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Specification of standards for information transmission by digitally coded signals in the field-blanking interval of 625-line television systems

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I am pleased to introduce this Specification of the unified television standards for information transmission in the field blanking interval.

The pages which follow are the result of much hard work by the combined Working Group members who are named in Appendix IX. They deserve praise for their efforts, which have resulted in this agreed Specification of the technical parameters for a fascinating and potentially very valuable additional service for television viewers.

Chairman
Joint Executive Committee

October 1974

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Foreword

Two systems designed to carry public information services—BBC CEEFAX and IBA ORACLE—have been the subject of engineering test transmissions in the UK. Both operate by inserting a digital signal during part of the field blanking interval of the television waveform. Since the details of the signal coding differed for the two systems, there was obviously a need to define a unified engineering specification for data broadcasting. To meet this need, a joint BBC/IBA/BREMA Executive Committee was formed in June 1973 and this in turn set up a Combined Working Group (for the Constitution of these bodies see Appendix IX) with the following terms of reference:-

> 'Examine the technical aspects of CEEFAX and ORACLE and recommend a common data broadcasting standard aimed at providing a reliable and high quality service.'

The Working Group held its first meeting on 7 July 1973 and has had six subsequent meetings, culminating in that of 18 March at which this Specification was agreed.

Test transmissions to this Specification in preparation for a public service commenced in April in the United Kingdom. These tests will include the evaluation of public reaction. In view of the likelihood of eventual vhf, as well as the present uhf transmissions of 625-line colour television in the United Kingdom, and to ensure the compatibility of the Specification with Systems B and G, test transmissions are also expected to take place later this year on vhf in Germany. These tests are needed to investigate the anticipated greater problems of data reception on vhf due to low field-strength, multipath propagation and impulsive interference as well as the effect of the lower video bandwidths used by Systems B and G.

In preparing this Specification as many options as possible have been left open to the receiver designers and to the broadcasters so that the system may evolve using experience in both engineering and programme aspects. The range of facilities allowed for is indicated by this list of the more important features of the Specification:-

a) a fast access time
b) capitals and lower case characters
c) display in six colours plus white
d) 'flashing' display
e) a simple graphics display
f) subtitles
g) 'boxing'
h) news-flashes
i) up to 100 pages per magazine

The Working Group has given much thought to producing a Specification which gives the optimum results in a television service area, but nevertheless feels that it is important to point out a fundamental difference between analogue television signals and the digital signals used in a data broadcasting service. It is well understood that, as one travels away from a television transmitter, the quality of the received pictures ultimately becomes impaired by noise and other disturbances; however, a viewer may choose to receive pictures many miles outside the normal service area, if he is prepared to tolerate very poor picture quality. This option does not exist in the case of a digital transmission such as specified in this document. The displayed information is perfect or near-perfect within and sometimes well beyond the television service area, but when noise or other disturbances exceed a critical level, proper data reception rapidly fails and becomes impossible.

Summary

The Specification contains the information necessary to define the alphanumerics data broadcasting system and covers those details necessary to relate the alphanumerics and graphics aspects, the latter being specified in a separate addendum.

A description is given of the system parameters, using figures and tables to carry much of the detailed information, and this is supported by a number of explanatory appendices.

The main technical features of the system are listed:-

1. Data pulses are transmitted during the television field-blanking interval using a bit-rate of 6·9375 MBits/s.

2. Each television data line carries information for a complete 40-character row.

3. Each page consists of 24 rows of 40 characters using both upper- and lower-case characters, coded using the ISO-7 code; a special top row called the Page-Header carries information for control and display purposes.

4. The system allows a maximum access time of about 15 seconds with a total of about 60 pages.

5. All the data-words are 8 bits in length; parity protection is used for the character data words while Hamming Codes are used for addressing and control purposes, permitting the correction at the receiver of single errors in these data-words.

6. News-flashes and subtitles are provided.

7. Every page-header will carry clock-time information to provide a display and to permit the automatic time-selection of certain pages etc.

8. Control characters are used to provide colouring and flashing of selected words.

9. A simple graphics facility is provided.

Certain aspects of the design of equipment required to operate to this specification are the subject of patent applications.

1. INTRODUCTION

This Specification defines the alphanumeric data broadcasting system and includes the details necessary to relate the alphanumerics and graphics* aspects.

The Specification is in two parts the first of which, together with the associated figures, gives a description of the system parameters. The second part is a group of appendices that carry supporting information of an explanatory nature.

2. SPECIFICATION

2.1 Definition of Terms

To avoid confusion, the following terms have been used in the description of the system.

Page—a page resembles a page of type-script formed from horizontal rows of letters and figures displayed as an image on the screen of a television receiver. The video signal producing this image is generated electronically by alphanumeric character generators within the receiver.

Magazine—each page is separately numbered and a group of pages is known as a Magazine.

Character row—the pages are formed from horizontal rows of alphanumeric characters (letters and figures): to avoid confusion, the word 'row' is used in preference to the word 'line' which describes the horizontal component of scanning in television.

Updating—the editorial action of putting new information into the system is known as updating and can take place at any time as decided by an editor.

Re-writing—the data signal describing the pages might typically require about fifteen seconds to describe the whole of the magazine. The process of repeatedly transmitting or using this data to describe the pages, whether updating has just taken place or not, is described as re-writing.

2.2 Television Data Lines

Initially two per television field, using lines 17 (330) and 18 (331) as shown in Fig. 1**. At the defined bit-rate (see 2.7) each data line carries data for one 40-character row.

* Graphics transmissions are specified in a separate addendum to this specification

** Future extension may be possible using additional television data lines. For this reason, it is advisable that receivers operate by recognition of framing and address codes, rather than by identification of particular television lines.

2.3 Page Format

40 characters per row, 24 rows per page including a special top row called the Page-Header.

2.4 Magazine

Up to 100 pages per magazine; up to eight magazines per television channel†.

2.5 Transmission Sequence

Pages are transmitted one at a time; although pages will generally be transmitted in numerical order, they may, in fact, be in any order. The transmission of each page begins with the Page-Header, followed by the character rows in numerical order. To save transmission time any blank rows at the bottom of a page will probably not be transmitted. Should experience show that manufacturers see no virtue in 'flywheel' row-addressing, it may be decided to omit the transmission of other blank rows: thus the current page-header may be repeated at the clock-time 'seconds' changeover to increase accuracy.

2.6 Page-Header Transmission

This relates to the top row of each page (designated Row 'O')‡ and always carries heavily-protected data not intended for display, as well as certain information for display, eg., page number, date, clock-time and source or service identification. Details can be seen in Figs. 2 and 3; see also Section 2.15.

2.7 Character-Row Transmission

Full details are given in Fig. 4.

2.8 Bit-Rate

6·9375 MBits/s (444 x line-frequency)

2.9 Access Time

This is the time to obtain a complete page after selection and, for example, will be a maximum of about 15 seconds with an average of 7·5 seconds when 60 full pages are being transmitted.

2.10 Types of Page

All kinds of page may be transmitted (see Appendix I); it should be noted that all pages may be selectable on a basis of clock-time.

† The total number of pages transmitted on a television channel using two data lines per field will be limited by access time (see 2.9) and, hence, the number of magazines and the pages in each of those magazines will be similarly limited. Page No. 99 has been reserved for Engineering test purposes.

‡ To allow receiver designers the option of using the new page-header to cause the old data to be erased from the receiver store, the first Row ('0') of a page will not be followed in the same field-blanking time by a different row of that page.

2.11 Subtitles and News-Flashes

These pages use control-bits in the page-header and control-characters to assist with suppression of the page-header and superimposing or keying-in to the television picture at the receiver; details appear in Section 2.16 below and Appendix VI.

2.12 Character (Primary) Coding

This will be ISO-7* (BS 4730 : 1974), ie., ASCII with selected 'National usage' characters. This coding includes upper- and lower-case characters. For all characters, bit number 1 (b_1) is transmitted first.

The choice of an existing character coding standard has been dictated by expediency so that 'off the shelf' components may be used. However, some of the characters in ISO-7 (or ASCII) are not likely to be required and it is envisaged that, in the early stages, a new special character-font will be designed and adopted which will contain an additional number of useful characters covering, for example, arithmetic symbols as well as some foreign language characters.

In order for such a change to be made at a later date, it is recommended that character generators in experimental receivers be changeable.

2.13 Transmission (Secondary) Coding

No secondary coding is used; ie., direct transmission of coded characters and addresses including synchronising and framing signals uses simple, on/off, binary NRZ** form.

2.14 Clock-Run-In and Framing Code

Fig. A2 and Appendix IV give details of the Clock-run-in and Framing Code. The clock-run-in consists of a 1010 .... sequence for the generation of correctly phased clock-pulses in the receiver. The framing code is to allow the receiver to achieve word-synchronism with the data to follow. The framing code has been designed to be capable of operating correctly in the presence of an error; details of how this may be done are given in Appendix IV.

The clock-run-in consists of 16 bits (eight '1's and eight '0's ending with a '0').

2.15 Addresses

Every data-line carries a Row Address numbered 0 to 23 beginning with Row '0', the Page-Header.

The Page Address (number) is carried by the Page-Header only.

Clock-time addresses are also carried by each Page-Header for the selection of pages by time-code at the receiver.

All addresses are heavily protected by the use of Hamming Codes as described in Section 2.17 below, and in Appendices II and III. Details are given in Figs. 5 to 8 inclusive.

The above data, in respect of page number and clock-time (hours and minutes only) is intended for control purposes within the receiver and therefore may not be in step with true clock-time.

The Page Address and Clock-time Address are coded in 1, 2, 4, 8 BCD form, as shown in Figs. 6, 7 and 8.

2.16 Control Functions

There are two types of control function:

Control characters from columns '0' and '1' of the ISO-7 code table; details are given in Table 1.

Control bits in certain address words; details are given in Table 2.

i. Control characters (Table 1)

Not all control characters have been allocated; those that have been allocated† are listed below.

a) Flashing

Two characters will be used to instruct the receiver to make either a flashing or steady display of following characters.

b) Colouring and Graphics

Seven control characters will be used to instruct the receiver to display alphanumeric characters in one of seven colours, and a further seven characters have been allocated for coloured graphics.

c) Subtitle and News-Flash 'boxing'

Two control characters have been allocated to permit subtitles or news-flashes to be inset into the normal television picture. Each of these control characters is transmitted twice in succession and it is intended that the 'box' should be opened (or closed) in between the pair; further information is given in Appendix VI and Fig. A6

To avoid transmitting a control character at the beginning of every row, it is assumed that all character-rows begin in the 'Steady', and 'Alphanumeric White' and 'unboxed' condition.

It is intended that control characters be suppressed in the receiver and displayed as 'space' characters.

ii Control bits (Table 2)

a) Magazine Identification

To allow future extension, control bits C_1, C_2 and C_3 (see Table 2 and Fig. 5) are used to identify up to eight magazines on each channel.

* ASCII and ISO-7 characters differ only in the £ sign. For control purposes, a modified ISO-7 code is used.

** Non-return-to-zero

† Control character ETX, ISO-7 Location 0/3, is reserved for internal use by the broadcasters.

b) 'Clear Page' Command
When a page has been updated and new information is being transmitted for the first time, the 'Clear Page' bit C_4 (see Table 2 and Fig. 7) may be set to '1' on the Page-Header. A 'Clear Page' command for a particular page and new information for that page will not be transmitted in the same field-blanking period to allow time for the receiver store to be cleared.

c) Identification of Subtitle and News-Flash Pages
These pages are identified by special control bits as shown in Table 2;

C_5 set to '1' for News-flash pages
C_6 set to '1' for subtitle pages.

2.17 Protection

Characters are transmitted in 8-bit data groups formed from 7-bit character codes plus one (odd) parity bit.

Addresses are transmitted in 8-bit code groups, protected by the use of a Hamming error-correcting code which allows the correction at the receiver of any single error and the detection of any double error in each group. Details of the Hamming Code words are given below and additional background information is given in Appendix II.

The Hamming Code words are 8-bit words comprising 4 message-bits and 4 protection-bits. The use of 4 protection-bits permits any single error in the received code group to be corrected, and any double or other even number of errors (except eight) to be detected.

The order in which message and protection-bits are transmitted is as follows:

Message-bits Nos. 2, 4, 6, 8
Protection-bits Nos. 1, 3, 5, 7

The bits are transmitted in numerical order beginning with number 1. Where the message represents a binary or BCD number, the first (lowest-numbered) message-bit is the least-significant bit.

The complete code is shown in Table 3. The four parity checks are as follows: (see also Table 4)

Parity check A is carried out over bits 1, 2, 6, 8
Parity check B is carried out over bits 2, 3, 4, 8
Parity check C is carried out over bits 2, 4, 5, 6
Parity check D is carried out over all bits

Table 4 indicates the appropriate action to correct single errors, ie., it gives the parity failure decode routing when failure of the individual checks produces a '1' at each checker output. It also indicates the conditions recognised as double errors, namely $\bar{D} \cdot (A + B + C)$.

2.18 Graphics

A specification covering the transmission of simple graphics signals for the portrayal of maps etc., at the receiver forms an addendum to this main specification. These graphics transmissions will be compatible with the more important alphanumerics data transmissions.

2.19 Spectrum of Transmitted Data Signals

Fig. 9 shows the approximate pulse spectrum, using raised-cosine data pulses, the spectra of which are truncated before transmission by means of a filter. Further work to optimise the characteristics of the band-limiting filter is in progress.

The present band-limitation modifies the shape of the raised-cosine data-pulse, diminishing the pulse-power and causing an overswing of about 7%. Further information is given in Appendix VII.

2.20 Transmissions for Low-Cost Receivers

This specification has been prepared with the possibility of transmissions for low-cost receivers in mind although no details of the transmissions are included. This matter is further considered in Appendix VIII.

Table 1

Control Character Allocation*

ISO-7 LOCATION	KEY			GRAPHICS SHIFT	BLUE	GREEN	RED	ISO-7 NAME	DISPLAY CONTROL USAGE
	b_7	b_6	b_5	b_4	b_3	b_2	b_1		
1/0	0	0	1	0	0	0	0	DLE	NOT IN USE
1/1	0	0	1	0	0	0	1	DC1	GRAPHICS RED
1/2	0	0	1	0	0	1	0	DC2	GRAPHICS GREEN
1/3	0	0	1	0	0	1	1	DC3	GRAPHICS YELLOW
1/4	0	0	1	0	1	0	0	DC4	GRAPHICS BLUE
1/5	0	0	1	0	1	0	1	NAK	GRAPHICS MAGENTA
1/6	0	0	1	0	1	1	0	SYN	GRAPHICS CYAN
1/7	0	0	1	0	1	1	1	ETB	GRAPHICS WHITE
1/8	0	0	1	1	0	0	0	CAN	NOT IN USE
1/9	0	0	1	1	0	0	1	EM	ALPHA$^{\underline{n}}$. RED
1/10	0	0	1	1	0	1	0	SUB	ALPHA$^{\underline{n}}$. GREEN
1/11	0	0	1	1	0	1	1	ESC	ALPHA$^{\underline{n}}$. YELLOW
1/12	0	0	1	1	1	0	0	FS	ALPHA$^{\underline{n}}$. BLUE
1/13	0	0	1	1	1	0	1	GS	ALPHA$^{\underline{n}}$. MAGENTA
1/14	0	0	1	1	1	1	0	RS	ALPHA$^{\underline{n}}$. CYAN
1/15	0	0	1	1	1	1	1	US	ALPHA$^{\underline{n}}$. WHITE
0/12	0	0	0	1	1	0	0	FF	FLASH
0/13	0	0	0	1	1	0	1	CR	STEADY
0/14	0	0	0	1	1	1	0	SO	END BOX
0/15	0	0	0	1	1	1	1	SI	START BOX

* Control character ETX, ISO-7 Location 0/3, is reserved for internal use by the broadcasters.

It is assumed that all character-rows begin in the 'Steady', 'Alphanumerics White' and 'unboxed' conditions.

Table 2

The Use of Control Bits

Function	Control Bit Identity	Bit Value	Location	Reference Fig. No.
Magazine Identification*	C_1 C_2 C_3	2^0 2^1 2^2	Control and row address group	5
Clear Page	C_4	1 = CLEAR	Minutes–Tens	7
News-flash	C_5	1 = ON	Hours–Tens	8
Subtitle	C_6	1 = ON		
Unallocated	C_7 to C_{14}		Page-Header Spare Control	2 and 3

* The use of three bits allows eight magazines. Magazine numbers 1 to 7 (inclusive) will be identified by the corresponding binary value represented by C_1, C_2 and C_3; Magazine No. 8 will have the binary value 000.

Note: The 'Clear Page' control bit will be set to '1' as a signal to the receiver to clear the page-store.

Table 3

Code Table of Hamming-Code

Protection Bits: positions 1, 2, 4, 8; Message Bits: positions 3, 5, 6, 7

DECIMAL MESSAGE VALUE	BIT POSITION NUMBER 1	2	3	4	5	6	7	8
0	1	0	1	0	1	0	0	0
1	0	1	0	0	0	0	0	0
2	1	0	0	1	0	0	1	0
3	0	1	1	1	1	0	1	0
4	0	0	1	0	0	1	1	0
5	1	1	0	0	1	1	1	0
6	0	0	0	1	1	1	0	0
7	1	1	1	1	0	1	0	0
8	0	0	0	0	1	0	1	1
9	1	1	1	0	0	0	1	1
10	0	0	1	1	0	0	0	1
11	1	1	0	1	1	0	0	1
12	1	0	0	0	0	1	0	1
13	0	1	1	0	1	1	0	1
14	1	0	1	1	1	1	1	1
15	0	1	0	1	0	1	1	1

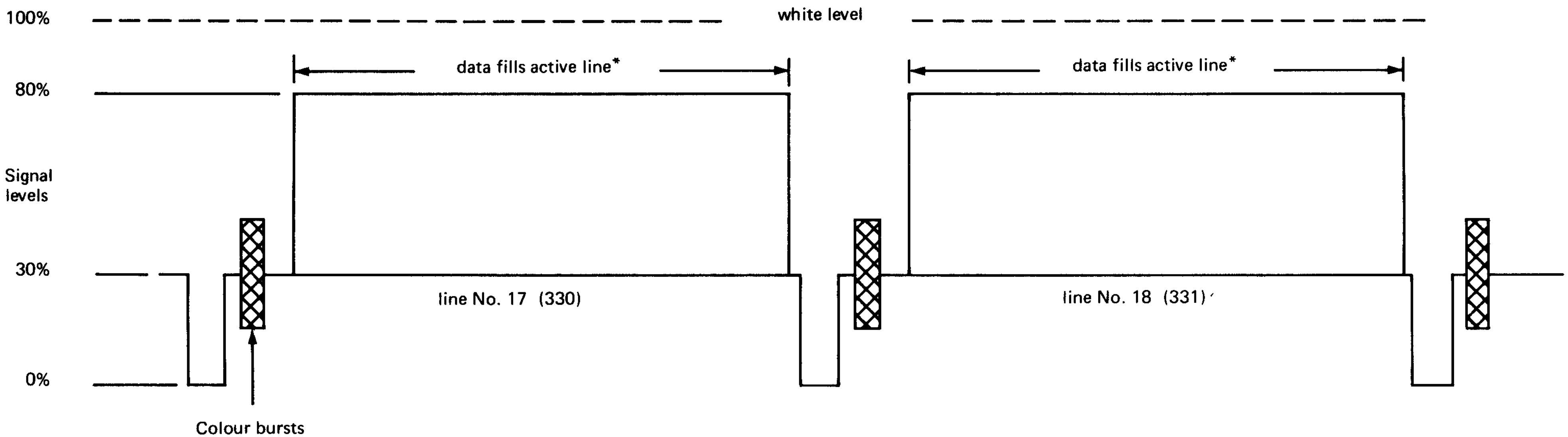
Table 4

Hamming-Coded Words—Parity Decode Routing

A, B, C and D are the parity checks referred to in Section 2.17 of the Specification

D	C	B	A	
0	0	0	0	→ ERROR FREE RECEPTION
0	0	0	1	REJECT EVEN ORDER ERROR
0	0	1	0	REJECT EVEN ORDER ERROR
0	0	1	1	REJECT EVEN ORDER ERROR
0	1	0	0	REJECT EVEN ORDER ERROR
0	1	0	1	REJECT EVEN ORDER ERROR
0	1	1	0	REJECT EVEN ORDER ERROR
0	1	1	1	REJECT EVEN ORDER ERROR
1	0	0	0	→ COMPLEMENT BIT 7
1	0	0	1	→ COMPLEMENT BIT 1
1	0	1	0	→ COMPLEMENT BIT 3
1	0	1	1	→ COMPLEMENT BIT 8
1	1	0	0	→ COMPLEMENT BIT 5
1	1	0	1	→ COMPLEMENT BIT 6
1	1	1	0	→ COMPLEMENT BIT 4
1	1	1	1	→ COMPLEMENT BIT 2

'0'=PARITY CHECK 'CORRECT'
'1'=PARITY CHECK 'FAILED'



* Active line as defined by CCIR document 11/431 (March 1974)

FIG. 1
LEVEL AND POSITIONING OF DATA ON TELEVISION LINES

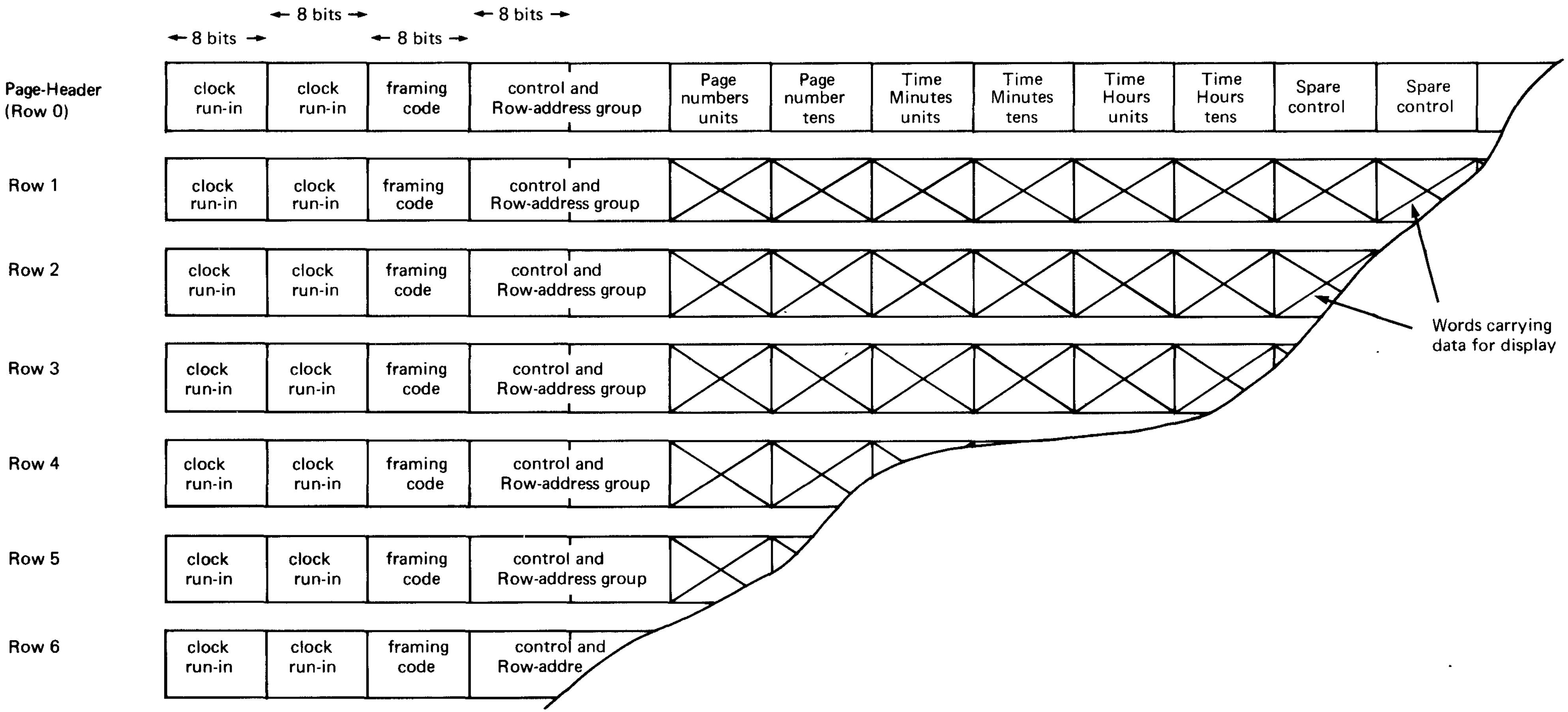


FIG. 2

FUNCTIONS OF 8 BIT CONTROL-WORDS AT START OF PAGE-HEADER AND ROW TRANSMISSIONS

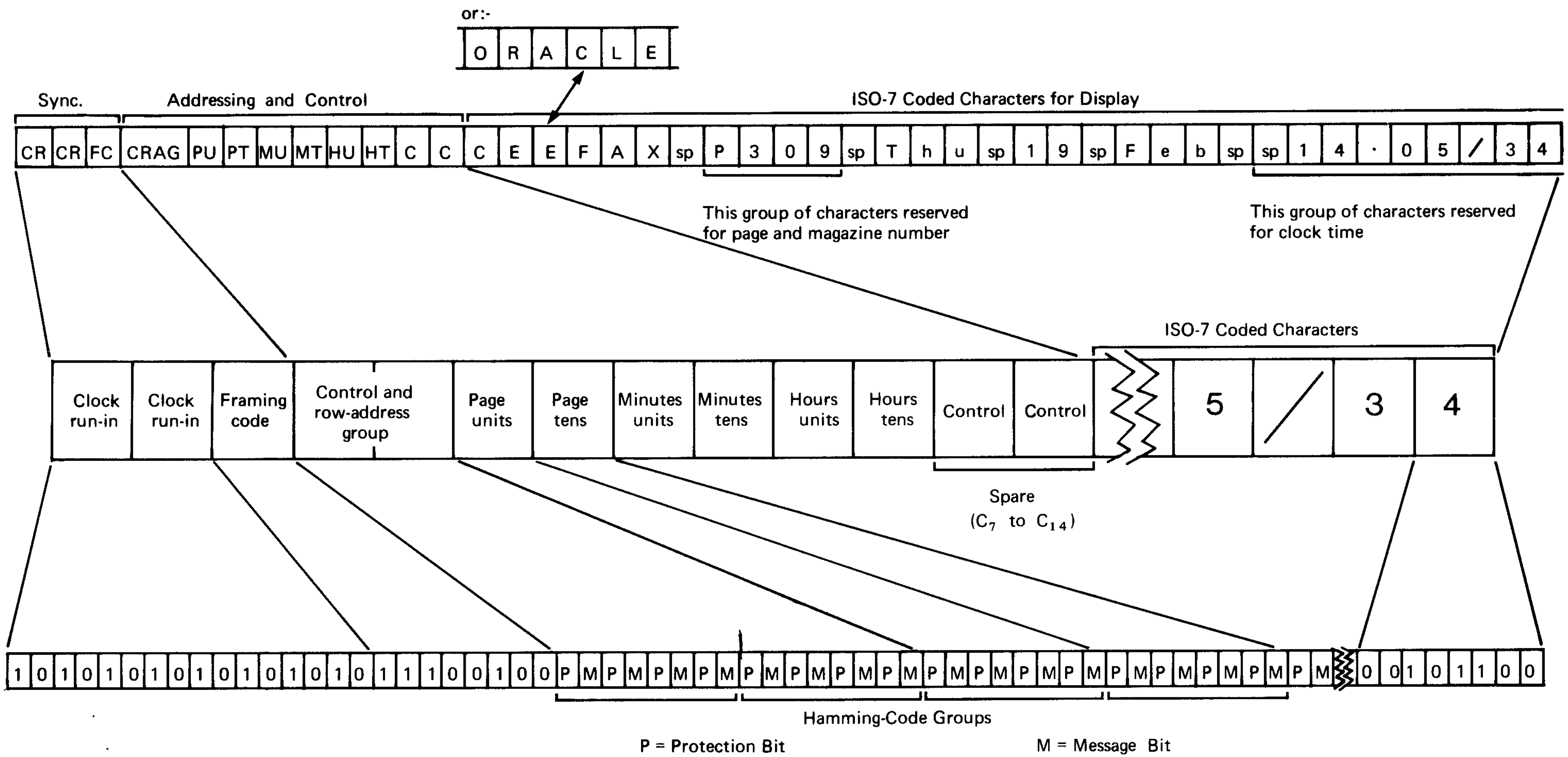


FIG. 3

LAYOUT OF PAGE-HEADER TRANSMISSION

The Entire Transmission is Formed From 8-Bit Bytes

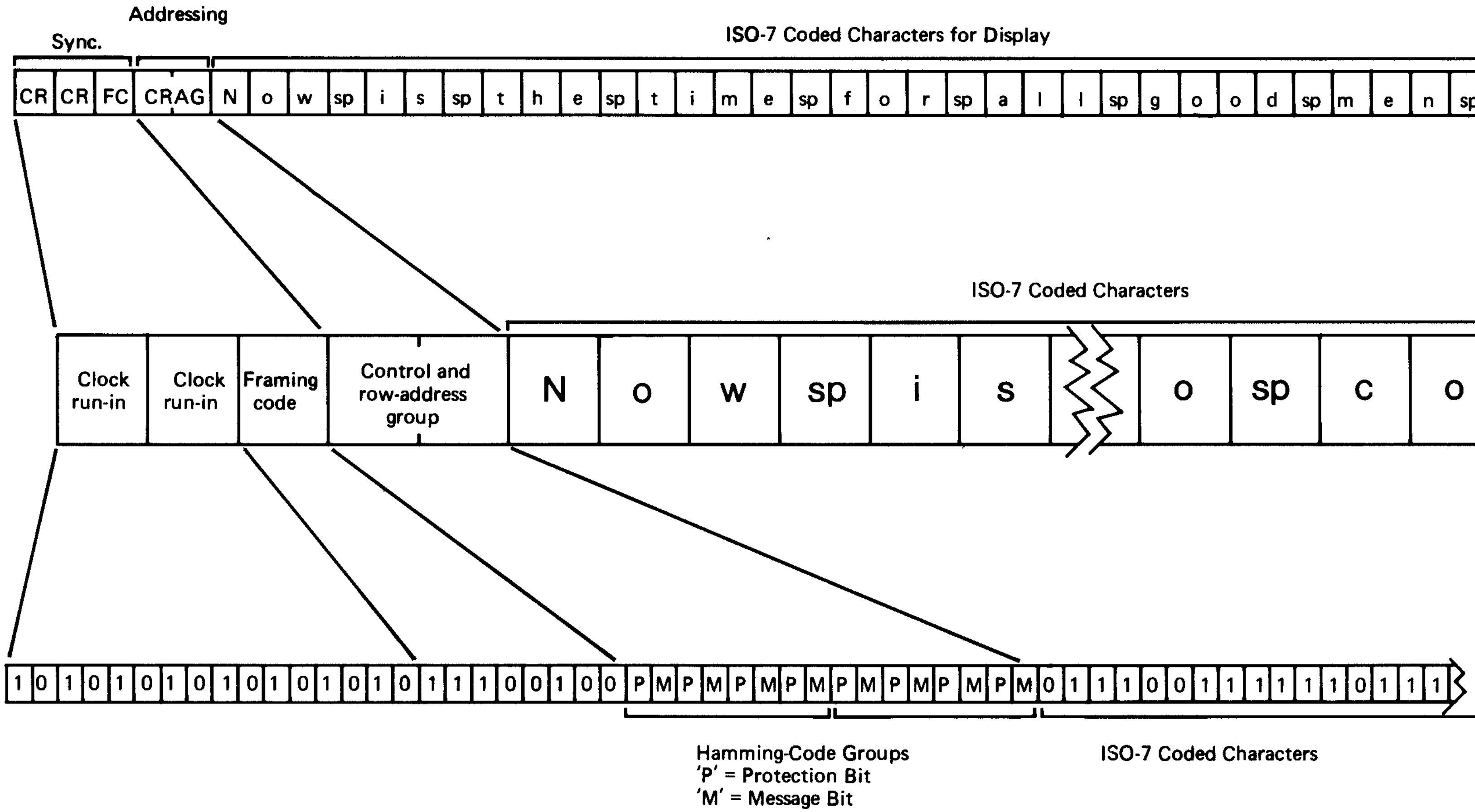


FIG. 4

LAYOUT OF ROW TRANSMISSION

The Entire Transmission is Formed From 8-Bit Bytes

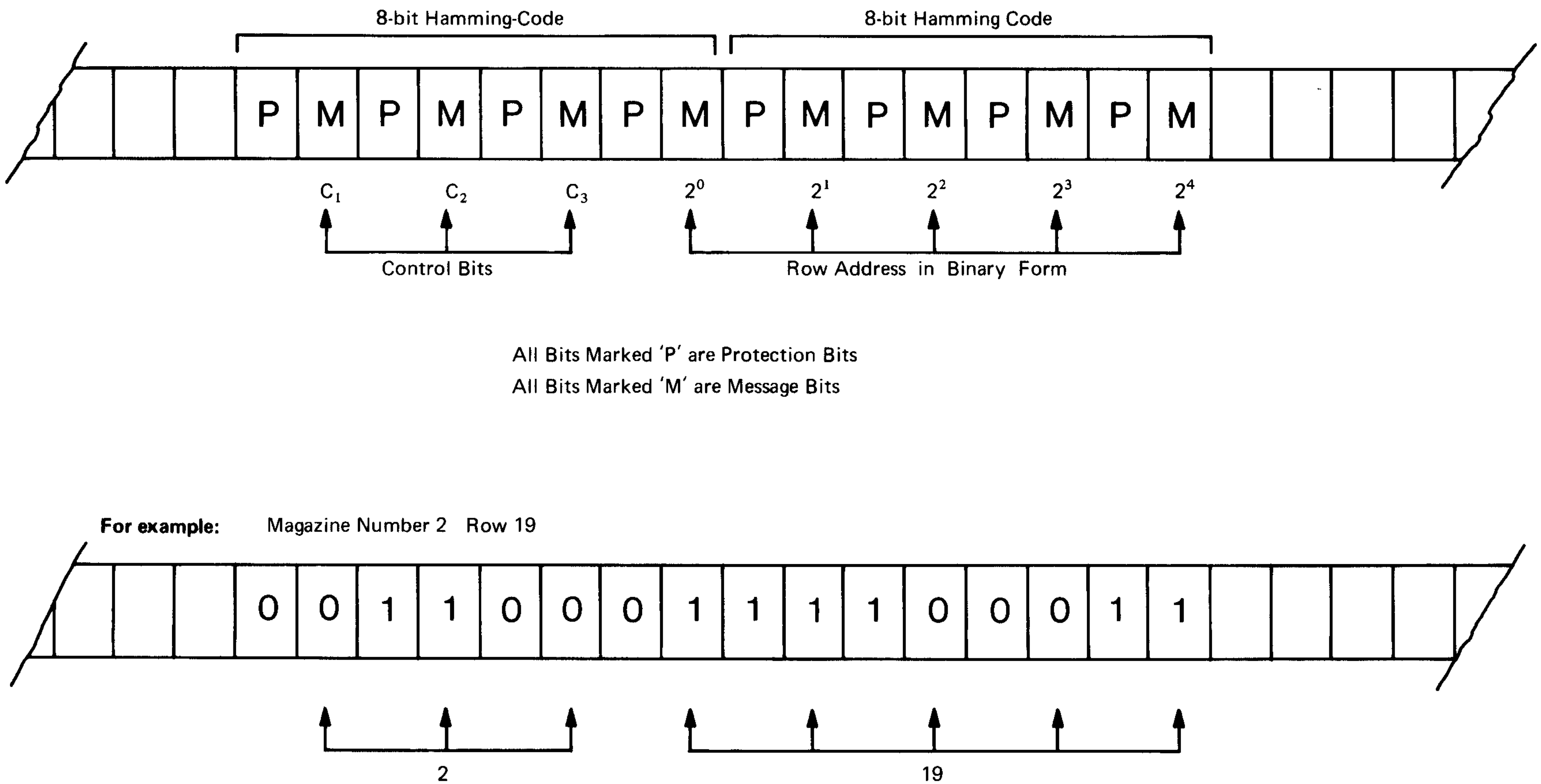


FIG. 5

ARRANGEMENT OF CONTROL AND ROW-ADDRESS GROUP FOR TRANSMISSION AS TWO 8-BIT HAMMING CODES

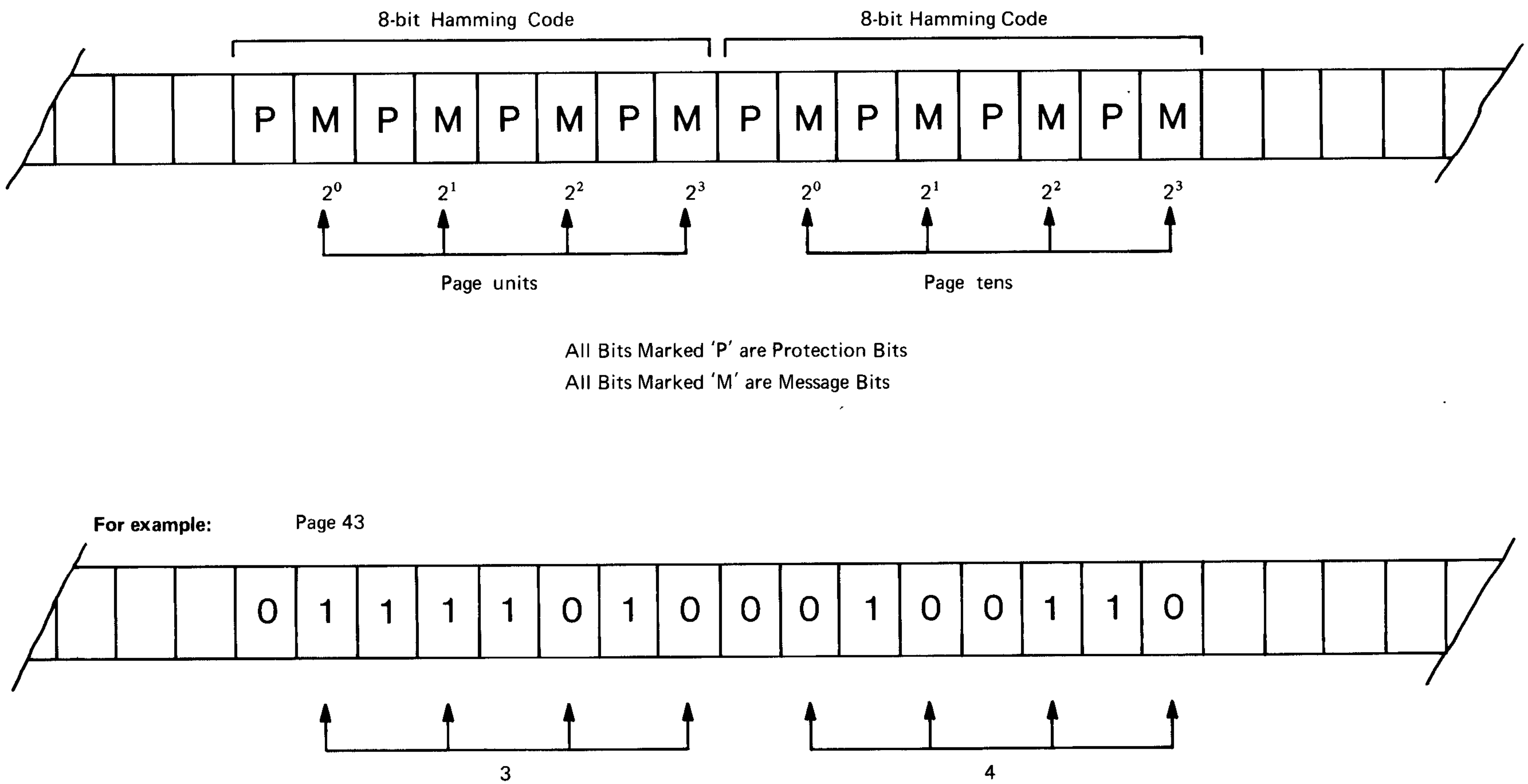


FIG. 6

ARRANGEMENT OF PAGE-ADDRESS FOR TRANSMISSION AS TWO 8-BIT HAMMING CODES

The 'Page Number' is in Binary-Coded-Decimal

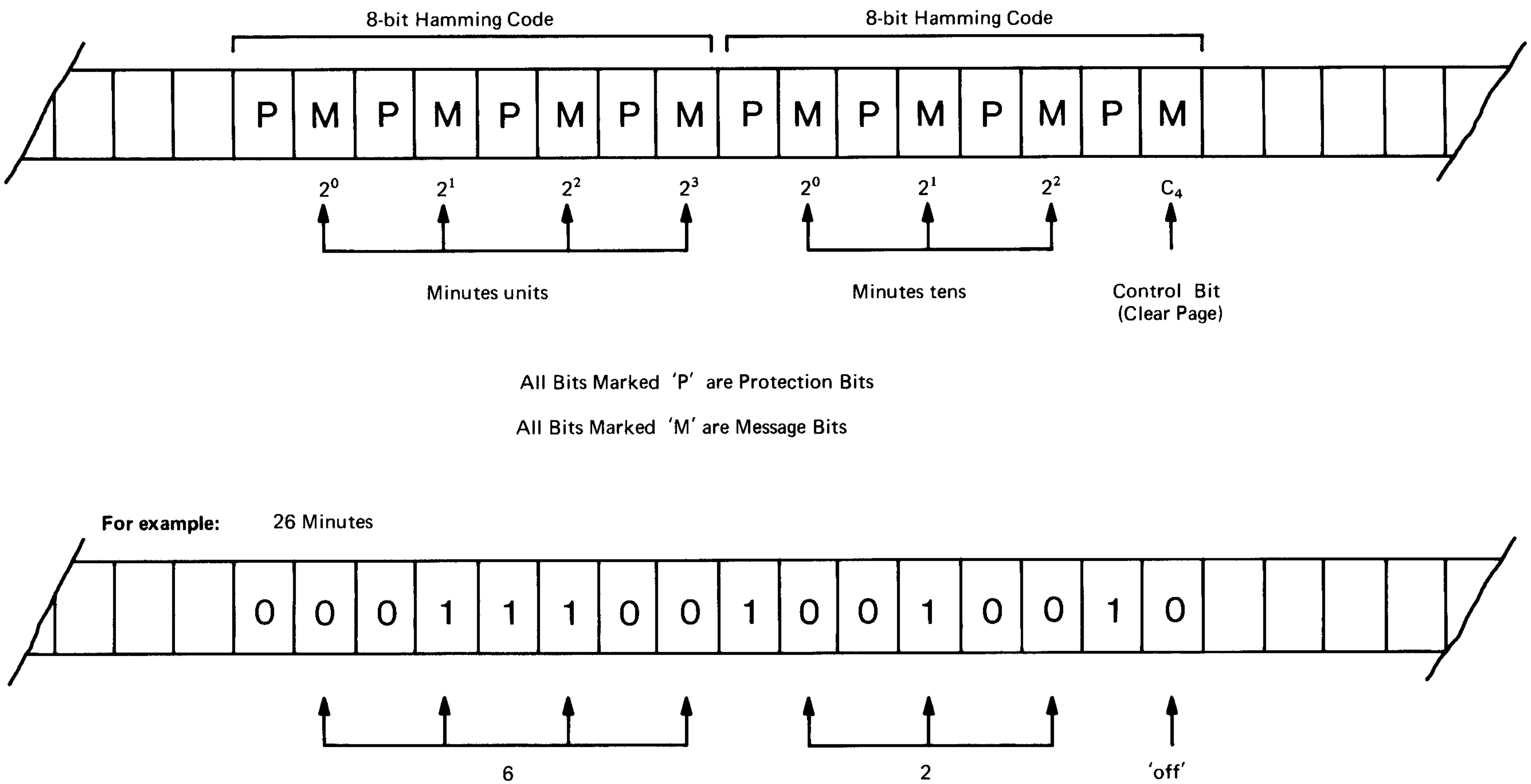


FIG. 7

ARRANGEMENT OF MINUTES ADDRESS FOR TRANSMISSION AS TWO 8-BIT HAMMING CODES

The 'Minutes Address' is in Binary-Coded-Decimal

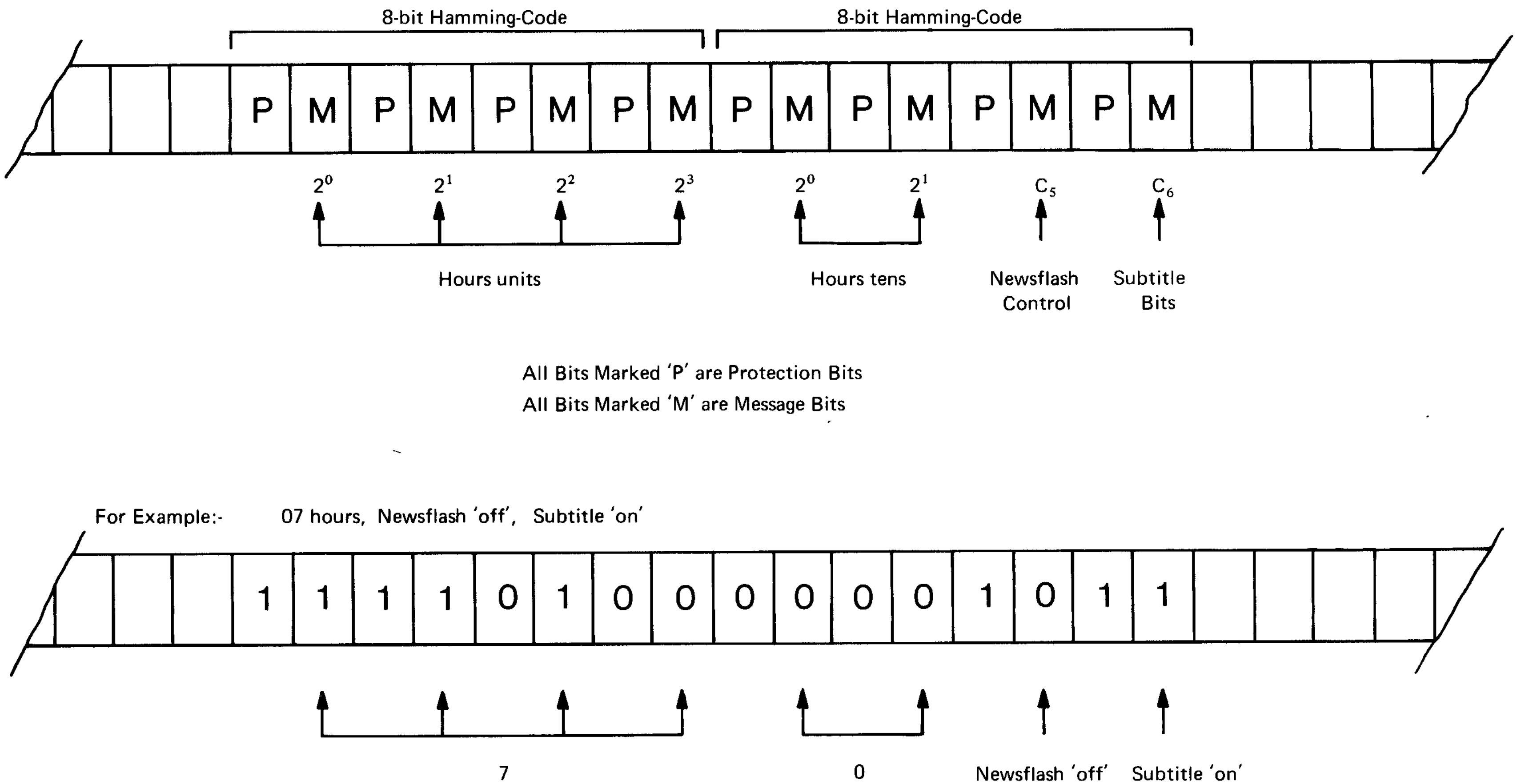


FIG. 8

ARRANGEMENT OF HOURS ADDRESS FOR TRANSMISSION AS TWO 8-BIT HAMMING CODES

The 'Hours Address' is in Binary-Coded-Decimal

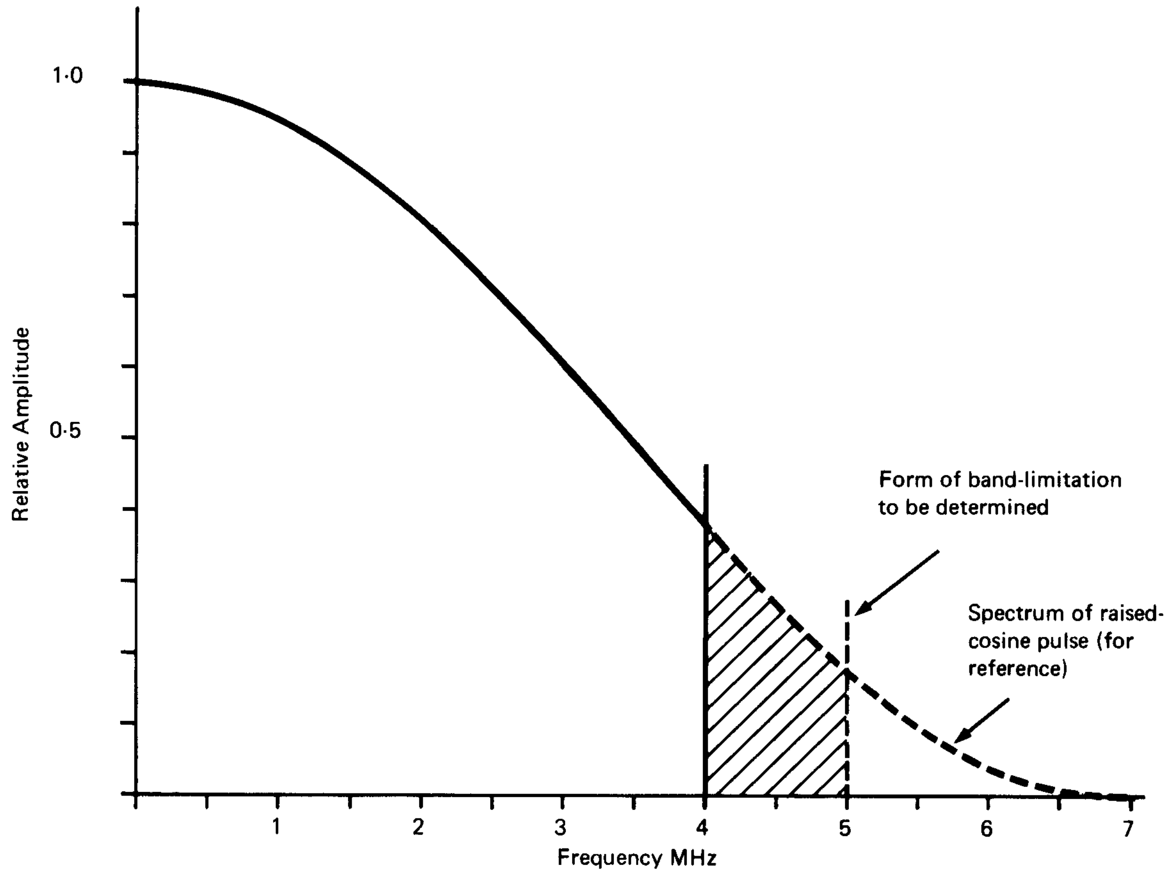


FIG. 9

APPROXIMATE SPECTRUM OF TRANSMITTED PULSE

THE TRANSMISSION OF GRAPHICS INFORMATION

1. General

The provision of a graphics facility is referred to in various parts of the main body of the Specification. In particular, changes between the alphanumerics and graphics modes are achieved by use of the control characters listed in Table 1. These control characters will be placed in the naturally-occurring spaces between alphanumeric text and graphic symbols.

It will be noted from Table 1 that all the control characters shown using column 1 of the ISO-7 table* are intended to set the receiver to either the graphics or the alphanumerics mode, depending upon whether bit b_4 is '0' or '1' respectively.

Each alphanumerics character, together with the spaces separating it vertically and horizontally from adjacent characters can be regarded as being located in a 'display rectangle'. In the graphics mode, each such display rectangle is divided into two parts in the horizontal direction and three parts in the vertical direction, to form six cells as shown in Fig. 10. A specific bit of the transmitted character code is allocated to each cell to define its 'on' (1) or 'off' (0) state; the allocation of data bits is also shown in Fig. 10. Thus, while in the alphanumerics mode, a character-generator in the receiver provides the signal for display, in the graphics mode the display is controlled directly from the six received data pulses which cause the corresponding cells in the display rectangle to be illuminated (1), or not (0).

Fig. 11 shows an example of the portrayal of both alphanumerics and graphics information.

2. Display Aspects

The height, in television lines, of the display rectangle will depend upon such factors as the total display height to be used in the receiver for 24 rows of characters or rectangles and the type of alphanumerics character-generator used. The receiver designer may wish to make the number of lines from each television field in the height of the display rectangle either 10 or 11 (20 or 22 raster lines). These numbers are not divisible by three and some asymmetry of the cell sizes must then be permitted. Also the cells may be either contiguous or separated. Methods of dividing the rectangles into six contiguous or separated cells are shown in Fig. 12. The example shown in Fig. 11 uses ten scanning lines divided in the ratio 3 : 4 : 3. Several methods of division into six cells will give an acceptable display but it is likely that, after a trial period, a preferred method will evolve.

* ie., ISO-7 location in Table 1 is prefixed 1/

3. Alphanumerics-with-Graphics

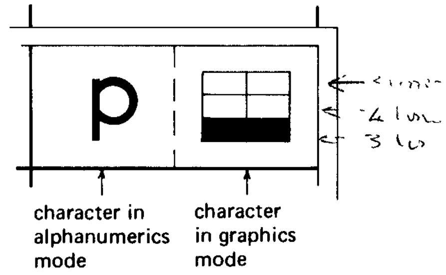
As has been seen from Fig. 10, bits 1, 2, 3, 4, 5 and 7 of the character code are used to control the illumination of the six cells of the display rectangle and hence the graphics character. For all graphics characters bit No. 6 will be '1'.

However, while still in the graphics mode, it is intended that the receiver should be able to display the equivalent ISO-7 alphanumeric mode capital alphabet character ('blast-through alphanumerics'). This is accomplished by transmitting bit No. 6 as '0' when those characters in columns 4 and 5 of the ISO-7 table (consisting mainly of the upper case alphabet) will be displayed, having been generated in the normal way by character-generator. This enables upper-case alphabetic characters to be mixed closely with graphics characters without using a control character and without the blank space this would cause to be displayed. Details of the character codes are shown in Fig. 13.

Table 5 lists all the character codes including the functions of the allocated control codes and the interpretation of the displayed character codes in the alphanumerics and graphics modes.

b4	b3	b2	b1	Row \ Column (b7 b6 b5)	0 (0 0 0)	1 (0 0 1)	2 (0 1 0)	2 graphics	3 (0 1 1)	3 graphics	4 (1 0 0)	4	5 (1 0 1)	5	6 (1 1 0)	6 graphics	7 (1 1 1)	7 graphics
0	0	0	0	0			SP		0		@ (2)	@ (2)(3)	P	P (3)	` (2)		p	
0	0	0	1	1		Graphics Red	!		1		A	A (3)	Q	Q (3)	a		q	
0	0	1	0	2		Graphics Green	"		2		B	B (3)	R	R (3)	b		r	
0	0	1	1	3	(1)	Graphics Yellow	£ (2)		3		C	C (3)	S	S (3)	c		s	
0	1	0	0	4		Graphics Blue	$		4		D	D (3)	T	T (3)	d		t	
0	1	0	1	5		Graphics Magenta	%		5		E	E (3)	U	U (3)	e		u	
0	1	1	0	6		Graphics Cyan	&		6		F	F (3)	V	V (3)	f		v	
0	1	1	1	7		Graphics White	'		7		G	G (3)	W	W (3)	g		w	
1	0	0	0	8			(		8		H	H (3)	X	X (3)	h		x	
1	0	0	1	9		Alpha^n Red	)		9		I	I (3)	Y	Y (3)	i		y	
1	0	1	0	10		Alpha^n Green	*		:		J	J (3)	Z	Z (3)	j		z	
1	0	1	1	11		Alpha^n Yellow	+		;		K	K (3)	[(2)	[(2)(3)	k		{ (2)	
1	1	0	0	12	Flash	Alpha^n Blue	,		<		L	L (3)	\ (2)	\ (2)(3)	l		| (2)	
1	1	0	1	13	Steady	Alpha^n Magenta	-		=		M	M (3)	] (2)	] (2)(3)	m		} (2)	
1	1	1	0	14	End Box	Alpha^n Cyan	.		>		N	N (3)	↑ (2)	↑ (2)(3)	n		— (2)	
1	1	1	1	15	Start Box	Alpha^n White	/		?		O	O (3)	_	_ (3)	o		DEL	

control characters (4)
(columns 1 and 2)
to be displayed as spaces



b_1	b_2
b_3	b_4
b_5	b_7

Graphics display rectangle showing the allocation of bit numbers to the individual cells

Notes

(1) This character code (position 0/3) is reserved for internal use by broadcasters

(2) UK version of national use character in the ISO-7 code

(3) In the graphics mode when bit 6 = 0 the corresponding alphanumerics-mode character should be displayed

(4) All character rows start in the 'Steady', 'Alphanumeric White' and 'unboxed' condition, without control characters.

TABLE 5

CHARACTER CODES FOR DATA BROADCASTING

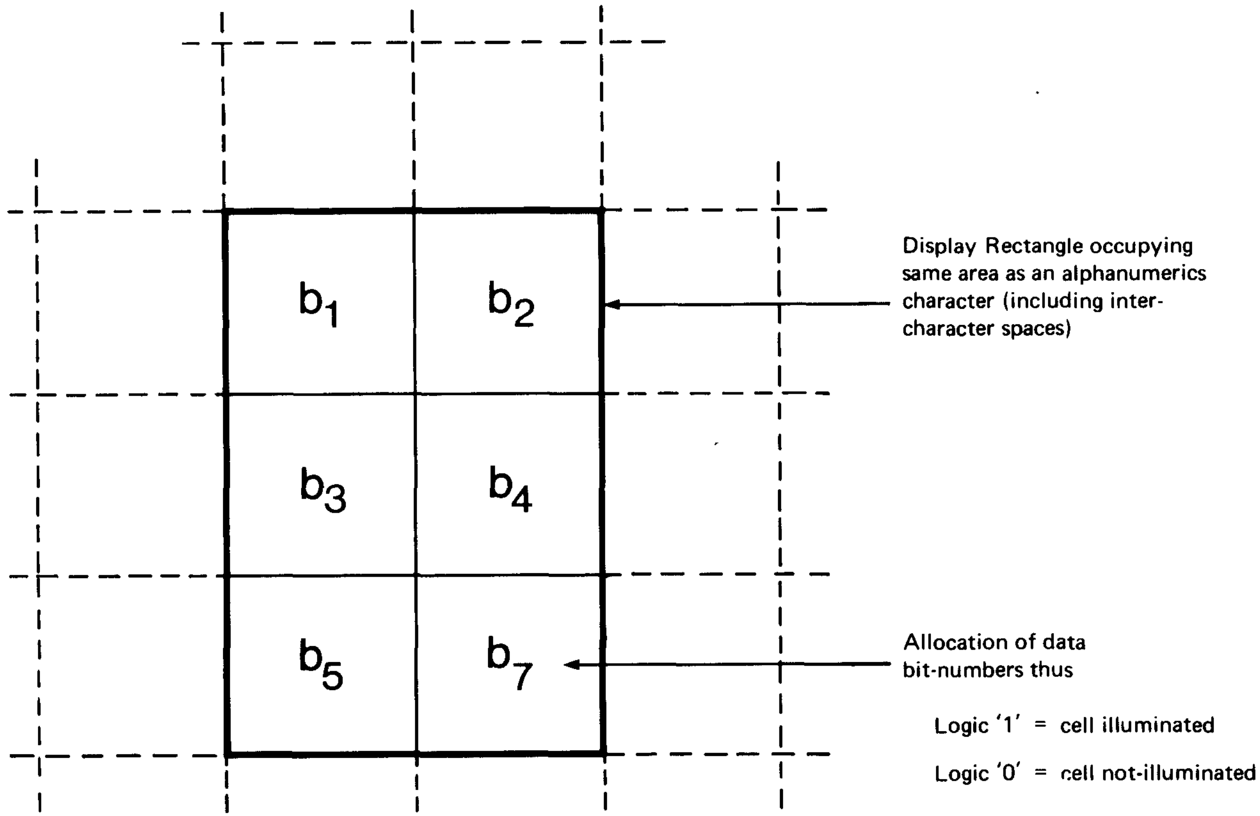
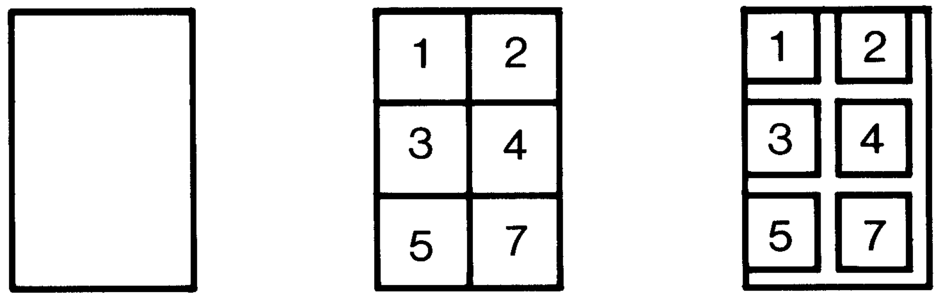


FIG. 10
GRAPHICS DISPLAY RECTANGLE

FIG. 11
A DISPLAY OF GRAPHICS WITH ALPHANUMERICS



Alphanumerics Character Rectangle

Rectangle with Graphics Cells Touching

Rectangle with Graphics Cells Separated

FIG. 12

EXAMPLES OF ALPHANUMERICS AND GRAPHICS DISPLAYS

Transmitted Bit-Number

	8	7	6	5	4	3	2	1
BIT 6 '1'	P		1					

Bits 1, 2, 3, 4, 5, 7 define graphics cell illumination

Transmitted Bit-Number

	8	7	6	5	4	3	2	1
BIT 6 '0'	P		0					

Bits 1, 2, 3, 4, 5, 7 define upper-case alphabet alphanumerics

P = Parity Bit

FIG. 13

CHARACTER CODES FOR GRAPHICS AND 'BLAST-THROUGH' ALPHANUMERICS

Appendix I

EXAMPLES OF TYPES OF PAGE

Type A

Simple pages, for selection by the viewer at any time and updated occasionally.

Type B

'Rotating' pages, in which case information for several pages would be presented under the same heading or page number and would be repeated in sequence, allowing the reader ample time to read each page and having an overall cycling time of several minutes. The repetition rate and number of these pages will be controlled by editorial decisions at the transmitting terminal and the receiver will merely respond to such decisions in exactly the same way as when Type A pages are updated and re-written.

Type C

Pages transmitted perhaps once only during a day and pre-selected according to a clock-time code. Such pages can be transmitted at the rate of one per minute to give a 'dial-now and read-later' facility at the receiver, a particular page being captured and stored for later reading.

The transmission of such a clock-time coded page will be initiated following the receipt of a minute time-pulse at the transmitting terminal. Thus the transmission of a page will take place according to the relative timings of the data cycle and clock-time. During the one-minute transmission period available, about four complete but identical pages will be transmitted to give added protection from interference.

Appendix II

THE FORM AND RECEPTION OF HAMMING-CODE* WORDS

1. The Form of the Code

The Hamming-Code words used for control and address transmissions are 8-bit words comprising 4 message-bits and 4 protection-bits. The use of 4 protection-bits permits any single error in the received code group to be corrected, and any double or other even number of errors (except 8) to be detected.

The order in which message and protection-bits are transmitted is immaterial from the point of view of code operation but for purposes outlined in Appendix III the order chosen is as follows:

Message-bits Nos. 2, 4, 6, 8
Protection-bits Nos. 1, 3, 5, 7

The bits are transmitted in numerical order beginning with number 1. Where the message represents a binary or BCD number, the first (lowest-numbered) message-bit is the least-significant bit.

Three protection-bits are used to ensure that odd parity is maintained over designated groups of bits in the code word as transmitted. Parity checking of these groups of bits in the word, as received, reveals the presence of errors, the outputs of the parity checker can be taken as a three-bit word describing the bit-position of the erroneous bit. That bit can then be corrected by simply complementing it.

The fourth parity check is performed over the entire code group. Satisfaction of this check, when some or all of the other checks fail, indicates the presence of an even number of errors.

Although the code provides for the correction of a single error in any of the eight bits, an economy of equipment at the receiver would normally be achieved by correcting only the message bits.

The complete code proposed is shown in Table 3. The four parity checks are as follows:

Parity check A is carried out over bits 1, 2, 6, 8
Parity check B is carried out over bits 2, 3, 4, 8
Parity check C is carried out over bits 2, 4, 5, 6
Parity check D is carries out over all bits.

Table 4 indicates the appropriate action to correct single errors, ie., it gives the parity failure decode routing when failure of the individual checks produces a '1' at each checker output. It also indicates the conditions recognised as double errors, namely $\bar{D} \cdot (A + B + C)$.

2. Reception and Correction of the Code

Fig. A1 shows the equipment necessary to receive the code, correct single errors and reject even-numbered errors (except eight). Only the message-bits are corrected.

Portions of the parity checkers may be combined for economy, but are shown separately in the figure for clarity.

* Hamming R.W., 1950 Error detecting and error correcting codes.
Bell System Technical Journal Vol. 29 No. 2 pp 147-160.

Appendix III

THE TRANSPOSITION OF HAMMING-CODED INFORMATION TO AID THE DESIGN OF A SIMPLE RECEIVER

The eight-bit Hamming-Code* words used for control and addressing each consist of 4 message-bits and 4 protection-bits. Under good reception conditions the protection-bits might not be necessary and, for simple receivers, it might therefore be advantageous if the message-bit could be extracted from the data-word in a simple way.

In one possible method, the group of protection-bits could be sent first, before the message-bits in serial transmission. Then, on reception, the eight-bits could be clocked at normal bit-rate into a 4-bit shift-register. Thus, after eight clock-pulses, the first four (protection) bits would have passed right through the register and have been lost and the last four (message) bits would be in the register, ready for analysis.

Using a method such as this, however, problems arise in the case of row addresses because more than four message-bits are required for the message and two successive data-words thereby become involved. If message-bits from two separate words were to be assembled in a single register, on reception, some form of intermittent clocking would be required to avoid the four protection-bits which occur between each group of message bits.

It is arranged that, in each eight-bit Hamming-Code word, the protection-bits are interleaved serially with the message-bits for transmission. On reception, it is then possible to clock a shift-register only when alternate bits are present (ie., at half normal clock-rate) and thus to fill the register with only the protection-bits or only the message-bits, according to the clock-phase. This is a process which can continue across word boundaries and the message-bits from any number of Hamming-Code words (4 message-bits per word) can be assembled into a single register of suitable length.

In the receiving equipment there must already exist a divider which divides the incoming clock-rate by eight, in order to identify the beginning of each new data-word. The output of the first stage of this divider thus will provide a convenient source of half-clock-rate waveform which may be used to clock the shift-register. This waveform will have a transition during each incoming bit period and the transitions will either be positive during message-bits and negative during protection-bits or vice versa depending upon the system design. It will be necessary to ensure that the register is clocked from the type of transition which occurs during each message bit. Once the correct clock-phase has been chosen it will remain correct because the divide-by-eight counter will count in the same way for all data words.

Appendix IV

CLOCK RUN-IN AND FRAMING CODE

All data systems require 'preamble' signals to ensure, at the receiver, both that the decoding clock-pulses start up in the correct phase relative to the data bits to follow and that the necessary framing is achieved to identify the start of the message. The clock run-in is formed from a simple 1010.... sequence 16 bits in length. The eight-bit framing code has been devised after computer-analysis of all 256 (2^8) possibilities. It begins at the end of the clock run-in sequence as shown in Fig. A2.

The eight-bit framing code is also used as a test word in the receiver which is compared with the incoming data as it passes through a shift-register. When the eight bits of the test word correspond with eight bits of the incoming data a start-pulse is produced. By careful choice of the framing code it has been arranged that, before the incoming data has reached the correct position, the number of bits of the incoming data which correspond with the bits of the test word never exceeds five out of the total of eight. Fig. A3 shows the principle.

An error in one of the incoming data bits being compared with the test word could thus increase the number of corresponding bits to 6 or reduce it to 4. If 7 or 8 correspondences are accepted as recognition of the framing code, then the framing code itself may have one bit in error and still be correctly recognised.

False recognition of the framing code will not occur until there are at least two incorrect bits in any group of eight bits. These two incorrect bits must also be in positions where they increase the number of correspondences with the test word; greater numbers of incorrect bits are tolerable in some positions.

The cost, complexity, and package-count for a circuit which will detect the framing code in the presence of a one-bit error are about the same as for the early system used in CEEFAX and ORACLE. A simple detection system not allowing for recognition in the presence of an error would, of course, be cheaper.

It is thought that in practice the search for correspondence between the test word and the framing code in a decoder could be made from the beginning of the

* Hamming R.W., 1950 Error detecting and error correcting codes.
Bell System Technical Journal Vol. 29 No. 2 pp 147-160.

active television line until just after the expected position of the framing code. This interval could be timed by a 'monostable'.

Because the bits forming the clock-run-in must start the clock-generator before they can be clocked into the shift-register for comparison, those at the beginning of the sequence may be missed by the shift register. However, it will be seen that the system will in fact continue to work even if all of the clock-run-in bits are missed.

A possible circuit for this application is shown in Fig. A4.

Appendix V

PAGE-HEADER DISPLAY

Data transmitted on the Page-Header will fall into two categories:-

1. **Addressing data**, containing page numbering and other information. This is not intended to be displayed by the receiver, and is described in Section 2.15.

2. **Display data**, coded in ISO-7 form, intended to be displayed as Row '0', ie., the top row of the page.

The display data will have the same form on each Page-Header, and will contain the following information:

1. **The name**	eg. CEEFAX or ORACLE
2. **The page and magazine number**	eg. P 309
3. **The day of the week**	eg. Thu (Thursday)
4. **The date**	eg. 28 Feb.
5. **The time of day**	eg. 14.05/34 (hours. mins/secs)

The form of display of this information is shown in Fig. A5.

The time of day contains 'seconds' information; it follows that, for a useful display of seconds, the time of day should be extracted from every Page-Header incoming to the receiver. If the remaining parts of the Page-Header are similarly extracted from every Page-Header, the page number will change every quarter-second, ie., at the page-writing interval (thus indicating the number of the page being transmitted at the time). The receiver designer may decide to display the page number in this way, or to arrange that the page number is extracted only from the Page-Header of the selected page (thus indicating the number of the page being displayed).

Appendix VI

THE DISPLAY OF NEWS-FLASHES AND SUBTITLES

Characters intended for display as news-flashes or subtitles are intended to be superimposed on the picture. Characters may, for example, be simply added directly to the picture signal, or they may be 'keyed-in' by means of a video switch used to switch between the television picture signal and the signal describing the alphanumeric characters, thus creating a 'box', as shown in Fig. A6. Control of the switching signal is by means of transmitted control-characters, as detailed in Section 2.16 and Table 1, the characters being used to 'open' and 'close' the box. Each of these control characters is transmitted twice, as shown, to provide additional ruggedness under conditions of interference. The box should be opened between the pair of 'Start Box' control characters and closed either after the first of a pair of 'End Box' control characters or on reaching the end of a row.

The box may be up to 39 characters in width (ie., advisably a maximum of 37 displayed characters) and of any shape, according to the transmitted control-characters, as shown in Fig. A6; a short box (ie., less than 39 characters) will necessarily have control-characters located at each end of each row of the box.

The control-characters must be suppressed in the receiver by being displayed as 'space' characters.

Of course, other methods of display are possible for news-flashes or subtitles, according to the wishes of the receiver designer.

Appendix VII

SPECTRUM OF TRANSMITTED DATA SIGNALS

Reception tests have shown that the noise-immunity of data transmitted over the television channel is not significantly less for data at a rate of just under 7MBits/s than for data at the lower rate of 4·5 MBits/s.

The results were in agreement with theory which suggests that 7·8 MBits/s may readily be transmitted in a 5·5 MHz bandwidth.

The above tests were carried out using raised-cosine data pulses, the spectra of which were truncated at 4·4 MHz before transmission by means of a sharp-cut, phase-corrected low-pass filter.

The band limitation was introduced at the transmitter to prevent the pulse-shape depending upon the variable characteristics at the limit of the pass-band of domestic receivers. The cut itself modifies the shape of the raised-cosine data-pulse diminishing the pulse-power and causing an overswing of about 7%.

Fig. 9 shows the approximate pulse-spectrum. Further work to optimise the characteristics of the band-limiting filter is in progress.

Appendix VIII

TRANSMISSIONS FOR LOW-COST RECEIVERS

Consideration has been given to special transmissions for low-cost receivers and, to keep this option open, this specification has been prepared with the possibility in mind. No details of the transmissions had been decided at the time this specification was printed.

Receivers of the transmissions would not employ a conventional character-generator and would probably display a short row of special characters, perhaps moving horizontally in 'Times Square' fashion.

The low-cost receiver transmissions would use a special method of coding (which might allow self-clocking decoding in the receiver) and the signals would be ignored by normal receivers. It is envisaged that the additional transmissions could be carried by the same data lines used for normal transmissions, in place of the normal data and at widely and uniformly space intervals. The exact method will depend upon the way in which the details of the transmission sequence evolve during the forthcoming months. For example, the option of row-adaptive working is still open* and, if this option is taken up (following discussions with receiver designers) the transmissions for low-cost receivers would be greatly facilitated.

* See Section 2.5

Appendix IX

Constitution of BBC/BREMA/IBA Executive Committee and its Combined Working Group

a) Executive Committee

K.I. Jones, OBE	(BREMA)
J. Redmond	(Director of Engineering, BBC)
K.S. Spencer, **(Chairman)**	(BREMA)
F.H. Steele	(Director of Engineering, IBA)

b) Combined Working Group

S.M. Edwardson	BBC Research Department
W.J. Pitts	Decca Radio & Television Ltd.
J. Schaffer	Decca Radio & Television Ltd.
Dr. A.J. Biggs	General Electric Co. Ltd.
B.S. Barnaby	General Electric Co. Ltd.
W.N. Anderson, OBE	IBA Experimental and Development Department
G.A. McKenzie	IBA Automation and Control Section
W.A. Montgomery	ITT Consumer Products (UK) Ltd.
R.A. Dilworth	Ministry of Posts and Telecommunications (subsequently the Home Office)
P.L. Mothersole	Philips Electrical Ltd.
G.O. Crowther	Philips Electrical Ltd.
B. Pike	Pye Ltd.
B.J. Rogers	Rank Radio International Ltd.
H.L. Baker	Rediffusion Consumer Electronics Ltd.
K.I. Jones, OBE, **(Chairman)**	Thorn Consumer Electronics Ltd.

Secretaries

D.P. Doo	(BREMA)
J.L. Singer	(BREMA)

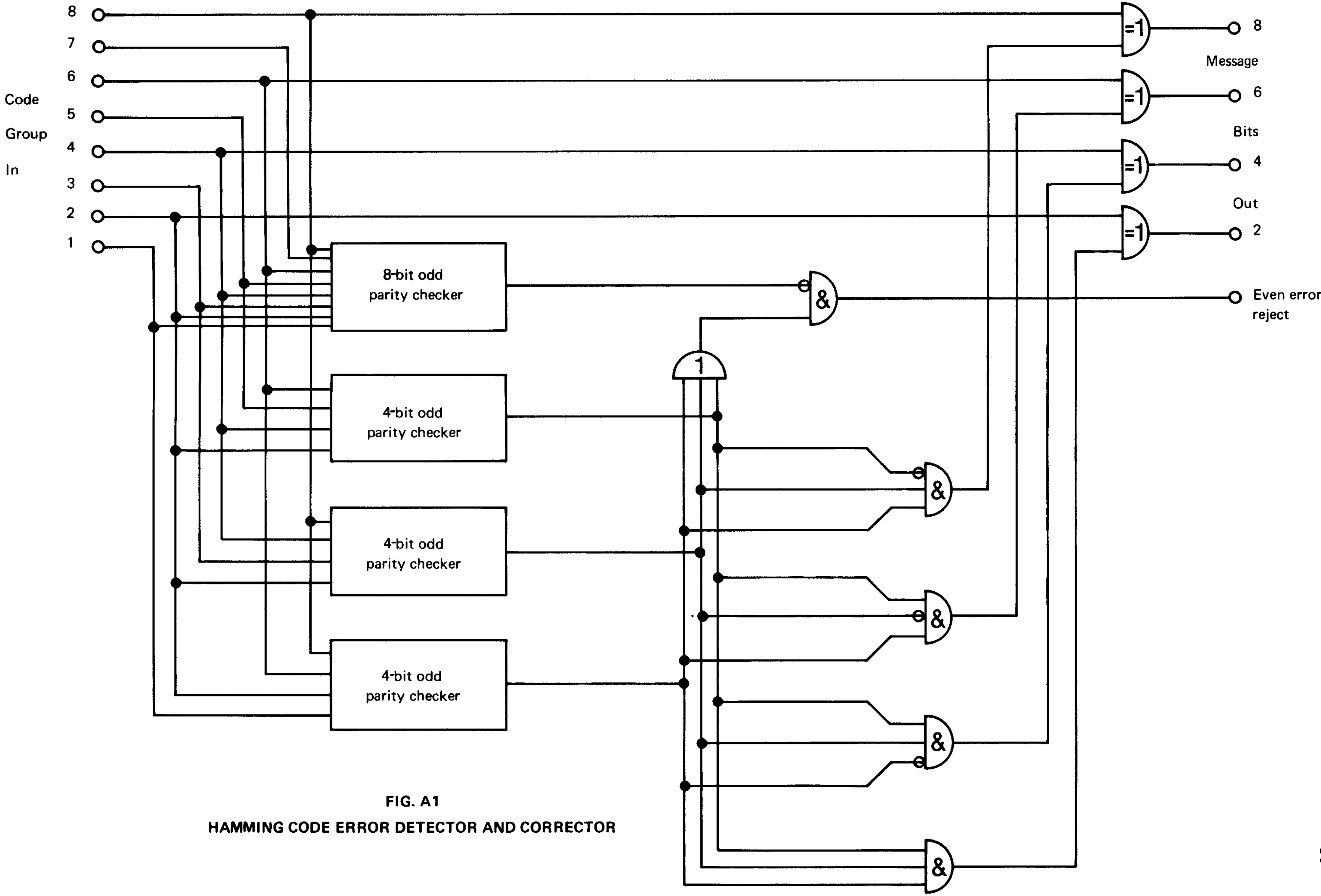


FIG. A1

HAMMING CODE ERROR DETECTOR AND CORRECTOR

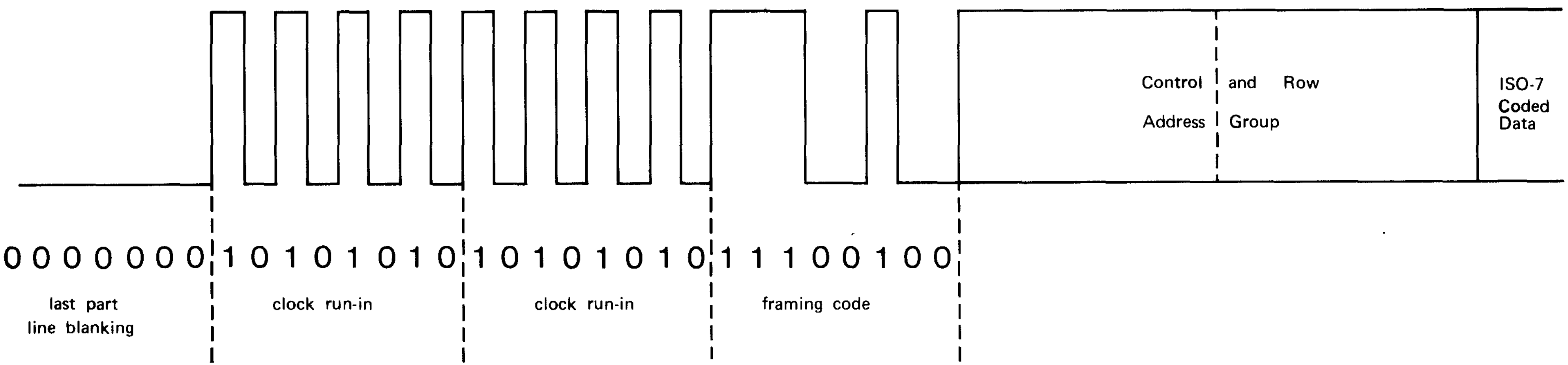
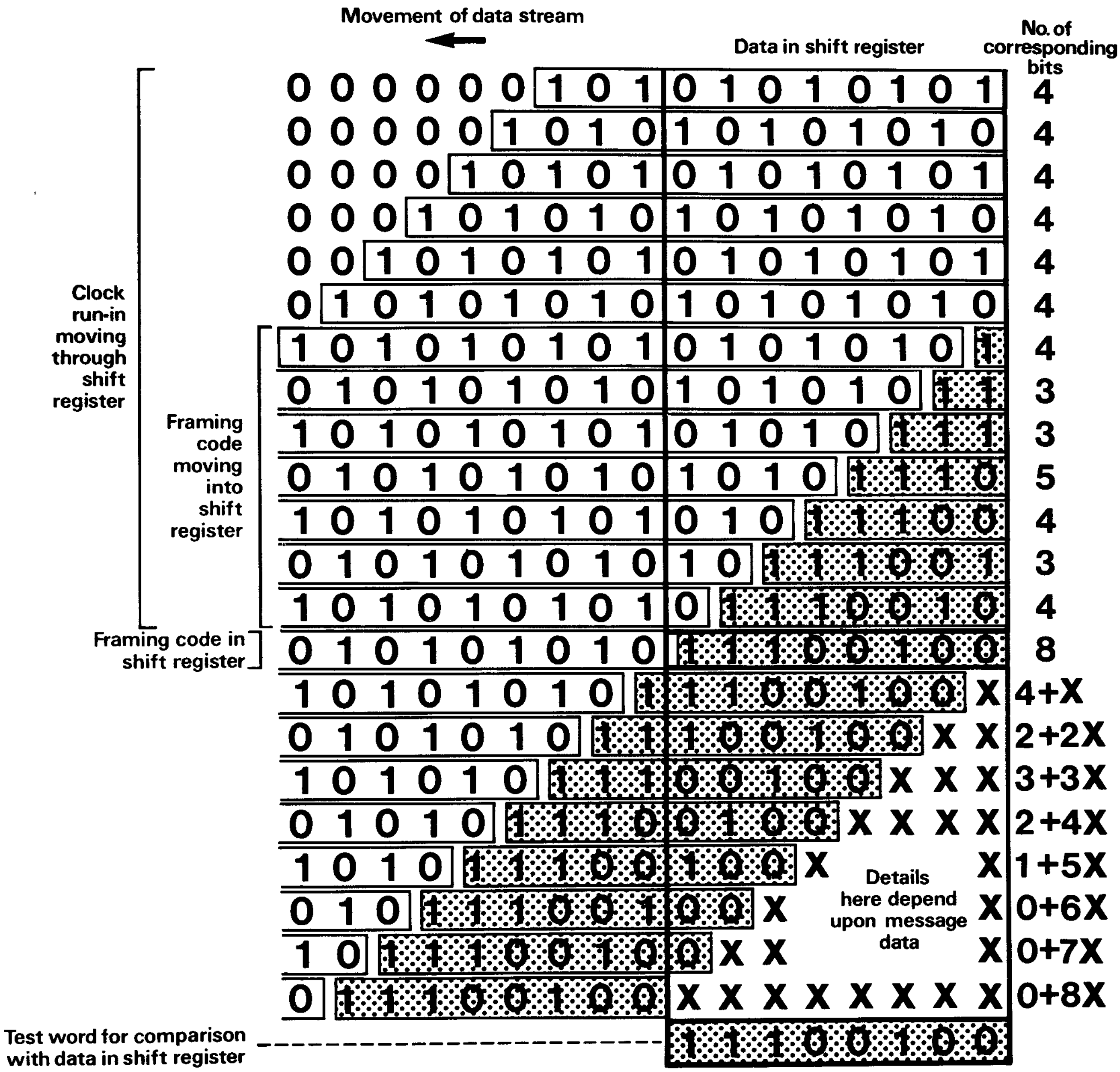


FIG. A2

CLOCK RUN-IN AND FRAMING CODE



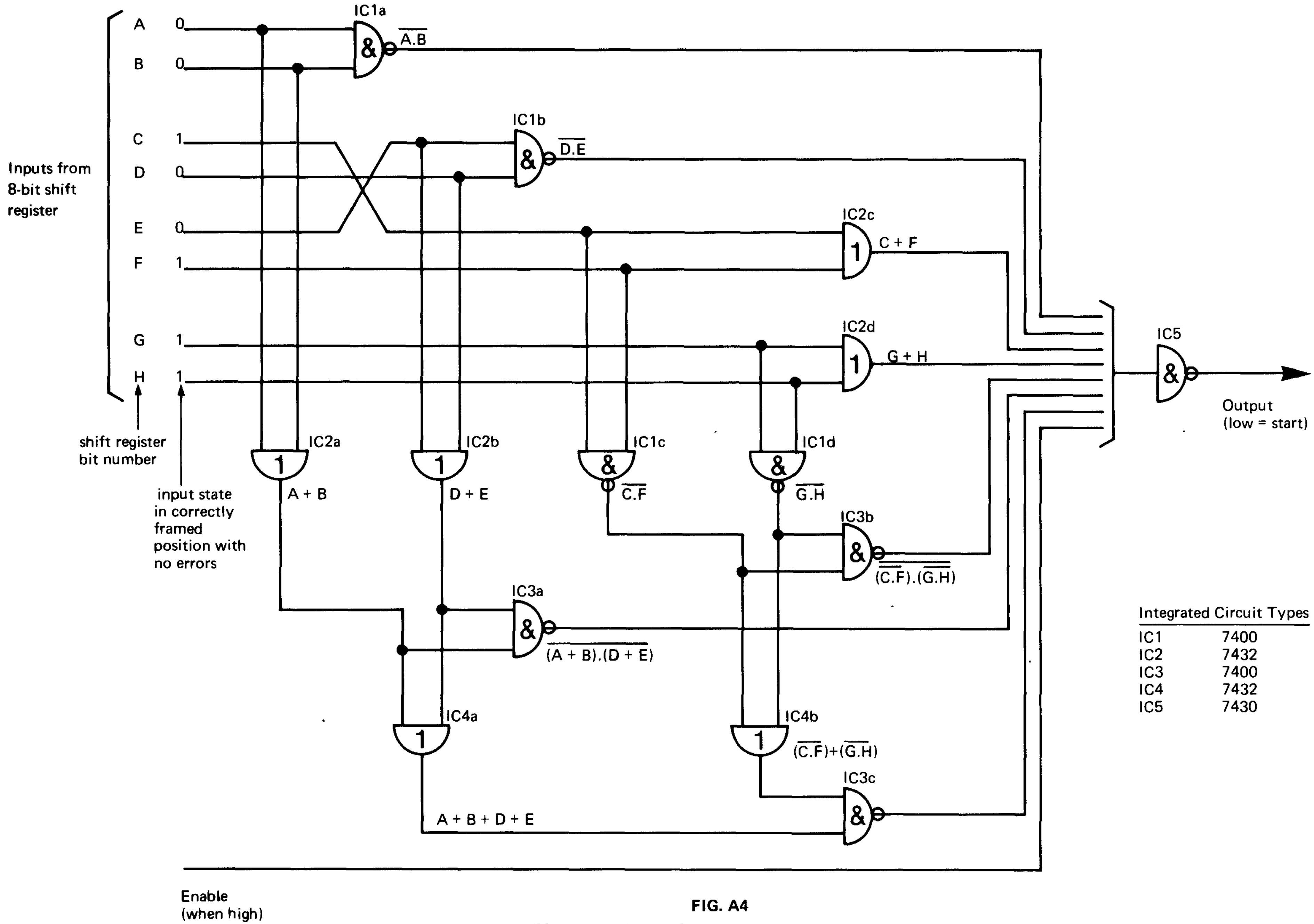
X represents a bit in the control and row address group

For clarity the framing code group has been shaded

FIG. A3

OPERATION OF FRAMING CODE

Diagram showing contents of shift register in each clock period



Integrated Circuit Types	
IC1	7400
IC2	7432
IC3	7400
IC4	7432
IC5	7430

FIG. A4
POSSIBLE CIRCUIT FOR FRAMING-CODE DETECTOR

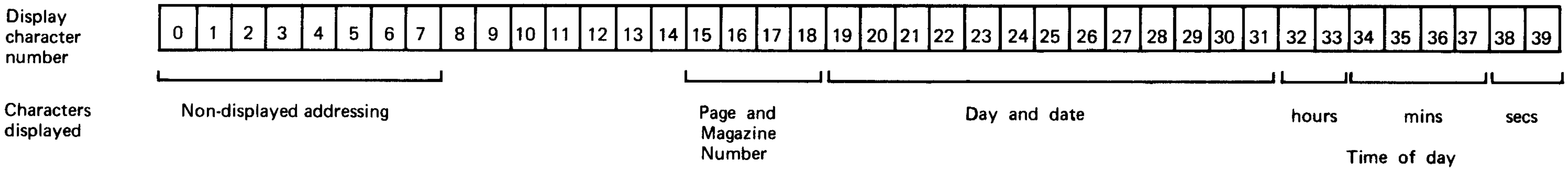


FIG. A5
ARRANGEMENT OF PAGE HEADER DISPLAY

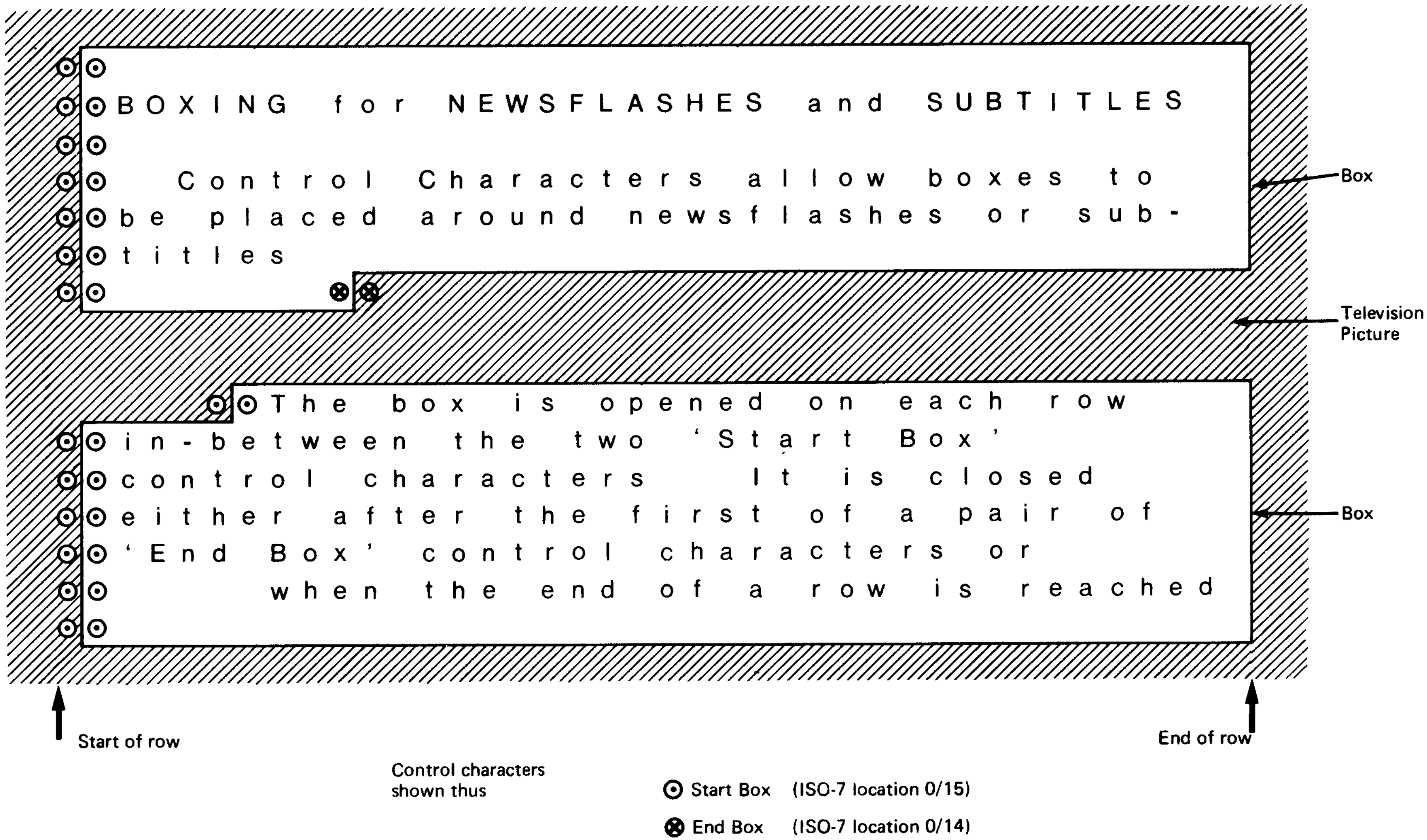


FIG. A6
DETAILS OF NEWSFLASH AND SUBTITLE BOXING