compression method of the present invention and a portion enclosed by the bracket [ ] shows a portion subjected to compression based on the run-length compression method.

For example, a code corresponding to the relative position equal to 1 and the length equal to 3 results in {1, 3} and a code corresponding to the kind of data equal to 5 and the length equal to 2 results in [5, 2]. Provided that the coordinate of data of interest is (x, y), the range of reference to the dictionary is (x−1, y−1) , (x, y−1) and (x+1, y−1) in terms of relative position. In the case of FIG. **52**A, the 0th row is subjected to run-length compression since there is no dictionary to which the reference is to be made. Data at the coordinates (0, 0) to (3, 0) of the image data are all the same and 2, and hence the resulting code is [2, 4]. Data at (4, 0) is 3 and only one of this data exists. Therefore, the resulting code is [3, 1]. Data at (5, 0) to (7, 0) are all the same and 4, and hence the resulting code is [4, 3]. Accordingly, the resulting codes for the 0th row are [2, 4] [3, 1] [4, 3], as shown by the 0th row in FIG. **53**.

A processing for the 1st row shown in FIG. **52**A is performed handling the 0th row as a dictionary. Data at (0, 1) is compared with data at (0, 0) but this comparison indicates no matching. The data at (0, 1) is thereafter compared with data at (1, 0) but this comparison too indicates no matching. Therefore, on the determination that the dictionary includes no matching partial data string, the run-length compression is applied. Data at (0, 1) to (2, 1) are all 5, and hence the resulting code is [5, 3]. Data at (3, 1) is 4 and does not match data at (2, 0), (3, 0) and (4, 0). The run-length compression is applied and the resulting code is [4, 1]. Data at (4, 1) is 3 and matches data at (4, 0) among (3, 0), (4, 0) and (5, 0), and data at (4, 1) to (5, 1) match data of the dictionary at (4, 0) to (5, 0). The resulting code is {0, 2}. Data at (6, 1) and data at (7, 1) do not match data of the dictionary. The resulting codes are [1, 1] and [3, 1], respectively. Accordingly, the resulting codes for the 1st row are [5, 3] [4, 1] {0, 2} [1, 1] [3, 1], as shown by the 1st row in FIG. **53**.

A processing for the 2nd row shown in FIG. **52**A is performed handling the 1st row as a dictionary. Data at (0, 2) matches data of the dictionary at (0, 1) which is the relative position 0 and also matches data of the dictionary at (1, 1) which is the relative position 1. The length of a matching partial data string of the dictionary in the case of the relative position 0 is (0, 1) to (1, 1) or 2 whereas the length of a matching partial data string of the dictionary in the case of the relative position 1 is (1, 1) to (5, 1) or 5. Namely, the length of the partial string of the dictionary for the relative position 1 is greater than that for the relative position 0. The resulting code is {1, 5}. The above processing is repeated up to the last line. As a result, a code string shown in FIG. **53** is obtained for the image data shown in FIGS. **52**A to **52**C.

Next, actual codes are allotted to the code string of FIG. **53** by use of codes shown in FIG. **54** and FIGS. **55**A and

55B. A code **361** in the case of the run-length compression is composed of identifier plus kind of data plus length, as shown in FIG. **55**A. The identifier is represented by one bit fixed and is allotted with 0 in the case of the run-length compression. Regarding the first line, however, only the run-length compression is involved and hence the identifier is omitted. The kind of data means raw data. In the present embodiment, one pixel is represented by four bits fixed. With the length being represented by a variable-length code, a code **361***a* shown in FIG. **55**A is allotted in the accordance with the length. For example, [2, 4] at the 0th row of the code string shown in FIG. **53** results in 000101110.

A code **362** in the case of the dictionary compression is composed of identifier plus relative position plus length, as shown in FIG. **55**B. In the case of the dictionary compression, the identifier is allotted with 1. With the relative position being represented by a variable-length code, a code **362***a* shown in FIG. **55**B is allotted in the accordance with the relative position. With the length too being represented by a variable-length code, a code shown in FIG. **54** is allotted, in the accordance with the length of a partial data string to be compressed (that is, the length of the partial data string on the immediately preceding line), for each value of T which is a larger one of x_1 and x_2 (T=MAX (x_1, x_2)) where x_1 is the position of a pixel of interest from a leading pixel of the current line ($0 \leqq x_1 \leqq 7$ in the present embodiment) and x_2 is the position of a leading pixel of a partial data string on the immediately preceding line from a leading pixel of the immediately preceding line ($0 \leqq x_2 \leqq 7$ in the present embodiment). For example, {0, 2} in the 5th row of the code string shown in FIG. **53** is such that x_1 is 0 and x_2 is 0 since the relative position is 0. Accordingly, $T=x_1=x_2=0$. In the case of T=0, a code corresponding to the length equal to 2 is 10, as shown in FIG. **54**. Therefore, {0, 2} in the 5th row of the code string shown in FIG. **53** results in 1010. Also, {−1, 6} in the 5th row of the code string shown in FIG. **53** is such that x_1 is 2 and x_2 is 1 since the relative position is −1. Accordingly, $T=x_1=2$. In the case of T=2, a code corresponding to the length equal to 6 is 1111, as shown in FIG. **54**. Therefore, {1, 6} in the 5th row of the code string shown in FIG. **53** results in 1111111.

The reason why a code corresponding to the length is prepared for each value of T in the case of the dictionary compression is as follows. In principle, if a different code is allotted in accordance with the length, it is not necessary to allot the code for each value of T. However, the maximum value, which the length of a partial data string to be compressed or the length of a partial data string on the immediately preceding line string can take, never becomes larger than a dot length from a pixel of interest to a pixel positioned at the last of the current line and never becomes larger than a dot length from a pixel on the immediately preceding line corresponding to the pixel of interest to a pixel positioned at the last of the immediately preceding line. Accordingly, the maximum possible value of the length of the partial data string to be compressed or the length of the partial data string on the immediately preceding line string is the value of a smaller one of the dot length from the pixel of interest to the pixel positioned at the last of the current line and the dot length from the pixel on the immediately preceding line corresponding to the pixel of interest to the pixel positioned at the last of the immediately preceding line. In the present embodiment, therefore, a larger one of the position x_1 and the position x_2 is taken as T and and a different code is allotted in accordance with the length of the partial data string for each value of T, so that the uselessness of the allotment of codes for values outside of the range of values which the length can take is completely eliminated, thereby improving the redundancy of coding to enhance the compression ratio. In FIG. **54**, a hyphen "-" shows that no variable-length code is allotted. The reason why no variable-length code is allotted when T=7, is that the length is always 1 in the case of T=7.

The result of transformation of the code string of FIG. **53** into the actual codes is shown in FIG. **56**. The capacity of the image data shown in FIGS. **52**A to **52**C is 256 bits whereas the data capacity of the code string shown in FIG. **56** is 163 bits. The use of the algorithm of the fourth data compression method according to the present invention results in the compression of the original image data to about 64%.

A procedure for decompressing or expanding the code compressed in accordance with the above manner will be shown using FIGS. **57** and **58**. FIG. **57** is a block diagram showing an example of the construction of a decompression circuit. FIG. **58** is a flow chart of a data decompression algorithm. In FIG. **57**, reference numeral **329** denotes an input buffer, numeral **330** an identifier buffer, numeral **331** a run-length decoder, numeral **332** a dictionary decoder, numerals **333** and **334** selectors, numeral **335** a length buffer, numeral **336** a comparator, numeral **337** a length counter, numeral **338** an adder, numeral **339** a decompression buffer, numeral **340** a pointer, numeral **341** a dictionary pointer, numeral **342** a dictionary buffer, numeral **343** an input signal line, and numeral **344** an output signal line.

Next, the outline of the operation of the decompression circuit having the above construction will be shown on the basis of a flow shown in FIG. **58**. First, the compressed data is taken into the input buffer **329** through the input signal line **343**. One bit at the beginning is stored into the identifier buffer. In step S**345**, the pointer **340** and the length counter **337** are initialized to 0. Then, the flow goes to step S**346**. If the content of the identifier buffer **330** is 1, the succeeding data is data subjected to dictionary compression. Therefore, the data is passed through the dictionary decoder **332** to decode relative position information and length information. First, the relative position information is extracted from a bit string length including the 2nd and subsequent bits succeeding the beginning 1st bit. The decoded relative position information (−1, 0 or 1) and the content of the pointer **340** (0 in the instant case) are inputted to the adder **338** to determine the position x_2 of a leading pixel of a partial data string on the dictionary and this position x_2 is stored into the dictionary pointer **341** (step S**347**). Next, the value of T (T=MAX(x_1, x_2)) is determined on the basis of the position x_1 of a pixel of interest on the current line indicated by the pointer **340** and the position x_2 of the leading pixel of the partial data string on the dictionary determined by the adder **338**. The length information is extracted from a bit string length succeeding the bit string length representing the relative position on the basis of the determined value of T and the length buffer (step S**348**).

In step S**349**, data of the dictionary buffer **342** indicated by the dictionary pointer **341** is stored into the decompression buffer **339** indicated by the pointer **340**. Next, each of the dictionary pointer **341** and the pointer **340** is advanced by one (steps S**350** and S**353**). The length counter **337** is incremented and the content of the length counter **337** and the content of the length buffer **335** are compared through the comparator **336** (step S**354**). If the content of the length buffer **335** and the content of the length counter **337** do not match (step S**355**), the flow goes to step S**349** through step S**356** so that steps S**349**, S**350**, S**353** and S**354** are successively repeated until the matching is obtained. In the case where the matching is obtained, the length counter **337** is

initialized to 0 (step S357) and the flow thereafter goes to step S346 for decompression of a new code.

In the case where it is determined in step S346 that the identifier is 0, the succeeding data is data subjected to run-length compression. Therefore, the data is passed through the run-length decoder 331 to decode raw data and length information. First, the raw data is extracted from a bit string length including the 2nd to 5th bits succeeding the beginning 1st bit. Next, the length information is extracted from a bit string length including the 6th and subsequent bits. The decoded length information is stored into the length buffer 335 (step S351) and the raw data is stored into the decompression buffer 339 indicated by the pointer 340 (step S352). Next, the pointer 340 is advanced by one (step S353). The length counter 337 is incremented and the content of the length counter 337 and the content of the length buffer 335 are compared through the comparator 336 (step 354). If the content of the length buffer 335 and the content of the length counter 337 do not match (step S355), the flow goes to step S352 through step S356 so that steps S352, S353 and S354 are successively repeated until the matching is obtained. In the case where the matching is obtained, the length counter 337 is initialized to 0 (step S357) and the flow thereafter goes to step S346 for decompression of a new code. In the case where the inputted data is the compressed data of the first line, the identifier is omitted but the data includes only data subjected to run-length compression. In this case, the flow goes to step S351 without making the judgement of the identifier in step S346.

The above processing is repeated up to the last code. If data stored in the decompression buffer 339 reaches data corresponding to one line of the image data, the contents of the decompression buffer 339 are all copied into the dictionary buffer 342 and the content of the dictionary buffer 342 or the restored data is outputted through the output signal line 344. Thereby, the decompression operation for image data corresponding to one line is completed. When the decompression for the next line is to be made, the flow goes to step S354 again.

In the above-mentioned example of compression, the dictionary is searched in the dictionary reference range for the longest partial data string existing on the dictionary and the searched-out partial data string is encoded. However, there may also be considered the case where the longest partial data string is divided into a plurality of partial data strings and the divisional partial data string is compressed after composition thereof with another partial data string, and the case where partial data strings, which are not the longest, are combined and compressed.

The former case is as follows. For example, the partial data string b shown in FIG. 52B is divided into two parts or a partial data string c "5543" and a partial string data d "4" shown in FIG. 52C and the partial data string d "4" and "3" at the 2nd row and 5th column are composed into a partial data string e "43". A code for the partial data string c is {1, 4} and a code for the partial data string e "43" is {−1, 2} since the partial data string e matches "43" continuing from the 1st row and 4th column of the immediately preceding line. Accordingly, a code for the 2nd row results in {1, 4} {−1, 2} [5, 1] [4, 1]. This code will be referred to as code a'. The latter case is as follows. For example, a partial data string "55" for the relative position 0 is selected for the 2nd row and 0th column and a partial data string "434" for the relative position +1 is selected for the 2nd row and 2nd column. Thereby, a code for the 2nd row results in {0, 2} {1, 3} {−1, 1} [5, 1] [4, 1]. This code will be referred to as code b'.

Thus, three patterns including the pattern shown in the above-mentioned example of compression may exist as the code for the 2nd row shown in FIG. 52A. The code for the 2nd row shown in FIG. 53 will be referred to as code c'. When the actual codes shown in FIG. 54 and FIGS. 55A and 55B are allotted to the codes a', b' and c', the code a' spans 25 bits, the code b' spans 26 bit and the code c' spans 24 bits. The code c' is efficient. However, when codes other than those shown in FIG. 54 and FIGS. 55A and 55B are allotted to the codes a', b' and c', a different result will be obtained and there may be the case where the code a' or b' results in the shortest code. Accordingly, it does not necessarily follow that the best way includes searching for the longest partial data string on the dictionary and encoding the longest partial data string. It is desirable to select the combination of partial data strings on the dictionary which provides the shortest code when the actual codes are allotted.

Even if the combination of partial data strings on the dictionary is changed so that the resulting code becomes the shortest, as mentioned above, no influence is given on the data decompression method so long as the encoding rule (using the leading position and the length of the same partial data length in the immediately preceding line) is not changed.

As explained in detail in the foregoing, according to the fourth data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial data string. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. Further, a different code is allotted in accordance with the length of an immediately preceding partial data string for each value of the position x_1 and/or the position x2. Therefore, the redundancy of the code representing the length of the immediately preceding partial data string can be improved, thereby enhancing the compression ratio. Furthermore, compression such as run-length compression is applied to the first line of the image data and a partial data string for which the reference to the dictionary is impossible. Thereby, a higher compression ratio is obtained.

(Fifth Data Compression/Decompression Method of the Invention)

In order to facilitate the understanding of a fifth data compression/decompression method of the present invention, the principle of the fifth data compression/decompression method will be explained using the drawings. In the fifth data compression/decompression method of the present invention, data of the immediately preceding in successively scanned two-dimensional image data (shown in FIG. 59) is held as reference data, using a property that a certain pixel(s) in the image data is similar to a group of pixels in the neighborhood thereof. (A buffer for storing the reference data will hereinafter be referred to as "dictionary" A'.) The reference to the dictionary A' is made to detect from the current line a partial data string C' to be compressed which is a partial data string having a pixel of interest B' as its leading pixel and a length equal to one or more pixels and matches data of the dictionary A' to the longest extent. Next, there are outputted a code which differs in accordance with the relative position on a two-dimensional space of the pixel of interest B' and a leading pixel E' of an immediately preceding partial data string D' on the dictionary A' corresponding to the partial data string C' to be compressed, and

a code which differs in accordance with the length of the immediately preceding partial data string D' (two dots in the shown example). Thereby, the data compression of the partial data string C' to be compressed is performed. Also, in the case where the above data compression is performed continuously two or more times, that is, in the case where a partial data string G' to be compressed is detected which has, as a pixel of interest, data F' succeeding the the partial data string C' to be compressed, a code corresponding to a relative position to be outputted as the compressed data of the partial data string G' to be compressed is allotted with a code which differs, in accordance with the relative position on the two-dimensional space of the pixel of interest F' and a leading pixel J' of an immediately preceding partial data string H' on the dictionary A' corresponding to the partial data string G' to be compressed, for each value of T' which is the previously outputted relative position of the compressed data of the partial data string C' to be compressed. (In the shown example, T'=0 since the pixel of interest B' and the leading pixel E' of the immediately preceding partial data string D' takes the same pixel position.) It is preferable that the code is not a fixed-length code but a variable-length code in order to enhance the compression ratio by allotting a short code to data which has a high probability of occurrence. In the fifth data compression/decompression method of the present invention, there is detected from the current line a partial data string to be compressed which is a partial data string having a pixel of interest as its leading pixel and a length equal to one or more pixels and matches data of the dictionary to the longest extent. Therefore, in the case where the above-mentioned data compression continues on the same line two or more times, a relative position in the second or subsequent data compression never matches a relative position in the data compression performed immediately before. For example, in the case where the relative position of the immediately preceding partial data string to be compressed takes the same pixel position (T'=0), the relative position of the present partial data string to be compressed never takes the same pixel position. Accordingly, in the case where the above-mentioned data compression continues on the same line two or more times, it is not required that in the second or subsequent data compression, a code should be allotted to the same relative position as a relative position in the data compression performed immediately before. In the fifth data compression/decompression method of the present invention, therefore, in the case where the above-mentioned data compression continues on the same line two or more times, a code representing a relative position in data compression to be presently performed is prepared for each value of T' in the second or subsequent data compression where T' is a relative position in the data compression performed immediately before. Therefore, the uselessness of the allotment of the code to the relative position upon data compression performed immediately before is eliminated, thereby improving the redundancy of coding to enhance the compression ratio.

In the case where a pixel of interest is positioned at the lead of the current line, a leading pixel of an immediately preceding partial data string is never positioned on the left side of the pixel of interest. In the above-mentioned data compression, therefore, in the case where the pixel of interest is positioned at the lead of the current line, it is not necessary to allot a code to a relative position at which the leading pixel of the immediately preceding partial data string is placed on the left side of the pixel of interest. Also, in the case where a pixel of interest is positioned at the last of the current line, a leading pixel of an immediately preceding partial data string is never positioned on the right side of the pixel of interest. In the above-mentioned data compression, therefore, in the case where the pixel of interest is positioned at the last of the current line, it is not necessary to allot a code to a relative position at which the leading pixel of the immediately preceding partial data string is placed on the right side of the pixel of interest. In the fifth data compression/decompression method of the present invention, therefore, it is preferable that a code representing a relative position is prepared for each value of S' which is S'=0 when x'=0, S'=1 when $1 \leqq x' \leqq H'-2$, and S'=2 when x'=H'−1 where H' is the number of pixels in one line of two-dimensional image data and x' is the position of a pixel of interest from a leading pixel of the current line ($0 \leqq x' \leqq H'-1$), and the code is prepared for each value of T' and S' in the case where the above-mentioned data compression continues on the same line two or more times. Thereby, the uselessness of the allotment of a code to an impossible relative position in the case where the pixel of interest is positioned at the lead or the last of the current line, is eliminated so that the redundancy of coding is further improved to enhance the compression ratio.

It is preferable that the range of reference to the dictionary is limited to fall within a range in which the degree of similarity of a partial data string with a pixel of interest as its leading pixel to a partial data string on the dictionary is high. Also, in the case where a partial data string having a pixel of interest as its leading pixel does not match a partial data string on the dictionary, run-length compression or the like is applied.

In the fifth data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line, as mentioned above. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial data string. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. Further, in the case where the detection of a partial data string to be compressed continues on the same line two or more times, a code corresponding to a relative position to be outputted as the compressed data of the partial data string to be compressed which is subjected to the second or subsequent detection is allotted with a code which differs in accordance with a relative position for each value of T'. Therefore, it is possible to improve the redundancy of the code representing the relative position, thereby enhancing the compression ratio. Furthermore, by applying compression such as run-length compression to the first line of the image data and a partial string for which the reference to the dictionary is impossible, a higher compression ratio is obtained.

An embodiment of the fifth data compression/decompression method of the present invention will now be explained. As shown in FIG. **60**, a data compression circuit according to an embodiment of a fifth data compression apparatus for realizing the fifth data compression method of the present invention includes a line buffer **405**, a dictionary buffer **406** for holding data of the immediately preceding line, a comparator **407**, a code generator **408**, an adder **409**, a pointer **410**, a relative position counter **411**, a pointer buffer **412**, a length counter **413**, a relative position and length buffer **414**, a selector **415**, and a partial string buffer **416**. In FIG. **60**, reference numeral **417** denotes a line buffer input signal line, reference numeral **418** a dictionary buffer input signal line, and reference numeral **419** a code output line.

Next, the outline of the operation of the data compression circuit having the above construction will be shown on the basis of a flow shown in FIG. **61**. First or in step **S420**, the pointer **410** and so forth are initialized, and successively inputted image data is stored into the line buffer **405** through the line buffer input signal line **417**. At this time, data pushed out of the line buffer **405** is stored into the dictionary buffer **406** through the dictionary buffer input signal line **418**. Next or in step **S421**, the judgement is made of whether or not line data inputted to the line buffer **405** is data of the first line. In the case where the line data inputted to the line buffer **405** is data of the first line, run-length compression is performed (step **S425**) since data to which the reference is to be made is not still stored in the dictionary buffer **406**. Namely, a search is made for a partial data string on the current line which continues to the longest possible extent. First, data of the line buffer **405** indicated by the pointer **410** is stored into the partial string buffer **416**. Also, the pointer **410** is advanced by one so that the data of the line buffer **405** is inputted to the comparator **407** through the selector **415** for comparison with data of the partial string buffer **416**. If the result of comparison indicates the matching, the length counter **413** is incremented and the next data indicated by the pointer **410** is inputted to the comparator **407** through the selector **415** for comparison with data of the partial string buffer **416**. The comparison with data of the partial string buffer **416** is repeated with the pointer **410** being advanced one by one until the matching ceases to be obtained. Thereby, the count value of the length counter **413**, at the point of time when the result of comparison indicates no matching, is measured as the length L of a partial data string on the current line which includes the same continuous pixels. Next, data of the length L of the partial data string counted by the length counter **413** and raw data stored in the partial string buffer **416** are inputted to the code generator **408**. The code generator **408** encodes the data of the length L of the partial data string and the raw data and outputs the resulting code through the code output line **419** (step **S426**). Thus, all data of the first line are processed.

If line data inputted to the line buffer **405** is data of the second or subsequent line (step **S421**), data on the current line stored in the line buffer **405** is searched for a partial data string to be compressed which has data of the line buffer **405** indicated by the pointer **410** as its leading pixel and a length corresponding to one or more pixels and which matches data on the dictionary to the longest possible extent (step **S422**). (This partial data string will be defined as partial data string made the object of search.) The search for the partial data string to be compressed, as shown as one flow step **S422** in FIG. **61**, is made in accordance with the following procedure. The concept of the search for the partial data string to be compressed will be explained using 8×8 image data shown in FIGS. **62**A and **62**B by way of example. In the present embodiment, the judgement of whether or not a line preceding by one line to the partial data string made the object of search includes the same partial data string as the partial data string made the object of search, is made by performing a search as to whether or not the same pixel as a leading pixel (defined as pixel of interest) of the partial data string made the object of search exists between a position returned by one from the pixel of interest (defined as relative position −1) and a position advanced by one therefrom (defined as relative position +1). Namely, the compression in step **S424** is performed in the case where the same pixel string exists in the immediately preceding line within a range shifted by one pixel to the right and left.

Speaking in conjunction with FIG. **62**A, (1) an example of relative position −1 is a partial data string "554" continuing from "5" at the 3rd row and 1st column. Since this partial data string "554" is the same as a partial data string "554" continuing from "5" at the 2nd row and 0th column, it is determined that the same partial data string exists at a position shifted by one pixel to the left. (2) An example of relative position 0 is a partial data string "34" continuing from "3" at the 1st row and 4th column. Since this partial data string "34" is the same as a partial data string "34" continuing from "3" at the 0th row and 4th column, it is determined that the same partial data string exists at a position shifted by zero pixel. (3) An example of relative position +1 is a partial data string "55434" continuing from "5" at the 2nd row and 0th column. Since this partial data string "55434" is the same as a partial data string "55434" continuing from "5" at the 1st row and 1st column, it is determined that the same partial data string exists at a position shifted by one pixel to the right.

In step **S422**, data of the pointer **410** is first stored into the pointer buffer **412** and the relative position counter **411** is initialized. Next, data of the line buffer **405** indicated by the pointer **410**, that is, a pixel of interest is taken into the partial string buffer **416**. A search is made as to whether or not a pixel matching the pixel of interest taken in the partial string buffer **416** exists for each of a pixel at the relative position −1, a pixel at the relative position 0 and a pixel at the relative position +1 in the immediately preceding line stored in the dictionary buffer **406**. In the case where there is no matching pixel, the length "0" is written into the relative position and length buffer **414** for each relative position and the flow proceeds to step **S423**. In FIG. **62**A, regarding "4" at the 1st row and 3rd column, the pixels at the 0th row and 2nd column and the 0th row and 3rd column are both "2" and the pixel at the 0th row and 4th column is "3". Accordingly, "0" is written as length data for a point (1, 3) into the relative position and length buffer **414** for all the relative positions −1, 0 and +1. In the case where there is a matching pixel, the pointer **410** and the length counter **415** are incremented and data of a pixel next to the pixel of interest is taken into the partial string buffer **416**. At this time, the position of a leading pixel of the partial data string made the object of search under searching in the present search or the pixel of interest from a leading pixel of the current line is remained in the pointer buffer **412**.

In the case where the matching for the pixel of interest is found at the relative position −1, a search regarding the pixel next to the pixel of interest is made in such a manner that data of a pixel at the relative position −1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **416**. Also, in the case where the matching is found at the relative position 0, a search regarding the pixel next to the pixel of interest is made in such a manner that data of a pixel at the relative position 0 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **416**. Further, in the case where the matching is found at the relative position +1, a search regarding the pixel next to the pixel of interest is made in such a manner that data of a pixel at the relative position +1 in the data of the immediately preceding line is compared with the pixel taken in the partial string buffer **416**. In the case where the result of each comparison indicates the matching, the next pixel pointer **410** is incremented to take data of the next pixel into the partial string buffer **416** and the length counter **415** is incremented. This operation is repeated until the result of each comparison indicates no matching. Thereby, the count value of the length counter **415**, at a point of time when the result of comparison indicates no matching, is measured as the length L of a

partial data string which has the same data string as data of the immediately preceding line. This length information L is counted for each of the relative position −1, the relative position 0 and the relative position +1. Namely, after the length L has been counted for the relative position −1 in a manner mentioned above, the length L is stored as length information of the relative position −1 into the relative position and length buffer **414** at the column of the relative position −1. Subsequently, in order to make a search regarding the relative position 0, the position of the pixel of interest from the leading pixel of the current line temporarily stored in the pointer buffer **412** is returned into the pixel pointer **410** and the relative position counter **411** is incremented. With the pixel counter **410** being incremented, the comparison is similarly made for the next data of on the right side of the pixel of interest until the data matching relevant to the relative position 0 ceases to be obtained. Thereby, the length information L is determined. Subsequently, a similar search is made regarding the relative position +1.

Considering a partial data string which has "5" at the 2nd row and 0th column in FIG. **62**A as its leading pixel, this pixel is at the lead of the current line and hence no data exist at the relative position −1 of the preceding line. Therefore, the length L for the relative position −1 is 0. Regarding to the relative position 0, "5" exists at the 1st row and 0th column. Therefore, the length counter **413** is incremented and data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **416** for comparison with "5" of the 1st row and 1st column. Since this comparison too indicates the matching, the length counter **413** is incremented and data "4" of the 2nd row and 2nd column next to "5" of the 2nd row and 1st column is taken into the partial string buffer **416** for comparison with "5" of the 1st row and 2nd column. Since this comparison indicates no matching, the number "2" of matching data until this point of time provides L=2 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position 0.

Regarding the partial data string having "5" at the 2nd row and 0th column as its leading pixel, "5" exists at the 1st row and 1st column and this data matches the leading pixel. Therefore, the comparison for the next pixel is also made for the relative position +1. Namely, data "5" of the 2nd row and 1st column next to "5" of the 2nd row and 0th column is taken into the partial string buffer **416** and is then compared with "5" of the 1st row and 2nd column which is at the relative position +1. Since this comparison indicates the matching, the comparison is repeated while successively taking in the next pixel on the right side. When the comparison of "3" at the 2nd row and 5th column and "1" at the 1st row and 6th column is made, no matching is found. Accordingly, the value "5" of the length counter **413** at this time provides L=5 as the length L of the partial string with "5" at the 2nd row and 0th column as its leading pixel for the relative position +1.

With the above, three lengths including L (relative position −1)=0, L (relative position 0)=2 and L (relative position +1)=5 are stored in the relative position and length buffer **414** as the length L of the partial data string having "5" at the 2nd row and 0th column as its leading pixel. From thereamong, a partial data string having the greatest length L equal to 5 is selected as the partial data string to be compressed. In the case of FIG. **62**A, a partial data string a (55) corresponds to the same partial data string for the relative position 0 and a partial data string b (55434) corresponds to the same partial data string for the relative position +1, as shown in FIG. **62**B. Since the length of the partial data string a is 2 and the length of the partial data string b is 5, the partial data string b providing a high efficiency of compression is selected as the partial data string to be compressed.

In the case where the partial string data to be compressed is found (step **S422**), the flow goes through step **S423** to step **S424** in which the longest data among data stored in the relative position and length buffer **414** and data of the relative position for the longest data are inputted to the code generator **408**. The code generator **408** encodes the data of the relative position and the data of the length L of the partial data string to output the code through the code output line **419** (step **S426**).

On the other hand, if the lengths stored in the relative position and length buffer **414** are all 0, that is, if the partial data string to be compressed is not found, the flow goes through step **S423** to step **S425** in which the above-mentioned run-length compression is performed.

The above operation is repeated through steps **S427** and **428** up to the last line of the two-dimensional image data to perform the data compression or the encoding.

Next, explanation will be made of the data compression process of the 8×8 image data shown in FIGS. **62**A and **62**B. It is assumed that each data is represented by 4 bits. For convenience' sake, the coordinate of image data will be represented by (column, row) and the encoded code will be represented by {relative position, length} or [kind of data, length]. Namely, a portion enclosed by the brace { } shows a portion subjected to compression based on the fifth data compression method of the present invention and a portion enclosed by the bracket [ ] shows a portion subjected to compression based on the run-length compression method.

For example, a code corresponding to the relative position equal to 1 and the length equal to 3 results in {1, 3} and a code corresponding to the kind of data equal to 5 and the length equal to 2 results in [5, 2]. Provided that the coordinate of data of interest is (x, y), the range of reference to the dictionary is (x−1, y−1), (x, y−1) and (x+1, y−1) in terms of relative position. In the case of FIG. **62**A, the 0th row is subjected to run-length compression since there is no dictionary to which the reference is to be made. Data at the coordinates (0, 0) to (3, 0) of the image data are all the same and 2, and hence the resulting code is [2, 4]. Data at (4, 0) is 3 and only one of this data exists. Therefore, the resulting code is [3, 1]. Data at (5, 0) to (7, 0) are all the same and 4, and hence the resulting code is [4, 3]. Accordingly, the resulting codes for the first line are [2, 4] [3, 1] [4, 3], as shown by the 0th row in FIG. **63**.

A processing for the 1st row shown in FIG. **62**A is performed handling the 0th row as a dictionary. Data at (0, 1) is compared with data at (0, 0) but this comparison indicates no matching. The data at (0, 1) is thereafter compared with data at (1, 0) but the data at (0, 1) and the data (1, 0) do not match. Therefore, on the determination that there is no partial data string to be compressed which has a pixel of interest at the coordinate (0, 1) of the image data, the run-length compression is applied. Data at (0, 1) to (2, 1) are all 5, and hence the resulting code is [5, 3]. Data at (3, 1) is 4 and does not match data at (2, 0), (3, 0) and (4, 0). The run-length compression is applied and the resulting code is [4, 1]. Data at (4, 1) is 3 and matches data at (4, 0) among (3, 0), (4, 0) and (5, 0), and data at (4, 1) to (5, 1) match data of the dictionary at (4, 0) to (5, 0). The resulting code is {0, 2}. Data at (6, 1) and data at (7, 1) do not match data of the dictionary. The resulting codes are [1, 1] and [3, 1], respectively. Accordingly, the resulting codes for the 1st row are [5, 3] [4, 1] {0, 2} [1, 1] [3, 1], as shown by the 1st row in FIG. **63**.

A processing for the 2nd row shown in FIG. **62**A is performed handling the 1st row as a dictionary. Data at (0, 2) matches data of the dictionary at (0, 1) which is the relative position 0 and also matches data of the dictionary at (1, 1) which is the relative position 1. The length of a matching partial data string of the dictionary in the case of the relative position 0 is (0, 1) to (1, 1) or 2 whereas the length of a matching partial data string of the dictionary in the case of the relative position 1 is (1, 1) to (5, 1) or 5. Namely, the length of the partial string of the dictionary for the relative position 1 is greater than that for the relative position 0. A partial data string to be compressed which includes the image data (0, 2) as a pixel of interest, has the relative position equal to 1 and the length equal to 5. Accordingly, the resulting code is {1, 5}. The above processing is repeated up to the last line. As a result, a code string shown in FIG. **63** is obtained for the image data shown in FIGS. **62**A and **62**B.

Next, actual codes are allotted to the code string of FIG. **63** by use of codes shown in FIGS. **64**A and **64**B and FIGS. **65**A and **65**B. A code **461** in the case of the run-length compression is composed of identifier plus kind of data plus length, as shown in FIG. **64**A. The identifier is represented by one bit fixed and is allotted with 0 in the case of the run-length compression. Regarding the first line, however, only the run-length compression is involved and hence the identifier is omitted. The kind of data means raw data. In the present embodiment, one pixel is represented by four bits fixed. With the length being represented by a variable-length code, a code shown in FIG. **66**A is allotted in the accordance with the length. For example, [2, 4] at the 0th row of the code string shown in FIG. **63** results in 000101110.

A code **462** in the case of the dictionary compression is composed of identifier plus relative position plus length, as shown in FIG. **64**B. In the case of the dictionary compression, the identifier is allotted with 1. The relative position is represented by a variable-length code. In the case where the compression previously performed on the same line is the run-length compression in step **S425**, a code shown in FIG. **65**A is allotted in accordance with the relative position of a pixel of interest for each value of S' which is S'=0 when $x_1'=0$, S'=1 when $1 \leqq x_1' \leqq 6$, and S'=2 when $x_1'=7$ where H' is the number of pixels in one line of two-dimensional image data (H'=8 in the present embodiment) and x_1' is the position of the pixel of interest from a leading pixel of the current line ($0 \leqq x_1' \leqq 7$ in the present embodiment). For example, {−1, 2} in the 4th row of the code string shown in FIG. **63** is allotted with the code shown in FIG. **65**A since the compression performed immediately before is the run-length compression in step **S425**. The value of S' of {−1, 2} in the 4th row of the code string shown in FIG. **63** is 1 since $x_1'=2$, and hence the code thereof corresponding to the relative position −1 is 11. The reason why a different code is allotted in accordance with the relative position for each value of S' is as follows. In principle, if a different code is allotted in accordance with the relative position, it is not necessary to allot the code for each value of S'. However, in the case where S'=0, that is, in the case where a pixel of interest is positioned at the lead of the current line, a leading pixel of a partial data string (defined as immediately preceding partial data string) on the dictionary matching a partial data string to be compressed is never positioned on the left side of the pixel of interest. Accordingly, in the present embodiment, when S'=0, it is not necessary to allot a code to relative position −1 since the relative position never takes −1. Also, in the case where S'=2, that is, in the case where a pixel of interest is positioned at the last of the current line, a leading pixel of an immediately preceding partial data string is never positioned on the right side of the pixel of interest. Accordingly, in the present embodiment, when S'=2, it is not necessary to allot a code to relative position 1 since the relative position never takes 1. In the fifth data compression method of the present invention, therefore, a different code is allotted in accordance with a relative position for each value of S'. Thereby, the uselessness of the allotment of a code to an impossible relative position in the case where the pixel of interest is positioned at the lead or the last of the current line, is eliminated so that the redundancy of coding is improved to enhance the compression ratio. Thereby, in the present embodiment, the relative position when S'=0 and S'=2 can be represented by one bit, as shown in FIG. **65**A.

On the other hand, in the case where the compression previously performed on the same line is the compression in step **S424**, that is, in the case where the dictionary compression in step **S424** continues two or more time, a code shown in FIG. **65**B is allotted in accordance with the relative position of a pixel of interest for each value of S' mentioned above and T' which is the relative position of the compressed data previously outputted. For example, {0, 4} in the 4th row of the code string shown in FIG. **63** is allotted with the code shown in FIG. **65**B since the compression performed immediately before is the dictionary compression in step **S424**. For {0, 4} in the 4th row of the code string shown in FIG. **63**, S' is 1 since $x_1'=4$ and T' is −1 since the relative position of data by the compression in step **S424** performed immediately before is −1. Accordingly, a code for the relative position 0 results in 0. In the fifth data compression/decompression method of the present invention, there is detected from the current line a partial data string to be compressed which is a partial data string having a pixel of interest as its leading pixel and a length equal to one or more pixels and matches data of the immediately preceding line to the longest extent. Therefore, in the case where the dictionary compression in step **S424** continues on the same line two or more times, a relative position in the second or subsequent compression never matches a relative position in the compression performed immediately before. For example, in the case where the relative position in the compression performed immediately before is 0, a relative position in compression to be presently performed never takes 0. Accordingly, in the case where the dictionary compression in step **S424** continues on the same line two or more times, it is not required that in the second or subsequent compression, a code should be allotted to the same relative position as a relative position in the compression performed immediately before. In the fifth data compression/decompression method of the present invention, therefore, in the case where the dictionary compression in step **S424** continues on the same line two or more times, a code representing a relative position in compression to be presently performed is prepared for each value of T' in the second or subsequent compression where T' is a relative position in the compression performed immediately before. Therefore, the uselessness of the allotment of codes to values other than possible values of the relative position is eliminated, thereby improving the redundancy of coding to enhance the compression ratio. Thereby, in the present embodiment, the relative position can be represented by one bit, as shown in FIG. **65**B. Further, since the relative position when S'=2 and T'=−1 is always 0 and the relative position when S'=2 and T'=0 is always −1, it is not necessary to a code to such relative position. In FIGS. **65**A and **65**B, a hyphen "-" shows that no variable-length code is allotted.

The reason why no code is allotted in FIG. **65**B when S'=0, is that in the case where a pixel of interest is positioned at the lead of the current line, a partial data string to be compressed having this pixel of interest as its leading pixel is subjected to the first data compression performed on the same line.

The length too is represented by a variable-length code. A code shown in FIG. **66**B is allotted in the accordance with the length for each value of U which is a larger one of the position x_1' and a position x_2' (U=MAX (x_1', x_2')) where x_2' is the position of a leading pixel of an immediately preceding partial data string from a leading pixel of the immediately preceding line ($0 \leqq x_2' \leqq 7$ in the present embodiment). For example, {−1, 2} in the 4th row of the code string shown in FIG. **63** is such that x_2' is 1 since x_1' is 2 and the relative position is −1. Accordingly, $U=x_1'=2$. Therefore, a code for the length equal to 2 results in 10 from FIG. **66**B. Also, {0, 4} in the 4th row of the code string shown in FIG. **63** is such that x_2' is 4 since x_1' is 4 and the relative position is 0. Accordingly, $U=x_1'=x_2'=4$. Therefore, a code for the length equal to 4 results in 111 from FIG. **66**B.

The reason why a code corresponding to the length is prepared for each value of U in the case of the dictionary compression is as follows. In principle, if a different code is allotted in accordance with the length, it is not necessary to allot the code for each value of U. However, the maximum value, which the length of a partial data string to be compressed or the length of an immediately preceding partial data string can take, never becomes larger than a dot length from a pixel of interest to a pixel positioned at the last of the current line and never becomes larger than a dot length from a leading pixel of the immediately preceding partial data string to a pixel positioned at the last of the immediately preceding line. Accordingly, the maximum possible value of the length is the value of a smaller one of the dot length from the pixel of interest to the pixel positioned at the last of the current line and the dot length from the leading pixel of the immediately preceding partial data string to the pixel positioned at the last of the immediately preceding line. In the present embodiment, therefore, a larger one of the position x_1' and the position x_2' is taken as U and a different code is allotted in accordance with the length for each value of U, so that the uselessness of the allotment of codes for values outside of the range of values which the length can take is eliminated, thereby improving the redundancy of coding to enhance the compression ratio. In FIG. **66**B, a hyphen "-" shows that no variable-length code is allotted. The reason why no variable-length code is allotted when U=7, is that the length is always 1 in the case of T=U.

Thereby, for example, {−1, 2} in the 4th row of the code string shown in FIG. **63** results in 11110. Also, {0, 4} in the 4th row of the code string shown in FIG. **63** results in 10111.

The result of transformation of the code string of FIG. **63** into the actual codes is shown in FIG. **67**. The capacity of the image data shown in FIGS. **62**A and **62**B is 256 bits whereas the data capacity of the code string shown in FIG. **67** is 160 bits. The use of the algorithm of the fifth data compression method according to the present invention results in the compression of the original image data to about 62.5%.

A procedure for decompressing or expanding the code compressed in accordance with the above manner will be shown using FIGS. **68** and **69**. FIG. **68** is a block diagram showing an example of the construction of a decompression circuit. FIG. **69** is a flow chart of a data decompression algorithm. In FIG. **68**, reference numeral **429** denotes an input buffer, numeral **430** an identifier buffer, numeral **431** a run-length decoder, numeral **432** a dictionary decoder, numerals **433** and **434** selectors, numeral **435** a length buffer, numeral **436** a comparator, numeral **437** a length counter, numeral **438** an adder, numeral **439** a decompression buffer, numeral **440** a pointer, numeral **441** a dictionary pointer, numeral **442** a dictionary buffer, numeral **443** an input signal line, and numeral **444** an output signal line.

Next, the outline of the operation of the decompression circuit having the above construction will be shown on the basis of a flow shown in FIG. **69**.

First, the compressed data is taken into the input buffer **429** through the input signal line **443**. One bit at the beginning is stored into the identifier buffer **430**. In step S**445**, the pointer **440** and the length counter **437** are initialized to 0. Then, the flow goes to step S**446**. If the content of the identifier buffer **430** is 1, the succeeding data is data subjected to dictionary compression. Therefore, the data is passed through the dictionary decoder **432** to decode relative position information and length information. First, the relative position information (−1, 0 or 1) is extracted from a bit string length including the 2nd and subsequent bits succeeding the beginning 1st bit. Namely, in the case where data previously decompressed on the same line is data subjected to the dictionary compression, that is, in the case where the beginning 1st bit of the data previously decompressed is 1, it means that the input of data subjected to the dictionary compression on the same line continues two or more times. Therefore, the value of S' is determined on the basis of the position x_1' of a pixel of interest on the current line indicated by the pointer **440**. And, information of a relative position corresponding to a bit string length including the 2nd and subsequent bits succeeding the beginning 1st bit is extracted from the table shown in FIG. **65**B on the basis of the determined value of S' and the value relative position information T' previously decoded by the dictionary decoder **432**. On the other hand, in the case where data previously decompressed on the same line is data subjected to the run-length compression, that is, in the case where the beginning 1st bit of the data previously decompressed is 0, or in the case where data to be presently decompressed is the first data on the same line, the value of S' is determined on the basis of the position x_1' of a pixel of interest on the current line indicated by the pointer **440**. And, information of a relative position corresponding to a bit string length including the 2nd and subsequent bits succeeding the beginning 1st bit is extracted from the table shown in FIG. **65**B on the basis of the determined value of S'. Next, the decoded relative position information (−1, 0 or 1) and the content of the pointer **440** (or the position x_1' of the pixel of interest from a leading pixel of the current line) are inputted to the adder **438** to determine the position x_2' of a leading pixel of an immediately preceding partial data string on the immediately preceding line and this position x_2' is stored into the dictionary pointer **441** (step S**447**). Thereafter, the value of U (U=MAX(x_1', x_2')) is determined on the basis of the position x_1' of the pixel of interest on the current line indicated by the pointer **440** and the position x_2' of the leading pixel of the immediately preceding partial data string on the immediately preceding determined by the adder **438**. The length information is extracted from a bit string length succeeding the bit string length representing the relative position on the basis of the determined value of U and the length buffer (step S**448**).

In step S**449**, data of the dictionary buffer **442** indicated by the dictionary pointer **441** is stored into the decompression buffer **439** indicated by the pointer **440**. Next, each of the dictionary pointer **441** and the pointer **440** is advanced by one (steps S**450** and S**453**). The length counter **437** is

incremented and the content of the length counter **437** and the content of the length buffer **435** are compared through the comparator **436** (step S**454**). If the content of the length buffer **435** and the content of the length counter **437** do not match (step S**455**), the flow goes to step S**449** through step S**456** so that steps S**449**, S**450**, S**453** and S**454** are successively repeated until the matching is obtained. In the case where the matching is obtained, the length counter **437** is initialized to 0 (step S**457**) and the flow thereafter goes to step S**446** for decompression of a new code.

In the case where it is determined in step S**446** that the identifier is 0, the succeeding data is data subjected to run-length compression. Therefore, the data is passed through the run-length decoder **431** to decode raw data and length information. First, the raw data is extracted from a bit string length including the 2nd to 5th bits succeeding the beginning 1st bit. Next, the length information is extracted from a bit string length including the 6th and subsequent bits. The decoded length information is stored into the length buffer **435** (step S**451**) and the raw data is stored into the decompression buffer **439** indicated by the pointer **440** (step S**452**). Next, the pointer **440** is advanced by one (step S**453**). The length counter **437** is incremented and the content of the length counter **437** and the content of the length buffer **435** are compared through the comparator **436** (step **454**). If the content of the length buffer **435** and the content of the length counter **437** do not match (step S**455**), the flow goes to step S**452** through step S**456** so that steps S**452**, S**453** and S**454** are successively repeated until the matching is obtained. In the case where the matching is obtained, the length counter **437** is initialized to 0 (step S**457**) and the flow thereafter goes to step S**446** for decompression of a new code. In the case where the inputted data is the compressed data of the first line, the identifier is omitted but the data includes only data subjected to run-length compression. In this case, the flow goes to step S**451** without making the judgement of the identifier in step S**446**.

The above processing is repeated up to the last code. If data stored in the decompression buffer **439** reaches data corresponding to for one line of the image data, the contents of the decompression buffer **439** are all copied into the dictionary buffer **442** and the content of the dictionary buffer **442** or the restored data is outputted through the output signal line **444**. Then, the flow returns to step S**446** in which the decompression for the next line is made.

As explained in detail in the foregoing, according to the fifth data compression/decompression method of the present invention, a dictionary is required to store only the immediately preceding line, as mentioned above. Therefore, the capacity of the dictionary is very small. Also, the reference to the dictionary is made within a range in which the degree of similarity is high, and the reference is made to a longest possible partial data string. Therefore, a high compression ratio can be attained and a processing for compression/decompression can be performed at a high speed. Further, in the case where the detection of a partial data string to be compressed continues on the same line two or more times, a code corresponding to a relative position to be outputted as the compressed data of the partial data string to be compressed which is subjected to the second or subsequent detection is allotted with a code which differs in accordance with a relative position for each value of T'. Therefore, it is possible to improve the redundancy of the code representing the relative position, thereby enhancing the compression ratio. Furthermore, by applying compression such as run-length compression to the first line of the image data and a partial string for which the reference to the dictionary is impossible, a higher compression ratio is obtained.

What is claimed is:

1. A data compression apparatus comprising:

reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data;

buffer means for extracting a plurality of continuous data strings from an inputted signal of the current line to store them as a partial data string to be compressed;

scanning comparison means for detecting whether or not the same data string as a data string continuing from a pixel of interest of said partial data string to be compressed exists in the data stored in said reference memory means; and

code generating means by which in the case where the presence of the same data string is detected by said scanning comparison means, data of the position of a leading pixel of said partial data string relative to said pixel of interest and the length of said partial data string on the data of the immediately line stored in said reference memory means is determined and a corresponding code is outputted as data of that partial data string of the current line by referring to a table in which a different code is allotted in accordance with said relative position and the length of said partial data string for each position of the pixel of interest on the current line.

2. A data compression apparatus according to claim **1**, wherein variable-length codes in at least three different cases including the case where the relative position of a pixel of interest of input data of the current line and a leading pixel of the same partial data string of the immediately preceding line is the same pixel position, the case where the relative position is shifted to the left by one pixel and the case where the relative position is shifted to the right by one pixel are stored in said table.

3. A data compression apparatus according to claim **1**, wherein in the case where there is inputted data for which the same partial data string does not exist in the immediately preceding line, a corresponding code is outputted by referring to a run-length table in which a different variable-length code is allotted in accordance with the position of that data on the current line and the length of the same continuous data.

4. A data compression apparatus according to claim **2**, wherein in the case where there is inputted data for which the same partial data string does not exist in the immediately preceding line, a corresponding code is outputted by referring to a run-length table in which a different variable-length code is allotted in accordance with the position of that data on the current line and the length of the same continuous data.

5. A data compression apparatus according to claim **3**, wherein the variable-length codes stored in said run-length table are allotted with variable-length codes which are different from the variable-length codes stored in said table.

6. A data compression apparatus according to claim **4**, wherein the variable-length codes stored in said run-length table are allotted with variable-length codes which are different from the variable-length codes stored in said table.

7. A data decompression apparatus for compressed two-dimensional image data in which in the case where there exists in two-dimensional image data a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there is successively inputted, as data of the overlapping portion, data encoded by referring to a table in which a different code is allotted in accordance with the relative position and the length of a

partial data string on the immediately preceding line for each leading position of the compressed data on the current line, the apparatus comprising:

buffer memory means for holding data of the immediately preceding line;

inverse transformation tables provided for the respective positions of a pixel of interest on the current line for outputting data of the relative position and the length of a partial data string on the immediately preceding line in accordance with an inputted code; and

decoding means for selecting an inverse transformation table corresponding to the position on the current line of a pixel of interest to be subjected to the decoding of the inputted data, extracting said code from the inputted data to refer to the selected table on the basis of said code so that data of the relative position and the length of a partial data string on the immediately preceding line is derived from said inverse transformation table, and extracting, from said buffer memory means, data which continues from a bit corresponding to the relative position of said partial data string to the extent of the length of said partial data string, the extracted data being outputted as decompressed data.

8. A data decompression apparatus for compressed two-dimensional image data in which in the case where there exists in two-dimensional image data a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, data allotted with a code differing in accordance with the relative position and the length of a partial data string on the immediately preceding line for each leading position of the compressed data on the current line is successively inputted as data of the overlapping portion, and in which in the case where the same partial data string does not exist, that data is successively inputted together with data allotted with a code which differs in accordance with the position of that data on the current line and the length of the same continuous data, the apparatus comprising:

a counter for counting the position on the current line of a pixel of interest to be subjected to the decoding of the inputted data;

buffer memory means for holding data of the immediately preceding line;

inverse transformation tables provided for the respective positions of a pixel of interest on the current line for outputting data of the relative position and the length of a partial data string on the immediately preceding line or a run length in accordance with an inputted code;

a decoder for selecting an inverse transformation table corresponding to the count value of said counter, and extracting said code from the inputted data to refer to the selected table on the basis of said code so that a mode in which the partial data string exists or a mode in which the partial data string does not exist is outputted while data of the relative position and the length of a partial data string on the immediately preceding line or data of the length of the same continuous data is derived from said inverse transformation table;

first decoding means by which in the case of the mode in which the partial data string exists, data continuing from a bit corresponding to the relative position of said partial data string to the extent of the length of said partial data string is extracted from said buffer memory means and the extracted data is outputted as decompressed data; and

second decoding means by which in the case of the mode in which the partial data string does not exist, data succeeding said code is continuously outputted to the extent of the length of the same continuous data.

9. A data compression method for two-dimensional image data in which a compression processing is performed in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, the method comprising:

preparing tables which are provided for the respective values of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of a pixel of interest on the current line from a leading pixel thereof ($0 \leqq x \leqq H-1$) and in which a different code is allotted in accordance with the relative position of a leading pixel of said partial data string and said pixel of interest and the length of said partial data string on the immediately preceding line; and

determining, in the case where there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, the value of T on the basis of the position x of said pixel of interest on the current line and selecting the corresponding table on the basis of the determined value of T to output a code corresponding to the leading position and the length of the partial data string on the current line.

10. A data compression method according to claim **9**, wherein codes in at least three different cases including the case where the relative position of a pixel of interest of input data of the current line and a leading pixel of the same partial data string of the immediately preceding line is the same pixel position, the case where the relative position is shifted to the left by one pixel and the case where the relative position is shifted to the right by one pixel are stored in said table in the form of variable-length codes.

11. A data compression method according to claim **9**, wherein in the case where there is not detected in the current line a partial data string which is the same as the immediately preceding line, a corresponding code is outputted by referring to a run-length tables which are prepared for the respective values of T and in which a different code is allotted in accordance with the length of the same continuous data.

12. A data compression method according to claim **10**, wherein in the case where there is not detected in the current line a partial data string which is the same as the immediately preceding line, a corresponding code is outputted by referring to a run-length tables which are prepared for the respective values of T and in which a different code is allotted in accordance with the length of the same continuous data.

13. A data compression method according to claim **11**, wherein the codes stored in said run-length table are allotted with codes which are different from the codes stored in said table.

14. A data compression method according to claim **12**, wherein the codes stored in said run-length table are allotted with codes which are different from the codes stored in said table.

15. A data compression method according to claim **13**, wherein said table and said run-length table are united into

one so that codes for the length of the same partial data string in three different cases including the case where the relative position is the same pixel position, the case where the relative position is shifted to the left by one pixel and the case where the relative position is shifted to the right by one pixel and codes for the length of the same continuous data in the case of run length are stored in the form of different variable-length codes.

16. A data compression method according to claim **14**, wherein said table and said run-length table are united into one so that codes for the length of the same partial data string in three different cases including the case where the relative position is the same pixel position, the case where the relative position is shifted to the left by one pixel and the case where the relative position is shifted to the right by one pixel and codes for the length of the same continuous data in the case of run length are stored in the form of different variable-length codes.

17. A data decompression method for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there is successively inputted as data of the overlapping portion a code which differs in accordance with the relative position of a leading pixel of said partial data string and a pixel of interest and the length of said partial data string on the immediately preceding line for each value of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of said pixel of interest on the current from a leading pixel thereof ($0 \leqq x \leqq H-1$), the method comprising:

holding at least decompressed data of the immediately preceding line in a buffer;

determining the value of T on the basis of the position x of said pixel of interest to be decompressed on the current line to select a corresponding table on the basis of the determined value of T from tables which are prepared for the respective values of T and in which a different code is allotted in accordance with said relative position and said length; and

extracting said code from the inputted compressed data to refer to the selected table on the basis of the extracted code so that data continuing from a bit corresponding to the leading position of said partial data string to the extent of the length of said partial data string is extracted from said buffer for the inputted data of the current line and the extracted data is outputted as decompressed data.

18. A data compression/decompression method in which on a transmitting side, in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, the relative position of a leading pixel of said partial data string on the immediately preceding line and a pixel of interest on the current and the length of said partial data string are determined, and a corresponding code is outputted as compressed data by referring to tables which are prepared for the respective values of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of a pixel of interest on the current line ($0 \leqq x \leqq H-1$) and in which a different code is allotted in accordance with said relative position and said length, and in which on a receiving side, the method comprises:

holding at least decompressed data of the immediately preceding line in a buffer;

determining the value of T on the basis of the position x of a pixel of interest to be decompressed on the current line from a leading pixel thereof to select the table corresponding to the determined value of T; and

extracting said code from the inputted compressed data to refer to the selected table on the basis of the extracted code so that data continuing from a bit corresponding to the leading position of said partial data string to the extent of the length of said partial data string is extracted from said buffer for the inputted data of the current line and the extracted data is outputted as decompressed data.

19. A data compression/decompression method according to claim **18**, wherein codes in at least three different cases including the case where the relative position of a pixel of interest of input data of the current line and a leading pixel of the same partial data string of the immediately preceding line is the same pixel position, the case where the relative position is shifted to the left by one pixel and the case where the relative position is shifted to the right by one pixel are stored in said table.

20. A data compression apparatus comprising:

reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data;

buffer means for extracting a plurality of continuous data strings within the range of a predetermined length from an inputted signal of the current line to store them as a partial data string to be compressed;

scanning comparison means for detecting whether or not the same partial data string as a partial data string continuing from a pixel of interest of said partial data string to be compressed exists in the data stored in said reference memory means; and

code generating means by which in the case where said scanning comparison means detects the same partial data string, the relative position of a leading pixel of said partial data string and said pixel of interest and the length of said partial data string on the data of the immediately line stored in said reference memory means are determined, and a corresponding code is outputted as data of that partial data string on the current line by referring to tables which are prepared for the respective values of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of a pixel of interest on the current from a leading pixel thereof ($0 \leqq x \leqq H-1$) and in which a different code is allotted in accordance with said relative position and said length of the partial data string.

21. A data compression apparatus according to claim **20**, wherein variable-length codes in at least three different cases including the case where the relative position of a pixel of interest of input data of the current line and a leading pixel of the same partial data string of the immediately preceding

line is the same pixel position, the case where the relative position is shifted to the left by one pixel and the case where the relative position is shifted to the right by one pixel are stored in said table.

22. A data compression apparatus according to claim **20**, wherein in the case where there is not detected in the current line a partial data string which is the same as the immediately preceding line, a corresponding code is outputted by referring to a run-length tables which are prepared for the respective values of T and in which a different variable-length code is allotted in accordance with the length of the same continuous data.

23. A data compression apparatus according to claim **21**, wherein in the case where there is not detected in the current line a partial data string which is the same as the immediately preceding line, a corresponding code is outputted by referring to a run-length tables which are prepared for the respective values of T and in which a different variable-length code is allotted in accordance with the length of the same continuous data.

24. A data compression apparatus according to claim **22**, wherein the variable-length codes stored in said run-length table are allotted with variable-length codes which are different from the variable-length codes stored in said table.

25. A data compression apparatus according to claim **23**, wherein the variable-length codes stored in said run-length table are allotted with variable-length codes which are different from the variable-length codes stored in said table.

26. A data decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there is successively inputted as data of the overlapping portion a code which differs in accordance with the relative position of a leading pixel of said partial data string and a pixel of interest and the length of said partial data string on the immediately preceding line for each value of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of said pixel of interest on the current from a leading pixel thereof ($0 \leqq x \leqq H-1$), the apparatus comprising:

buffer memory means for holding decompressed data of the immediately preceding line;

inverse transformation tables which are prepared for the respective values of T and in which the relative position of a leading pixel of said partial data string and said pixel of interest and the length of said partial data string on the immediately preceding line are allotted in accordance with said code; and

decoding means for determining the value of T on the basis of the position x of a pixel of interest of the compressed data to be decompressed on the current line from a leading pixel thereof to select the inverse transformation table corresponding to the determined value of T, extracting said code from the inputted data to refer to the selected inverse transformation table on the basis of said code so that data of the leading position and the length of said partial data string on the immediately preceding line is derived from said inverse transformation table, and extracting, from said buffer memory means, data which continues from a bit corresponding to the leading position of said partial data string to the extent of the length of said partial data string, so that the extracted data is outputted as decompressed data.

27. A data decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there is successively inputted as data of the overlapping portion a code which differs in accordance with the relative position of a leading pixel of said partial data string and a pixel of interest and the length of said partial data string on the immediately preceding line for each value of T, T being T=0 when x=0, T=1 when $1 \leqq x \leqq H-N$, and T=x−H+N+1 when $H-N+1 \leqq x \leqq H-1$ where H is the number of pixels in one line of said two-dimensional image data, N is the maximum detection string length of said partial data string ($1 \leqq N \leqq H$) and x is the position of said pixel of interest on the current from a leading pixel thereof ($0 \leqq x \leqq H-1$), and in which in the case where there is not detected in the current line a partial data string which is the same as the immediately preceding line, a code differing in accordance with the length of the same continuous data for each value of T and the same data are successively inputted as compressed data of run length, the apparatus comprising:

a counter for counting the position x of a pixel of interest of compressed data to be decompressed on the current line from a leading pixel thereof;

buffer memory means for holding decompressed data of the immediately preceding line;

inverse transformation tables which are prepared for the respective values of T and in which data of the relative position of a leading pixel of said partial data string and said pixel of interest and the length of said partial data string on the immediately preceding line or a run length are allotted in accordance with an inputted code;

a decoder for determining the value of T on the basis of the position x of said pixel of interest on the current line from the leading pixel thereof counted by the count value of said counter to select the inverse transformation table corresponding to the determined value of T, and extracting said code from the inputted data to refer to the selected inverse transformation table on the basis of said code so that a mode flag for discriminating whether or not there is detected in the current line a partial data string which is the same as the immediately preceding line is outputted while data of said relative position and said length or data of the length of the same continuous data is derived from said inverse transformation table;

first decoding means by which in the case where there is detected in the current line a partial data string which is the same as the immediately preceding line, data continuing from a bit corresponding to said relative position to the extent of the length of said partial data string is extracted from said buffer memory means and the extracted data is outputted as decompressed data; and

second decoding means by which in the case where there is not detected in the current line a partial data string which is the same as the immediately preceding line, data succeeding said code is continuously outputted to the extent of the length of the same continuous data.

28. A data compression method in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string to be compressed which is a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the position of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line.

29. A data compression method according to claim 28, wherein the code corresponding to the length of said immediately preceding partial data string and outputted as compressed data of said partial data string to be compressed is allotted with a code which differs in accordance with the length of said immediately preceding partial data string for each value of T which is a larger one of said position x_1 and said position x_2.

30. A data compression method according to claim 28, wherein information concerning the position of said immediately preceding partial data string is represented as the relative position on a two-dimensional space of a pixel of interest on the current line and a leading pixel of an immediately preceding partial data string on the immediately preceding line.

31. A data compression method according to claim 29, wherein information concerning the position of said immediately preceding partial data string is represented as the relative position on a two-dimensional space of a pixel of interest on the current line and a leading pixel of an immediately preceding partial data string on the immediately preceding line.

32. A data compression method according to claim 30, wherein the range of reference to the immediately preceding line is limited to fall within a predetermined range of said relative position.

33. A data compression method according to claim 31, wherein the range of reference to the immediately preceding line is limited to fall within a predetermined range of said relative position.

34. A data decompression method for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string to be compressed which is a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the position of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line, the method comprising:

holding at least decompressed data of the immediately preceding line;

extracting information concerning the position of said immediately preceding partial data string from the inputted compressed data while determining the position x_2 of the leading pixel of said immediately preceding partial data string from the leading pixel of the immediately preceding line on the basis of the extracted information to extract information concerning the length of said immediately preceding partial string on the basis of the position x_1 of a pixel of interest to be decompressed from a leading pixel of the current line and/or said position x_2; and

extracting said immediately preceding partial data string from the held decompressed data of the immediately preceding line on the basis of the information concerning the position of said immediately preceding partial data string and the information concerning the length of said immediately preceding partial string to output said immediately preceding partial data string as decompressed data of the inputted compressed data.

35. A data compression/decompression method in which on a transmitting side, in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string to be compressed which is a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the position of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line, and

in which on a receiving side, the method comprises holding at least decompressed data of the immediately preceding line, extracting information concerning the position of said immediately preceding partial data string from the inputted compressed data while determining the position x_2 of the leading pixel of said immediately preceding partial data string from the leading pixel of the immediately preceding line on the basis of the extracted information to extract information concerning the length of said immediately preceding partial string on the basis of the position x_1 of a pixel of interest to be decompressed from a leading pixel of the current line and/or said position x_2, and extracting said immediately preceding partial data string from the held decompressed data of the immediately preceding line on the basis of the information concerning the position of said immediately preceding partial data string and the information concerning the length of said immediately preceding partial string to output said immediately preceding partial data string as decompressed data of the inputted compressed data.

36. A data compression apparatus comprising:

reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data;

buffer means for extracting a plurality of continuous data strings from an inputted signal of the current line to store them as a partial data string to be compressed;

scanning comparison means for detecting whether or not the same partial data string as said partial data string to be compressed exists in the data stored in said reference memory means; and

code generating means by which in the case where said scanning comparison means detects the same partial data string, a code differing in accordance with the position of an immediately preceding partial data string corresponding to said partial data string to be compressed on the data stored in said reference memory means and a code differing in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line are outputted as compressed data of said partial data string to be compressed.

37. A data compression apparatus according to claim **36**, wherein said buffer means successively increases the number of bits of the data extracted from the signal of the current line in the case where said scanning comparison means detects the same data string, the increase being repeated until said scanning comparison means ceases to detect the same data string, and wherein said buffer means stores, as the partial data string to be compressed, a partial data string detected by said scanning comparison means immediately before said scanning comparison means ceases to detect the same data string.

38. A data compression apparatus according to claim **36**, wherein said scanning comparison means makes comparison by extracting that portion of the data of the immediately preceding line stored in said reference memory means which is within a predefined pixel range from a pixel of interest.

39. A data compression apparatus according to claim **37**, wherein said scanning comparison means makes comparison by extracting that portion of the data of the immediately preceding line stored in said reference memory means which is within a predefined pixel range from a pixel of interest.

40. A data decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected in the current line a partial data string to be compressed which is a partial data string which is the same as the immediately preceding line to the extent of at least one or more pixels, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the position of an immediately preceding partial data string corresponding to said partial data string to be compressed on the immediately preceding line and a code which differs in accordance with the length of said immediately preceding partial data string for each value of the position x_1 of a pixel of interest as a leading pixel of said partial data string to be compressed from a leading pixel of the current line and/or the position x_2 of a leading pixel of said immediately preceding partial data string from a leading pixel of the immediately preceding line, the apparatus comprising:

buffer memory means for holding at least decompressed data of the immediately preceding line;

extracting means for extracting information concerning the position of said immediately preceding partial data string from the inputted compressed data while determining the position x_2 of the leading pixel of said immediately preceding partial data string from the leading pixel of the immediately preceding line on the basis of the extracted information to extract information concerning the length of said immediately preceding partial string on the basis of the position x_1 of a pixel of interest to be decompressed from a leading pixel of the current line and/or said position x_2; and

decoding means for extracting said immediately preceding partial data string from the decompressed data of the immediately preceding line stored in the buffer memory means on the basis of the information concerning the position of said immediately preceding partial data string and the information concerning the length of said immediately preceding partial data string to output said immediately preceding partial data string as decompressed data of the inputted compressed data.

41. A data compression method in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data-string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string,

wherein in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and outputted as compressed data of the partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T which is the relative position of compressed data previously outputted.

42. A data compression method in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on an immediately preceding line corresponding to said partial data string to be compressed for each value of S, S being S=0 when x=0, S=1 when $1 \leqq x \leqq H-2$, and S=2 when x=H−1 where H is the number of pixels in one line of the two-dimensional image data and x is the position of the pixel of interest from a leading pixel of the current line ($0 \leqq x \leqq H-1$) and a code which differs in accordance with the length of said immediately preceding partial data string.

43. A data compression method according to claim **42**, wherein in the case where the detection of said partial data string to be compressed continues on the same line two or

more times, a code corresponding to said relative position and outputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each of the value of T, T being the relative position of compressed data previously outputted and the value of said S.

44. A data compression method according to claim **41**, wherein the range of reference to the immediately preceding line is limited to the case where said relative position is the same pixel position and the case where said relative position is a position shifted by one pixel.

45. A data compression method according to claim **42**, wherein the range of reference to the immediately preceding line is limited to the case where said relative position is the same pixel position and the case where said relative position is a position shifted by one pixel.

46. A data compression method according to claim **43**, wherein the range of reference to the immediately preceding line is limited to the case where said relative position is the same pixel position and the case where said relative position is a position shifted by one pixel.

47. A data decompression method for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string, and in which in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and inputted as compressed data of the partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T, T being the relative position of compressed data previously inputted, the method comprising:

holding at least decompressed data of the immediately preceding line;

extracting information concerning said relative position and the length of said immediately preceding partial data string from the inputted compressed data and extracting, in the case where the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, information concerning said relative position on the basis of the value of T; and

extracting said immediately preceding partial data string from the held compressed data of the immediately preceding line on the basis of the extracted information concerning said relative position and said length of said immediately preceding partial data string to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

48. A data decompression method for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on an immediately preceding line corresponding to said partial data string to be compressed for each value of S, S being S=0 when x=0, S=1 when $1 \leqq x \leqq H-2$, and S=2 when x=H−1 where H is the number of pixels in one line of the two-dimensional image data and x is the position of the pixel of interest from a leading pixel of the current line ($0 \leqq x < H-1$) and a code which differs in accordance with the length of said immediately preceding partial data string, the method comprising:

holding at least decompressed data of the immediately preceding line;

determining the value of S on the basis of the position x of a pixel of interest to be compressed on the current line to extract information concerning said relative position on the basis of the determined value of S and information concerning the length of said immediately preceding partial data string from the inputted compressed data; and

extracting said immediately preceding partial data string from the held compressed data of the immediately preceding line on the basis of the extracted information concerning said relative position and the length of said immediately preceding partial data string to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

49. A data decompression method according to claim **48**, wherein in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and inputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each the value of T, T being the relative position of compressed data previously inputted and the value of said S, and

wherein in the case where the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, information concerning said relative position is extracted on the basis of the value of T and the value of S.

50. A data compression/decompression method in which on a transmitting side, in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are successively outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the immediately preceding line corresponding to

said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string, and in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and outputted as compressed data of the partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T, T being the relative position of compressed data previously inputted, and

in which on a receiving side, the method comprises holding at least decompressed data of the immediately preceding line, extracting information concerning said relative position and the length of said immediately preceding partial data string from the inputted compressed data, extracting, in the case where the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, information concerning said relative position on the basis of the value of T, and extracting said immediately preceding partial data string from the held compressed data of the immediately preceding line on the basis of the extracted information concerning said relative position and the length of said immediately preceding partial data string to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

51. A data compression/decompression method in which on a transmitting side, in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string on an immediately preceding line corresponding to said partial data string to be compressed for each value of S, S being S=0 when x=0, S=1 when $1 \leqq x \leqq H-2$, and S=2 when x=H−1 where H is the number of pixels in one line of the two-dimensional image data and x is the position of said pixel of interest from a leading pixel of the current line ($0 \leqq x \leqq H-1$) and a code which differs in accordance with the length of said immediately preceding partial data string, and

in which on a receiving side, the method comprises holding at least decompressed data of the immediately preceding line, determining the value of S on the basis of the position x of a pixel of interest to be compressed on the current line to extract information concerning said relative position on the basis of the determined value of S and information concerning the length of said immediately preceding partial data string from the inputted compressed data, and extracting said immediately preceding partial data string from the held compressed data of the immediately preceding line on the basis of the extracted information concerning said relative position and the length of said immediately preceding partial data string to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

52. A data compression/decompression method in which on a transmitting side, in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string on an immediately preceding line corresponding to said partial data string to be compressed for each value of S, S being S=0 when x=0, S=1 when $1 \leqq x \leqq H-2$, and S=2 when x=H−1 where H is the number of pixels in one line of the two-dimensional image data and x is the position of said pixel of interest from a leading pixel of the current line ($0 \leqq x \leqq H-1$) and a code which differs in accordance with the length of said immediately preceding partial data string, and in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and outputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each the value of T, T being the relative position of compressed data previously outputted and the value of said S, and

in which on a receiving side, the method comprises holding at least decompressed data of the immediately preceding line, determining the value of S on the basis of the position x of a pixel of interest to be compressed on the current line to extract information concerning said relative position on the basis of the determined value of S and information concerning the length of said immediately preceding partial data string from the inputted compressed data, extracting, in the case where the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, information concerning said relative position on the basis of the value of T and the value of S, and extracting said immediately preceding partial data string from the held compressed data of the immediately preceding line on the basis of the extracted information concerning said relative position and the length of said immediately preceding partial data string to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

53. A data compression apparatus comprising:

reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data;

buffer means for extracting from an inputted signal of the current line a plurality of partial data strings having a pixel of interest as its leading pixel and a length corresponding to one or more pixels to store them;

scanning comparison means for detecting a partial data string to be compressed which is that one of said partial data strings stored in said buffer means which matches data stored in said reference memory means to the longest extent; and

code generating means by which in the case where said scanning comparison means detects said partial data

string to be compressed, a code differing in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the data stored in said reference memory means and corresponding to said partial data string to be compressed and a code differing in accordance with the length of said immediately preceding partial data string are outputted as compressed data of said partial data string to be compressed, and by which in the case where said partial data string to be compressed is detected by said scanning comparison means on the same line continuously two or more times, a code corresponding to said relative position and outputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T, T being the relative position of compressed data previously outputted.

54. A data compression apparatus comprising:

reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data;

buffer means for extracting from an inputted signal of the current line a plurality of partial data strings having a pixel of interest as its leading pixel and a length corresponding to one or more pixels to store them;

scanning comparison means for detecting a partial data string to be compressed which is that one of said partial data strings stored in said buffer means which matches data stored in said reference memory means to the longest extent; and

code generating means by which in the case where said scanning comparison means detects said partial data string to be compressed, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string on the data stored in said reference memory means and corresponding to said partial data string to be compressed for each value of S, S being S=0 when x=0, S=1 when $1 \leqq x \leqq H-2$, and S=2 when x=H−1 where H is the number of pixels in one line of the two-dimensional image data and x is the position of said pixel of interest from a leading pixel of the current line ($0 \leqq x \leqq H-1$) and a code which differs in accordance with the length of said immediately preceding partial data string.

55. A data compression apparatus comprising:

reference memory means for holding data of the immediately preceding line for successively inputted two-dimensional image data;

buffer means for extracting from an inputted signal of the current line a plurality of partial data strings having a pixel of interest as its leading pixel and a length corresponding to one or more pixels to store them;

scanning comparison means for detecting a partial data string to be compressed which is that one of said partial data strings stored in said buffer means which matches data stored in said reference memory means to the longest extent; and

code generating means by which in the case where said scanning comparison means detects said partial data string to be compressed, there are outputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string on the data stored in said reference memory means and corresponding to said partial data string to be compressed for each value of S, S being S=0 when x=0, S=1 when $1 \leqq x \leqq H-2$, and S=2 when x=H−1 where H is the number of pixels in one line of the two-dimensional image data and x is the position of said pixel of interest from a leading pixel of the current line ($0 \leqq x \leqq H-1$) and a code which differs in accordance with the length of said immediately preceding partial data string, and by which in the case where said partial data string to be compressed is detected by said scanning comparison means on the same line continuously two or more times, a code corresponding to said relative position and outputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each of the value of said S and the value of T, T being the relative position of compressed data previously outputted.

56. A data compression apparatus according to claim **53**, wherein in the case where a partial data string matching the partial data string stored in said buffer means is detected by said scanning comparison means from the data stored in said reference memory means, data succeeding said partial data string stored in said buffer means is extracted by said buffer means from the signal of the current line to successively increase the length of the partial data string stored in said buffer means, the increase being repeated until said scanning comparison means ceases to detect the matching partial data string, and

said scanning comparison means detects, as said partial data string to be compressed, a partial data string stored in said buffer means immediately before said scanning comparison means ceases to detect the matching partial data string.

57. A data compression apparatus according to claim **54**, wherein in the case where a partial data string matching the partial data string stored in said buffer means is detected by said scanning comparison means from the data stored in said reference memory means, data succeeding said partial data string stored in said buffer means is extracted by said buffer means from the signal of the current line to successively increase the length of the partial data string stored in said buffer means, the increase being repeated until said scanning comparison means ceases to detect the matching partial data string, and

said scanning comparison means detects, as said partial data string to be compressed, a partial data string stored in said buffer means immediately before said scanning comparison means ceases to detect the matching partial data string.

58. A data compression apparatus according to claim **55**, wherein in the case where a partial data string matching the partial data string stored in said buffer means is detected by said scanning comparison means from the data stored in said reference memory means, data succeeding said partial data string stored in said buffer means is extracted by said buffer means from the signal of the current line to successively increase the length of the partial data string stored in said buffer means, the increase being repeated until said scanning comparison means ceases to detect the matching partial data string, and

said scanning comparison means detects, as said partial data string to be compressed, a partial data string stored in said buffer means immediately before said scanning comparison means ceases to detect the matching partial data string.

59. A data compression apparatus according to claim **53**, wherein said scanning comparison means makes comparison by extracting that partial data string from the data stored in said reference buffer means which has, as its leading pixel, data for which said relative position is the same pixel position or a position shifted by one pixel.

60. A data compression apparatus according to claim **54**, wherein said scanning comparison means makes comparison by extracting that partial data string from the data stored in said reference buffer means which has, as its leading pixel, data for which said relative position is the same pixel position or a position shifted by one pixel.

61. A data compression apparatus according to claim **55**, wherein said scanning comparison means makes comparison by extracting that partial data string from the data stored in said reference buffer means which has, as its leading pixel, data for which said relative position is the same pixel position or a position shifted by one pixel.

62. A data compression apparatus according to claim **56**, wherein said scanning comparison means makes comparison by extracting that partial data string from the data stored in said reference buffer means which has, as its leading pixel, data for which said relative position is the same pixel position or a position shifted by one pixel.

63. A data compression apparatus according to claim **57**, wherein said scanning comparison means makes comparison by extracting that partial data string from the data stored in said reference buffer means which has, as its leading pixel, data for which said relative position is the same pixel position or a position shifted by one pixel.

64. A data compression apparatus according to claim **58**, wherein said scanning comparison means makes comparison by extracting that partial data string from the data stored in said reference buffer means which has, as its leading pixel, data for which said relative position is the same pixel position or a position shifted by one pixel.

65. A data decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of said pixel of interest and a leading pixel of an immediately preceding partial data string on the immediately preceding line corresponding to said partial data string to be compressed and a code which differs in accordance with the length of said immediately preceding partial data string, and in which in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and inputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each value of T, T being the relative position of compressed data previously inputted, the apparatus comprising:

buffer memory means for holding at least decompressed data of the immediately preceding line;

extracting means by which information concerning said relative position and the length of said immediately preceding partial data string is extracted from the inputted compressed data, and by which when the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, information concerning said relative position is extracted on the basis of the value of T; and

decoding means for extracting said immediately preceding partial data string from the compressed data of the immediately preceding line stored in said buffer memory means on the basis of the information concerning said relative position and the length of said immediately preceding partial data string extracted by said extracting means to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

66. A data decompression apparatus for compressed two-dimensional image data in which in the case where the reference to data of the immediately preceding line for successively scanned two-dimensional image data results in that there is detected from the current line a partial data string to be compressed which has a pixel of interest as its leading pixel and a length corresponding to one or more pixels and which matches data of the immediately preceding line to the longest extent, there are successively inputted, as compressed data of said partial data string to be compressed, a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string on an immediately preceding line corresponding to said partial data string to be compressed for each value of S, S being S=0 when x=0, S=1 when $1 \leqq x \leqq H-2$, and S=2 when x=H−1 where H is the number of pixels in one line of the two-dimensional image data and x is the position of said pixel of interest from a leading pixel of the current line ($0 \leqq x \leqq H-1$) and a code which differs in accordance with the length of said immediately preceding partial data string, the apparatus comprising:

buffer memory means for holding at least decompressed data of the immediately preceding line;

extracting means for determining the value of S on the basis of the position x of a pixel of interest to be compressed on the current line to extract information concerning said relative position on the basis of the determined value of S and information concerning the length of said immediately preceding partial data string from the inputted compressed data; and

decoding means for extracting said immediately preceding partial data string from the compressed data of the immediately preceding line stored in said buffer memory means on the basis of the information concerning said relative position and the length of said immediately preceding partial data string extracted by said extracting means to output the extracted immediately preceding partial data string as decompressed data of the inputted compressed data.

67. A data decompression apparatus according to claims **66**, wherein in the case where the detection of said partial data string to be compressed continues on the same line two or more times, a code corresponding to said relative position and inputted as compressed data of a partial data string to be compressed which is subjected to the second or subsequent

detection, is allotted with a code which differs in accordance with the relative position of a pixel of interest and a leading pixel of an immediately preceding partial data string for each of the value of T, T being the relative position of compressed data previously inputted and the value of said S, and

wherein when the inputted compressed data is compressed data of a partial string data to be compressed which is subjected to the second or subsequent detection, said extracting means extracts information concerning said relative position is extracted on the basis of the value of T and the value of S.

68. A data decompression method for decompressing compressed two-dimensional image data which are produced by a data compressing method using first line data of a first line and second line data of a second line, said first line immediately preceding said second line, wherein

said data compressing method comprising the steps of:

preparing tables which are provided every position of a pixel of interest on said second line and in each of which codes are allotted so as to be different in accordance with a relative position of a leading pixel of said first partial data string to said pixel of interest and a length of said first partial data string;

comparing a first partial data string among said first line data and a second partial data string among said second line data; and

selecting, when said second partial data string is the same as said first partial data string, one of said tables in accordance with a position of said pixel of interest on said second line to output one of said codes which is allotted corresponding to a leading pixel of said first partial data string to said pixel of interest and the length of said first partial data, instead of said second partial data string,

said data decompressing method comprising the stops of:

preparing said tables;

holding at least said first line data included in said compressed two-dimensional image data;

selecting one of said tables in accordance with a position of a pixel to be decompressed on said second line;

extracting said one of codes included in said compressed two-dimensional image data;

referring said selected one of tables in accordance with said extracted one of codes to extract data, which comprises a corresponding bit corresponding to the relative position of the leading pixel of said first partial data string to said pixel to be decompressed and at least one bit following said corresponding bit by the length of said first partial data string, from said held first line data; and

reproducing said second line data by using said extracted data instead of said extracted one of codes.

69. A data compression/decompression method comprising:

a data compression method performed in a transmitting side and for compressing two-dimensional image data using first line data of a first line and second line data of a second line, said first line immediately preceding said second line, comprising the steps of:

preparing tables which are provided every position of a pixel of interest on said second line and in each of which codes are allotted **90** as to be different in accordance with a relative position of a leading pixel of said first partial data string to said pixel of interest and a length of said first partial data string;

comparing a first partial data string among said first line data and a second partial data string among said second line data; and

selecting, when said second partial data string is the same as said first partial data string, one of said tables in accordance with a position of said pixel of interest on said second line to output one of said codes which is allotted corresponding to a leading pixel of said fires partial data string to said pixel of interest and the length of said first partial data, instead of said second partial data string, and

a data decompressing method performed in a receiving side comprising the steps of:

preparing said tables;

holding at least said first line data included in said compressed two-dimensional image data;

selecting one of said tables in accordance with a position of a pixel to be decompressed on said second line;

extracting said one of codes included in said compressed two-dimensional image data;

referring said selected one of tables in accordance with said extracted one of codes to extract data, which comprises a corresponding bit corresponding to the relative position of the leading pixel of said first partial data string to said pixel to be decompressed and at least one bit following said corresponding bit by the length of said first partial data string, from said held first line data; and

reproducing said second line data by using said extracted data instead of said extracted one of codes.

70. A data compression/decompression method according to claim **52**, wherein codes in at least three different cases are stored in said table in the form of variable-length codes, said three different cases including a case where said relative position represents that said leading pixel is positioned at the same pixel position as said pixel of interest, a case where said relative position represents that said leading pixel shifts to the left by one pixel to said pixel of interest, and a case where said relative position represents that said leading pixel shifts to the right by one pixel to said pixel of interest.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,883,975
DATED : March 16, 1999
INVENTOR(S) : Narita, et. al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page, item [21] Change "526,663" to --08/526,663--.

Signed and Sealed this

Sixth Day of February, 2001

Attest:

Attesting Officer

Q. TODD DICKINSON

Director of Patents and Trademarks