(12) STANDARD PATENT (11) Application No. **AU 2005283852 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Burst transmission in a digital broadcasting network

(51) International Patent Classification(s)
H04H 20/95 (2008.01) *H04H 60/07* (2008.01)
H04L 1/00 (2006.01)

(21) Application No: **2005283852** (22) Date of Filing: **2005.08.12**

(87) WIPO No: **WO06/030329**

(30) Priority Data

(31) Number	(32) Date	(33) Country
0420540.7	**2004.09.15**	**GB**

(43) Publication Date: **2006.03.23**
(44) Accepted Journal Date: **2010.03.04**

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(56) Related Art
WO 2003/001338 A2
US 2003/0002499 A1

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 March 2006 (23.03.2006)

PCT

(10) International Publication Number
WO 2006/030329 A1

(51) International Patent Classification:
H04H 1/00 (2006.01) *H04L 1/00* (2006.01)

(21) International Application Number: PCT/IB2005/052677

(22) International Filing Date: 12 August 2005 (12.08.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0420540.7 15 September 2004 (15.09.2004) GB

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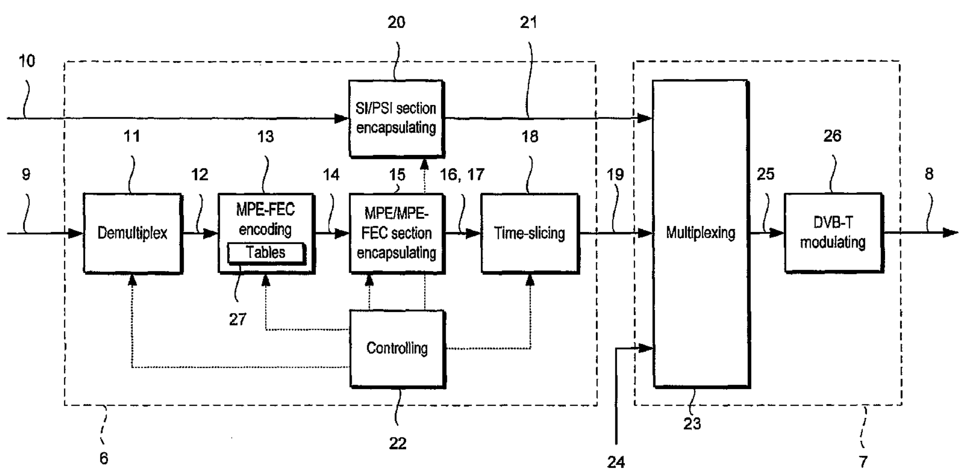
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: BURST TRANSMISSION IN A DIGITAL BROADCASTING NETWORK



(57) Abstract: A multiprotocol encapsulation forward error correction (MPE-FEC) frame comprising datagrams and FEC data. An MPE encapsulator places datagrams in MPE sections and FEC data in MPE-FEC sections. A time slicing block forms a sequence of bursts and dividing the MPE-FEC frame between bursts, such that MPE sections are sent in at least two bursts. The time slicing block add a burst number parameter to headers of the MPE and MPE-FEC sections to enable a terminal to determine whether to expect further bursts carrying data from the MPE-FEC frame.

WO 2006/030329 A1

Burst transmission in a digital broadcasting network

Field of the Invention

The present invention relates to a method of transmitting bursts in a digital broadcasting network, particularly, but not exclusively, to a method of transmitting bursts in a digital video broadcasting (DVB) network.

The present invention also relates to a network element for preparing bursts to be transmitted in a digital broadcasting network, particularly, but not exclusively, to a multiprotocol encapsulator (MPE) for use in a DVB network.

The present invention further relates to a terminal for receiving data from a digital broadcasting network, particularly, but not exclusively to a mobile, handheld terminal for receiving data from a DVB network

Background Art

ETSI EN 302 304 "Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H)" V1.1.1 (2004-06) specifies a system for delivering multimedia services via DVB networks to mobile, handheld terminals. The system is based on DVB data broadcasting specified in ETSI EN 301 192 "Digital Video Broadcasting (DVB); DVB Specification for data broadcasting" V1.4.1 (2004-06).

In DVB data broadcasting, data is delivered to a terminal in datagrams, which are placed in sections using Multi-Protocol Encapsulation (MPE). MPE sections in turn are mapped into MPEG-2 Transport Stream (TS) packets in accordance with ISO/IEC Standard 13818-1 "Information Technology-Generic coding of moving pictures and associated audio information: Systems" for transmission.

It is more difficult to receive data at a mobile, battery-powered terminal, than it is to a static, mains-powered terminal. For example, mobile reception is particularly prone to impulse noise. Furthermore, terminal battery power is limited.

DVB-H employs forward error correction (FEC) to provide robustness against noise and uses time slicing to allow a terminal to conserve battery life.

Data and associated FEC parity data may be prepared in a data frame known as an MPE-FEC frame and reference is made to Clause 9.3 in EN 302 304 *ibid.*.

A conventional MPE-FEC frame is arranged as a matrix with 255 columns and a flexible number of rows. The number of rows is signaled in service information (SI) and can have a value of up to 1024. Each position in the matrix holds a byte of data and so an MPE-FEC frame can hold up to almost 2 Mbits of data.

The left part of the MPE-FEC frame, consisting of the 191 leftmost columns, is dedicated to OSI layer 3 (in other words, Network layer) datagrams, such as Internet Protocol (IP) datagrams, and possible padding, and is called the application data table. The right part of the MPE-FEC frame, consisting of the 64 rightmost columns, is dedicated for the parity information of the FEC code and is called the RS data table. Each byte position in the application data table has an address ranging from 0 to 191 × no_of_rows - 1. Similarly, each byte position in the RS data table has an address ranging from 0 to 64 × no_of_rows - 1.

Layer 3 datagrams are introduced datagram-by-datagram, starting with the first byte of the first datagram in the upper left corner of the matrix and going downwards to the first column. The length of the datagrams may vary arbitrarily from datagram to datagram. Immediately after the end of one datagram, the following datagram starts. If a datagram does not end precisely at the end of a column, it continues at the top of the following column. When all datagrams have entered the application data table any unfilled byte positions are padded with zero bytes, which makes the leftmost 191 columns completely filled.

With all the leftmost 191 columns filled it is now possible, for each row, to calculate the 64 parity bytes from the 191 bytes of data and possible padding. The code used is Reed-Solomon RS(255,191,64). Each row then contains one RS codeword. Some of the rightmost columns of the RS data table may be discarded and hence not transmitted, to enable puncturing. The exact number of punctured RS columns does not need to be explicitly signaled and may change dynamically between frames. Thus, the RS data table is filled and the MPE-FEC frame is completed.

IP datagrams are mapped into MPE sections and RS columns are mapped into MPE-FEC sections.

The datagrams are carried in MPE sections in compliance with the DVB standard, irrespective of whether MPE-FEC is being used. This makes reception fully backwards compatible with MPE-FEC ignorant receivers. Each section carries a start address for the payload in the section header. This address indicates the byte position in the application data table of the first byte of the section payload. In case the datagram is divided over multiple MPE sections, each MPE section indicates the byte position in the application data table of the first byte of the datagram fragment carried within the section. The receiver will then be able to put the received datagram in the right byte positions in the application data table and mark these positions as "reliable" for the RS decoder, provided the section CRC-32 check shows that the section is correct.

The last section of the application data table contains a table boundary flag, which indicates the end of the datagrams within the application data table. If all previous sections within the application data table have been received correctly the receiver does not need to receive any MPE-FEC sections and, if time slicing is used, the receiver can be switched off without receiving and decoding RS data. If MPE-FEC sections are also received, the number of padding columns (columns filled with padding bytes only) in the application data table is indicated with 8 bits in the section header of the MPE-FEC sections; this value is used if RS decoding is performed.

RS columns are carried in MPE-FEC sections. Each section carries exactly one column of the RS data table. Punctured columns are not transmitted and not signalled explicitly.

Data can be transmitted in time-slicing bursts and reference is made to Clause 9.2 in EN 302 304 *ibid.*.

Time slicing involves sending data in bursts using significantly higher bit-rate compared to the bit-rate required if the data was transmitted using conventional bandwidth management. Within a burst, the time before the start of the next burst (delta-t) is indicated. Between the bursts, data of the elementary stream is not transmitted, allowing other elementary streams to use the bandwidth otherwise allocated. This enables a receiver to stay active only for a fragment of the time, while receiving bursts of a requested service.

Conventionally, the contents of one MPE-FEC frame is transmitted in one time-sliced burst. However, this arrangement suffers at least two drawbacks.

Firstly, the interleaving length of the application data and RS data is short and so the burst is still prone to noise. One solution is to lengthen the duration of the burst. However, this reduces the benefit of time slicing.

Secondly, if a burst carries data for more than one service, then the same level of error protection is used.

Summary of the Invention

The present invention seeks to provide a method of transmitting bursts in a digital broadcasting network, a network element for preparing bursts for transmission in digital broadcasting network and/or a terminal for receiving bursts from a digital broadcasting network.

According to a first aspect of the present invention there is provided a method comprising providing a first data frame, the data frame comprising data and forward error correction (FEC) data, forming a sequence of transmissions and dividing the first data frame between said transmissions, the data being divided between at least two transmissions. Thus, the interleaving length of the data frame can be increased.

At least one transmission may not include FEC data.

The method may further comprise providing a second data frame, the second data frame comprising data and FEC data, and dividing the data and the FEC data in the second data frame between the plurality of transmissions. The method may comprise dividing the first data frame into a first set of data frame blocks, dividing the second data frame into a second set of data frame blocks, interleaving the first and second sets of data frame blocks and sequentially placing the interleaved data frame blocks into the plurality of transmissions.

According to a second aspect of the present invention there is provided a method comprising providing a first data frame, said first data frame comprising data and forward error correction (FEC) data, providing a second data frame, said second data frame comprising data and FEC data and forming a transmission comprising said first and second data frames. Thus, if it is desired to transmit the first and second sets of data with different levels of forward error correction, they can still be transmitted in the same transmission.

The method may further comprise providing each data frame with a respective label for identifying an origin of the data. The method may further comprise providing each data frame with a respective label for locating the data frame in a sequence of data frames. The method may further comprise providing each transmission with a respective label for identifying the transmission within a sequence of transmissions. Providing the first data frame may comprise providing a first array comprising first and second portions, filling at least a part of the first array-portion with the data, determining FEC data in dependence upon the data in the first array- portion and placing said FEC data in the second array-portion. The method may comprise encapsulating the data into a first set of multiprotocol encapsulation (MPE) sections and encapsulating said corresponding FEC data into a second set of MPE sections. Forming said plurality of transmissions may comprise arranging said first and second sets of MPE sections temporally-offset groups. The first data frame may be a multiprotocol encapsulation-forward error correction (MPE-FEC) frame.

According to a third aspect of the present invention there is provided a method comprising receiving a first transmission, said transmission including data for a data frame, placing said data in a data frame, extracting, from said first transmission, an indication that a second transmission in a sequence of transmissions which includes said first transmission will follow, receiving said second transmission, said second transmission including further data for said data frame and placing said further data in said data frame.

According to a fourth aspect of the present invention there is provided a method comprising receiving a transmission, said transmission including data for a plurality of data frames, extracting sets of data from said transmission together with indications to which data frame said sets of data belong and placing each set of data in a corresponding data frame.

According to a fifth aspect of the present invention there is provided a computer program comprising instructions for causing data processing apparatus to provide a first data frame, the data frame comprising data and forward error correction (FEC) data, to form a sequence of transmissions and divide the first data frame between said transmissions, the first set of data being divided between at least two transmissions.

According to a sixth aspect of the present invention there is provided a computer program comprising instructions for causing data processing apparatus to provide a first data frame, said first data frame comprising data and forward error correction (FEC) data, to provide a second data frame, said second data frame comprising data and forward error correction data and to form a transmission comprising said first and second data frames.

According to a seventh aspect of the present invention there is provided a computer program comprising instructions for causing data processing apparatus to receive a first transmission, said transmission including data for a data frame; to place said data in a data frame; to extract, from said first transmission, an indication that a second transmission in a sequence of transmissions which includes said first

2005283852 20 Jan 2010

transmission will follow, to receive said second transmission, said second transmission including further data for said data frame and to place said further data in said data frame.

According to an eighth aspect of the present invention there is provided a computer program comprising instructions for causing data processing apparatus to receive a transmission, said transmission including data for a plurality of data frames, to extract data from said transmission together with indication to which data frame a set of data belong and to place said set of data in a corresponding data frame

According to a ninth aspect of the present invention there is provided a device configured to provide a first data frame, the first data frame comprising data and forward error correction (FEC) data, to form a sequence of transmissions and divide the first data frame between said transmissions, the first set of data being divided between at least two transmissions.

According to a tenth aspect of the present invention there is provided a network element configured to provide a first data frame, said first data frame comprising data and forward error correction (FEC) data, to provide a second data frame, said second data frame comprising data and FEC data and to form a transmission comprising said first and second data frames.

The device may be a multiprotocol encapsulation (MPE) encapsulator.

According to an eleventh aspect of the present invention there is provided a device configured to receive a first transmission, said transmission including data for a data frame, to place said data in a data frame, to extract, from said first transmission, an indication that a second transmission in a sequence of transmissions which includes said first transmission follow, to receive said second transmission, said second transmission including further data for said data frame and to place said further data in said data frame.

2005283852 20 Jan 2010

According to a twelfth aspect of the present invention there is provided a device configured to receive a transmission, said transmission including data for a plurality of data frames, to extract sets of data from said transmission together with indications to which data frame said sets of data belong and to place said set of data in a corresponding data frame.

Brief Description of the Drawings

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of an embodiment of a digital broadcasting network and an embodiment of handheld terminal according to the present invention;

Figure 2 is a functional block diagram of an embodiment of a multiprotocol encapsulator (MPE) according to the present invention and a transmitter;

Figure 3 is a process flow diagram of a method of operating the multiprotocol encapsulator (MPE) shown in Figure 2;

Figure 4 illustrates an example of a set of internet protocol (IP) streams;

Figure 5 is a simplified schematic diagram of an IP datagram;

Figure 6 illustrates IP streams filtered from the IP streams shown in Figure 4;

Figure 7 illustrates first and second coding tables for storing multiprotocol encapsulation-forward error correction (MPE-FEC) frames;

Figure 8 shows first and second coding tables being filled with IP datagrams;

Figure 9 illustrates first and second coding tables filled with IP datagrams and parity codewords;

Figure 10 illustrates a different way of viewing the completed coding tables shown in Figure 9 together with frame identity and frame counter parameters;

Figure 11 shows datagrams being read out from the first and second coding tables;

Figure 12 illustrates interleaving of MPE-FEC frame blocks;

Figure 13 illustrates preparation of an MPE section;

Figure 14 illustrates preparation of an MPE-FEC section;

Figure 15 is a schematic diagram of an MPE section;

Figure 16 is a schematic diagram of an MPE-FEC section;

Figure 17 illustrates a stream of MPE and MPE-FEC sections;

Figure 18 illustrates addition of delta-t and burst number parameters to an MPE or MPE-FEC section;

Figure 19 shows division of an MPE-FEC frame between a plurality of bursts in accordance with the present invention;

Figure 20 illustrates another way of dividing an MPE-FEC frame;

Figure 21 illustrates a prior art way of transmitting an MPE-FEC frame in one burst;

Figure 22 illustrates division of a large MPE-FEC frame between a plurality of bursts in accordance with the present invention;

Figure 23 illustrates inclusion of a plurality of MPE-FEC frames into one burst;

Figure 24 is a simplified process flow diagram of a method of operating a transmitter;

Figure 25 illustrates encapsulation of section fragments into transport stream (TS) packets;

Figure 26 is a schematic diagram of a TS packet;

Figure 27 illustrates multiplexing TS packets;

Figure 28 is a schematic diagram of a time slice and FEC identifier descriptor;

Figure 29 is a schematic diagram of a network information table (NIT);

Figure 30 is a schematic diagram of a mobile terminal;

Figure 31 is a functional block diagram of part of the a mobile terminal;

Figure 32 is a process flow diagram of a method of operating the mobile telephone shown in Figure 30 in accordance with the present invention;

Figure 33 illustrates decoding tables in a time slice buffer;

Figure 34 illustrates decapsulating an MPE or MPE-FEC section;

Figure 35; illustrates filling the decoding tables with payload of MPE and MPE-FEC sections;

Figure 36 illustrates complete decoding tables;

Figure 37 illustrates error correction;

Figure 37 illustrates another example of a decoding table; and

Figure 39 illustrates further examples of decoding tables.

Detailed Description of the Invention

Digital broadcasting network 1

Referring to Figure 1, a communications network 1 for delivering content to a mobile terminal 2 in accordance with the present invention is shown. The communications network 1 includes a handheld digital video broadcasting (DVB-H) network which is used as a broadcast access network to deliver content as an Internet Protocol Data Casting (IPDC) service. However, other digital broadcast networks may be used including other types of DVB network, such as a terrestrial DVB (DVB-T) network, a cable DVB (DVB-C) network or a satellite DVB (DVB-S) network, a Digital Audio Broadcasting (DAB) network, an Advance Television System Committee (ATSC) network, a terrestrial Integrated Services Digital Broadcasting-Terrestrial (ISDB-T) network and other networks which are similar to or based on such networks.

The network 1 includes sources 3_1, 3_2 of content, for example in the form of video, audio and data files, a content provider 4 for retrieving, re-formatting and storing content, a datacast service system server 5 for determining service composition, a multi-protocol encapsulation (MPE) encapsulator 6 and a transmitter 7 for modulating and broadcasting a signal 8 to receivers (not shown) including mobile terminal 2.

Other network elements may be provided, such as one or more gap-filler transmitters (not shown) for receiving and re-transmitting the signal 8. Furthermore, a communications network (not shown), such as a public land mobile network preferably in the form a 2nd or 3rd generation mobile network such as GSM or UMTS respectively, may be provided for providing a return channel from the mobile terminal 2 to the digital broadcasting network 1. A further communications network (not shown), such as the Internet, may be provided to connect distributed elements of the digital broadcasting network 1, such as content provider 4 and service system server 5.

MPE encapsulator 6

Referring to Figure 2, a functional block diagram of the MPE encapsulator 6 and transmitter 7 is shown.

The MPE encapsulator 6 receives content in the form of a plurality of internet protocol (IP) streams 9 having different IP addresses and service information data 10 which is used to create MPEG program specific information (PSI) and DVB service information (SI).

The MPE encapsulator 6 comprises an IP demultiplexing block 11 for filtering one or more desired IP streams and arranging the filtered IP streams into one or more filtered streams 12. Each filtered stream 12 may comprise one or more IP streams. The demultiplexing block 11 forwards the filtered stream 12 to an encoding block 13.

The MPE encapsulator 6 comprises an encoding block 13 for providing forward error correction (FEC) for the filtered streams 12. The encoding block 13 prepares and forwards MPE-FEC frames 14. If FEC is not used for a given filtered stream 12, then the encoder 13 does not perform encoding, but simply buffers the stream 12. The encoder 13 may also perform interleaving as will be described in more detail later.

The MPE encapsulator 6 further comprises an MPE/MPE-FEC section encapsulating block 15 for mapping data comprised in MPE-FEC frames 14 into MPE sections 16 and MPE-FEC sections 17. Reference is made to ETSI EN 301 192 “Digital Video Broadcasting (DVB); DVB Specification for data broadcasting” V1.4.1 (2004-06).

The MPE encapsulator 6 also comprises a time slicing block 18 for time-slicing the MPE sections 16 and MPE-FEC sections 17 into bursts 19. As will be explained in more detail later, the MPE encapsulator 6 can transmit data from one MPE-FEC frame 14 in more than one burst 19 and/or transmit data from more than one MPE-FEC frame 14 in one burst 19 in accordance with the present invention. The MPE encapsulator 6 can also transmit one MPE-FEC frame 14 in one burst 19 in a conventional way, but this will not be described here in detail.

The MPE encapsulator 6 also comprises an SI/PSI section encapsulating block 20 for mapping SI tables into sections 21 in accordance with ETSI EN 300 468 “Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems” V1.6.1 (2004-6).

The MPE encapsulator 6 also comprises a controlling block 22 for managing other elements of the encapsulator shown in Figure 2.

The functions of the MPE encapsulator 6 may be implemented by a computer (not shown) running a computer program (not shown).

The transmitter 7 includes a transport stream (TS) generating and multiplexing block 23. The TS generating and multiplexing block 23 divides MPE sections 16 and MPE-FEC sections 17 comprised in the bursts 19 into fragments places them into TS packets 25_A (Figure25) and multiplexes the TS packets with others, for example carrying MPEG-2 TV service 24, into a multiplex 25 in accordance with ISO/IEC Standard 13818-1 "Information Technology-Generic coding of moving pictures and associated audio information: Systems".

The transmitter 7 also includes a modulating block 26 for generating an r.f. signal 8 in accordance with ETSI EN 300 744 "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television (DVB-T)" V1.5.1 (2004-06).

Method of operating the MPE encapsulator 6

Referring to Figures 2 to 18, a method of operating the MPE encapsulator 6 will now be described.

For a given set of IP streams 9, the MPE encapsulator 6 can transmit data from one MPE-FEC frame 14 in more than one burst 19 and/or transmit data from more than one MPE-FEC frame 14 in one burst 19 in accordance with the present invention.

The MPE encapsulator 6 prepares a plurality of coding tables 27 for holding MPE-FEC frames 14 (step S1). This may simply comprise allocating memory for each coding table 27. As will be explained in more detail later, coding tables 27 and MPE-FEC frames 14 may hold more than 2 Mbits of data.

The MPE encapsulator 6 signals information about time slicing and MPE-FEC for enabling receivers to receive bursts 19 (step S2). This is described in more detail later.

Referring in particular to Figure 4, the demultiplexer 11 (Figure 2) receives a plurality of streams 9 including first and second streams 9_1, 9_2. The first stream 9_1 includes a first set of layer 3 datagrams 28_1 including datagrams $28_{1,1}$, $28_{1,2}$, $28_{1,3}$, $28_{1,4}$. The second stream 9_2 includes a second set of layer 3 datagrams 28_2 including datagrams $28_{2,1}$, $28_{2,2}$.

Referring to Figure 5, each datagram 28 of the first and second sets of datagrams 28_1, 28_2 is in the form of Internet Protocol (IP) datagram and comprise a header 29 and a payload 30. However, other types of data frames, such as UDP datagrams, can be used.

Referring now to Figure 6, the demultiplexer 11 (Figure 2) filters and outputs the first and second IP streams 9_1, 9_2 into first and second filtered streams 12_1, 12_2 respectively (step S3). In this example, each filtered stream 12_1, 12_2 comprises a single IP stream 9_1, 9_2. However, a filtered stream 12_1, 12_2 may comprise more than one IP stream.

Referring to Figure 7, the MPE-FEC encoder 13 includes first and second coding tables 27_1, 27_2 for the first and second filtered streams 12_1, 12_2 (Figure 6) respectively. Further coding tables (not shown) may be provided, for example, for additional filtered streams. Additionally or alternatively, further coding tables may be provided for the same filtered stream and may be combined to form a single, larger coding table.

The first coding table 27_1 provides an application data table 32_1 and a parity data table 33_1. Likewise, the second coding table 27_2 provides portions 32_2, 33_2 for storing an application data table and a parity data table.

The first coding table 32_1 may be arranged as a matrix with 255 columns 34_1 and a flexible number of rows 35_1. The number of rows 35_1 is signalled in service information (SI) 10 (Figure 2). Each position 36_1 in the coding table 27_1 holds one byte of data.

The second coding table 27_2 may also be arranged as a matrix with 255 columns 34_2 and a flexible number of rows 35_2. The number of rows 35_2 can be signaled in service information (SI) 10 (Figure 2). Each position 36_2 in the coding table 27_2 holds one byte of data.

Each position 36_1, 36_2 may hold more or less than one byte of data.

For the first coding table 27_1, the application data table 32_1 may be provided by the left-most part of the coding table 27_1 and may comprise 191 columns. The application data table 32_1 is reserved for datagrams 28_1 (Figure 6) from the first filtered stream 12_1 (Figure 6) and optional padding data (not shown). The parity data table 33_1 may be provided by the right-most part of the first coding table 27_1 and may comprise 64 columns. The parity data table 33_1 is reserved for parity data. Each position in the application data table 32_1 has an address ranging from 0 to (191 × no_of_rows – 1). Similarly, each position in the RS data table 33_1 has an address ranging from 0 to (64 × no_of_rows – 1). The first coding table 27_1 may be differently configured and may comprise a different number of columns. For example, the coding table 27_1 may be inverted. The application data table 32_1 may be provided by the right-most part of the coding table 27_1. The coding table 27_1 may be divided horizontally with the application data table 32_1 provided by an upper- or lower-most part of the coding table 27_1.

For the second coding table 27_2, the application data table 32_2 may provided by the left-most part of the coding table 27_2 and may comprise 191 columns 34_2. The application data table 32_2 is reserved for datagrams 28_2 (Figure 4c) from the second filtered stream 12_2 (Figure6) and optional padding data (not shown). The parity data table 33_2 may be provided by the right-most part of the coding table 27_2 and may comprise 64 columns 34_2. The parity data table 33_2 is reserved for parity data.

Each position in the application data table 32_2 has an address ranging from 0 to (191 × no_of_rows – 1). Similarly, each position in the parity data table 33_2 has an address ranging from 0 to (64 × no_of_rows – 1). The second coding table 27_2 may be differently configured and may comprise a different number of columns.

The coding tables 27_1, 27_2 may be differently arranged. For example, the application data tables 32_1, 32_2 may comprise the right-most columns of the tables 27_1, 27_2. The coding tables 27_1, 27_2 may be divided horizontally, rather than vertically, into upper and lower portions.

The first and second coding tables 27_1, 27_2 may have different-sized parity data tables 33_1, 33_2. In other words, different levels of FEC coding can be used.

The IP streams 9_1, 9_2 are directed to the first and second coding tables (step S4).

Referring to Figure 8, the first set of datagrams 28_1 are introduced datagram-by-datagram, starting with a first byte 37_1 of a first datagram $28_{1,1}$ in the upper left corner of the first coding table 27_1 and going downwards in a first, left-most column $34_{1,1}$. Immediately after the end of the first datagram $28_{1,1}$, a second datagram $28_{1,2}$ starts, followed by a third datagram $28_{1,3}$, a fourth datagram $28_{1,4}$ and so on.

The first and second coding tables 27_1, 27_2 may be filled differently. For example, the first byte 37_1 of the first datagram $28_{1,1}$ may be placed in the upper right corner of the first coding table 27_1 and going downwards or in the lower left or right corner and going upwards.

Each datagram 28_1 occupies a respective column 34_1 in the application data table 32_1. However, datagrams 28_1 may each occupy less than one column 34_1 or more than one column 34_1. Moreover, the length of each datagram 28_1 may vary from datagram to datagram. If a datagram 28_1 does not finish at the end of a column 34_1, it may continue at the top of the following column 34_1. When all the datagrams 28_1 have been entered into the application data table 32_1, any unfilled byte positions may be padded with zero bytes (not shown), thus completely filling the left-most 191 columns. However, padding need not explicitly added.

Likewise, the second set of datagrams 28_2 are introduced datagram-by-datagram, starting with a first byte 37_2 of a first datagram $28_{2,1}$ in the upper left corner of the second coding table 27_2 and going downwards in a first, left-most column $34_{2,1}$. Immediately after the end of the first datagram $28_{2,1}$, a second datagram $28_{2,2}$ starts and so on.

Each datagram 28_2 occupies a respective column 34_2 in the application data table 32_2. However, datagrams 28_2 may occupy less than one column 34_2 or more than a one column 34_2. Moreover, the length of the datagrams 28_2 may vary from datagram to datagram. If a datagram 28_2 does not end at the end of a column 34_2, it may continue at the top of the following column 34_2. When all datagrams 28 have entered the application data table 32_2, any unfilled byte positions may be padded with zero bytes (not shown), thus completely filling the left-most 191 columns. However, padding need not explicitly added.

Referring now to Figure 9, the application data table 32_1 is filled with datagrams 28_1 including datagrams $28_{1,1}$, $28_{1,2}$, $28_{1,3}$, $28_{1,4}$, $28_{1,r-1}$, $28_{1,r}$, $28_{1,r+1}$, $28_{1,n-1}$, $28_{1,n}$. As mentioned earlier, in some cases, the application data table 32_1 may only be partially filled with datagrams 28_1 and padding data may be added to fill it.

Once the application data table 32_1 is filled, parity data 38_1 in the form of a set of parity codewords 38_1 including parity codewords $38_{1,1}$, $38_{1,2}$, $38_{1,p}$ are calculated and placed in the parity data table 33_1 (step S5). Thus, a first parity codeword $38_{1,1}$ is calculated for a first row $35_{1,1}$, a second parity codeword $38_{1,2}$ is calculated for a second row $35_{1,2}$ an so on until a final parity codeword $38_{1,p}$ is calculated for a final row $35_{1,p}$.

Likewise, the second application data table 32_2 is filled with datagrams 28_2 including datagrams $28_{2,1}$, $28_{2,2}$, $28_{2,3}$, $28_{2,4}$, $28_{2,5}$, $28_{2,s-1}$, $28_{2,s}$, $28_{2,s+1}$, $28_{2,m-1}$, $28_{2,m}$.

Once the second application data table 32_2 is filled, parity data 38_2 in the form of parity codewords 38_2 including parity codewords $38_{2,1}$, $38_{2,2}$, $38_{2,q}$ are calculated and placed in the parity data table 33_2.

A Reed-Solomon (RS) parity code, in this example an RS(255,191,64) code, is used. Thus, the parity data tables 33_1, 33_2 are hereinafter referred to as an RS parity data table and the parity codewords 38_1, 38_2 are hereinafter referred to as RS codewords. Some of the columns of the RS data table 33_1, 33_2 may be discarded and hence not transmitted, to enable puncturing. The exact number of punctured RS columns does not need to be explicitly signaled and may change dynamically between frames. However, other codes may be used.

Referring to Figure 10, completed first and second coding tables 27_1, 27_2 holding respective frames of data, herein referred to as MPE-FEC frames $14_{1,1}$, $14_{2,1}$, are shown.

The first RS data table 33_1 can be divided column-wise to provide RS column data 40_1 including RS columns $40_{1,1}$, $40_{1,2}$, $40_{1,u-2}$, $40_{1,u-1}$, $40_{1,u}$. Likewise, second RS data table 33_2 can be divided column-wise to provide RS column data 40_2 including RS columns $40_{2,1}$, $40_{2,2}$, $40_{2,v-2}$, $40_{2,v-1}$, $40_{2,v}$.

A series of MPE-FEC frames $14_{1,1}$, $14_{1,2}$, $14_{2,1}$, $14_{2,1}$ (Figure 19) is generated for each filtered stream 12_1, 12_2. To identify each frame $14_{1,1}$, $14_{1,2}$, $14_{2,1}$, $14_{2,1}$, the frames $14_{1,1}$, $14_{1,2}$, $14_{2,1}$, $14_{2,1}$ (Figure 19) are labeled according to their filtered stream 12_1, 12_2, which is indicated using a frame identity parameter, Frame_id, and according to their position within the series of frames, which is indicated using a frame counter parameter, Frame_counter.

Thus, frame identity and frame counter parameters $41_{1,1}$, $42_{1,1}$, $41_{2,1}$, $42_{2,1}$ are generated for each frame $14_{1,1}$, $14_{2,1}$. In this example, Frame_id=1 and Frame_counter=1 for the first MPE-FEC frames $14_{1,1}$ and Frame_id=2 and Frame_counter=i for the second MPE-FEC frames $14_{2,1}$.

As mentioned earlier, the MPE encapsulator 6 can transmit data from one MPE-FEC frame 14 in more than one burst 19 and/or transmit data from more than one MPE-FEC frame 14 in one burst 19 in accordance with the present invention. The MPE encapsulator 6 can also transmit one MPE-FEC frame 14 in one burst 19 in a conventional way, but this will not be described.

In this case, each MPE-FEC frame $14_{1,1}$, $14_{2,1}$ will be transmitted in more than one burst 19_1, 19_2, 19_3 (Figure 19).

Referring to Figure 11, the datagrams 28_1, 28_2 are read out from the coding tables 27_1, 27_2.

As each datagram 28_1 or RS column 40_1 is read out from the first coding table 27_1, the encoder 13 may also output an address 43_1 of the first byte of the datagram 28_1, a table boundary flag 44_1 for indicating whether the datagram 28_1 or RS column 40_1 is the last in the frame $14_{1,1}$ and a frame boundary flag 45_1.

Likewise, as each datagram 28_2 or RS column 40_2 is read out from the second coding table 27_2, the encoder 13 may also output an address 43_2 of the first byte of the datagram 28_2 or RS column 40_2, a table boundary flag 44_2 for indicating whether the datagram 28_1 or RS column 40_2 is the last in the frame $14_{2,1}$ and a frame boundary flag 45_2.

The datagrams 28_1, 28_2 and RS columns 40_1, 40_2 are interleaved (steps S6 & S7).

A first datagram $28_{1,1}$ is read out from the first coding table 27_1 and datagrams are read out sequentially from the first coding table 27_1 until an r-1th datagram $28_{1,r-1}$ is read out. Then, a first datagram $28_{2,1}$ is read out from the second coding table 27_2 and datagrams are read out sequentially from the second coding table 27_2 until an s-1th datagram $28_{1,s-1}$ is read out.

An rth datagram $28_{1,r}$ is read out from the first coding table 27_1 and datagrams are read out sequentially from the first coding table 27_1 until an nth datagram $28_{1,n}$ is read out. Then, an s^{th} datagram $28_{2,s}$ is read out from the second coding table 27_2 and datagrams are read out sequentially from the second coding table 27_2 until an m^{th} datagram $28_{2,m}$ is read out.

A first RS column $40_{1,1}$ is read out from the first coding table 27_1 and RS column are read out sequentially from the first coding table 27_1 until a u^{th} RS column $40_{1,u}$ is read out. Then, an first RS column $40_{2,1}$ is read out from the second coding table 27_2 and RS columns are read out sequentially from the second coding table 27_2 until an v^{th} RS column $40_{2,v}$ is read out.

Referring to Figure 12, the effect of selectively reading out datagrams 28_1, 28_2 and RS columns 40_1, 40_2 from the coding tables 27_1, 27_2 in the order described earlier is to divide each MPE-FEC frames $14_{1,1}$, $14_{2,1}$ into three frame blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1,3}$ and interleave the frame blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1,3}$. The frame blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1,3}$ are unequal in size. However, MPE-FEC frames $14_{1,1}$, $14_{2,1}$ may each be divided into frame blocks which are equal in size or as close to equal in size as is practicable. The MPE-FEC frames $14_{1,1}$, $14_{2,1}$ may be divided into fewer or more blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1,3}$ or not divided at all. Furthermore, the frame blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1,3}$ may be interleaved in a different order. Moreover, the frame blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1,3}$ may be interleaved with other frame blocks from other frames (not shown) at least some of which may originate from the same filtered stream 12_1, 12_2.

Referring to Figures 13 and 14, datagrams 28 and RS columns 40 comprised in the frame blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1}$ (Figure 12) are supplied to the MPE/MPE-FEC section encapsulating block 15, together with respective frame identity and frame counter parameters 41, 42 for the frame $14_{1,1}$, $14_{2,1}$ (Figure 11) to which they belong and respective address data 43, table boundary flag 44 and burst boundary flag 45.

Referring in particular to Figure 13, the MPE/MPE-FEC section encapsulating block 15 generates and outputs MPE sections 16, each MPE section 16 comprising a header 46, a payload 47 and a trailer 48 (step S8).

When MPE/MPE-FEC section encapsulating block 15 receives a datagram 28, it maps the datagram 28 into the payload 47 and places corresponding frame identity and frame counter parameters 41, 42 into the header 46 (step S9). The MPE/MPE-FEC section encapsulating block 15 can also place address data 43, table boundary flag 44 and frame boundary flag 45 in the header 46 (step S10). The MPE/MPE-FEC section encapsulating block 15 may map more than one datagram 28 into the payload 47.

Referring to Figure 14, the MPE/MPE-FEC section encapsulating block 15 also generates and outputs MPE-FEC sections 17, each MPE-FEC section 17 comprising a header 49, a payload 50 and a trailer 51.

When the MPE/MPE-FEC section encapsulating block 15 receives an RS column 40, it maps the RS column 40 into a payload 50 of an MPE-FEC section 17 and places corresponding frame identity and frame counter parameters 41, 42 into the header 49. The MPE/MPE-FEC section encapsulating block 15 can also places address data 43, table boundary flag 44 and frame boundary flag 45 into the header 49.

MPE and MPE-FEC sections 16, 17 are compliant with Digital Storage Medium Command and Control (DSM-CC) section format, shown in Table 1 below:

Table 1

Syntax	No. of bits	Identifier
datagram_section() {		
table_id	8	uimsbf
section_syntax_indicator	1	bslbf
private_indicator	1	bslbf
Reserved	2	bslbf
section_length	12	uimsbf
MAC_address_6	8	uimsbf
MAC_address_5	8	uimsbf
Reserved	2	bslbf

payload_scrambling_control	2	bslbf
address_scrambling_control	2	bslbf
LLC_SNAP_flag	1	bslbf
current_next_indicator	1	bslbf
section_number	8	uimsbf
last_section_number	8	uimsbf
MAC_address_4	8	uimsbf
MAC_address_3	8	uimsbf
MAC_address_2	8	uimsbf
MAC_address_1	8	uimsbf
if (LLC_SNAP_flag == "1") {		
LLC_SNAP()		
} else {		
for (j=0;j<N1;j++) {		
IP_datagram_data_byte	8	bslbf
}		
}		
if (section_number == last_section_number) {		
for (j=0;j<N2;j++) {		
stuffing_byte	8	bslbf
}		
}		
if (section_syntax_indicator =="0") {		
Checksum	32	uimsbf
} else {		
CRC_32	32	rpchof
}		
}		

Referring to Figure 15, in an MPE section 16, a fifth MAC address field can be divided to provide first and second fields 52, 53 for storing frame identity and frame counter parameters 41, 42 respectively. The first and second fields 52, 53 may each comprise four bits. First, second, third and fourth MAC address fields are used to provide a real time parameter field 54. Reserved fields are used to provide third and fourth fields 55, 56 for storing a burst number 63 (Figure 18), which may comprise three or four bits. The burst number will be explained in more detail later. The first, second, third and fourth fields 52, 53, 55, 56 may be apportioned differently to permit use of smaller or larger values. If a different header structure is used or if further bits become available, then larger values of frame identity, frame counter and burst number 41, 42, 63 can be used.

Referring to Figure 16, in an MPE-FEC section 17, a fifth MAC address field can be divided to provide first and second fields 57, 58 for storing frame identity and frame counter parameters 41, 42 respectively. . The first and second fields 57, 58 may each comprise four bits. First, second, third and fourth MAC address fields are used to provide a real time parameter field 59. Reserved fields are used to provide third and fourth fields 60, 61 for storing a burst number 63, (Figure 18) which may comprise three or four bits. The first, second, third and fourth fields 57, 58, 60, 61 may be apportioned differently to permit use of smaller or larger values. If a different header structure is used or if further bits become available, then larger values of frame identity, frame counter and burst number 41, 42, 63 can be used.

The real time parameter fields 54, 59 are compliant with the syntax as shown in Table 2 below:

Table 2

Syntax	No. of bits	Identifier
realtime paramters() {		
delta_t	12	uimsbf
table_boundary	1	bslbf
burst_boundary	1	bslbf
Address	18	uimsbf
}		

The burst boundary field, burst_boundary, is used to indicate the end of a burst and receives the burst boundary flag 45 (Figure 13). The frame boundary flag 45 can be used to indicate different frames in the same burst.

Referring to Figure 17, the MPE/MPE-FEC section encapsulating block 15 outputs MPE sections 16 including 16_1, 16_2, 16_3, 16_4, 16_{a-1}, 16_a, 16_{a+1}, 16_{a+2}, 16_{a+3}, 16_{b-1}, 16_b, 16_{b+1}, 16_{c-2}, 16_{c-1}, 16_c, 16_{c+1}, 16_{d-2}, 16_{d-1} and MPE-FEC sections 17 including 17_1, 17_2, 17_{e-3}, 17_{e-2}, 17_{e-1}, 17_e, 17_{e+1}, 17_{f-3}, 17_{f-2}, 17_{f-1}.

The MPE sections 16 and MPE-FEC sections 17 comprise datagrams $28_{1,1}$, $28_{1,2}$, $28_{1,3}$, $28_{1,4}$, $28_{1,r-1}$, $28_{1,r}$, $28_{1,r+1}$, $28_{1,n-1}$, $28_{1,n}$, datagrams $28_{2,1}$, $28_{2,2}$, $28_{2,3}$, $28_{2,4}$, $28_{2,s-1}$, $28_{2,s}$, $28_{2,s+1}$, $28_{2,m-1}$, $28_{2,m}$, RS columns $40_{1,1}$, $40_{1,2}$, $40_{1,u-2}$, $40_{1,u-1}$, $40_{1,u}$ and RS columns $40_{2,1}$, $40_{2,2}$, $40_{2,v-2}$, $40_{2,v-1}$, $40_{2,v}$ interleaved in the order described earlier. However, the MPE sections 16 and MPE-FEC sections 17 can be interleaved in other, different orders.

Datagrams 28 are carried in MPE sections 16 irrespective of whether MPE-FEC is used. This makes reception fully backwards compatible with receivers (not shown) which are not enabled for MPE-FEC. As mentioned earlier, each MPE section 16 carries a start address 43 (Figure 13) for the payload 47 (Figure 13) in the section header 46 (Figure 13). This address 43 (Figure 13) indicates the byte position in the application data table of the first byte of the section payload 47 (Figure 13). If the datagram 28 is divided over multiple MPE sections 16, each MPE section 16 indicates the byte position in the application data table of the first byte of the datagram fragment carried within the section. A receiver (not shown) puts the received datagram 28 in the right byte positions in the application data table and marks these positions as "reliable" for the RS decoder, provided the section CRC-32 check shows that the section is correct.

The last section of the application data table contains a table boundary flag, which indicates the end of the datagrams within the application data table. If all previous sections within the application data table have been received correctly the receiver does not need to receive any MPE-FEC sections and, if time slicing is used, the receiver can be switched off without receiving and decoding RS data. If MPE-FEC sections 17 are also received, the number of padding columns, i.e. columns filled with padding bytes only, in the application data table is indicated with eight bits in the section header of the MPE-FEC sections. This value is only needed if RS decoding is performed. If the section carrying the table_boundary is lost, the receiver (not shown) may not know the exact position of where application data ends and padding starts. However, from the padding columns, it knows how many full columns were padding and so these can be marked as being reliable.

RS columns are carried in MPE-FEC sections 17. Each MPE-FEC section 17 carries exactly one column of the RS data table, although they can carry less than one column or more than one column. Punctured columns are not transmitted and the number of punctured columns is not signaled explicitly, but signaled with the last section number in MPE-FEC section header.

Referring to Figure 18, the time slicing module 18 receives the MPE sections 16 and MPE-FEC sections 17 and places corresponding values of delta t 62 and burst number 63 for each section 16, 17 into the header 46, 49 of the section 16, 17 (steps S11 & S12). The time slicing module 18 also calculates cyclical redundancy code (CRC-32) data 64 for each section 16, 17 and places the CRC-32 data 64 into the trailer 48, 51 of the section 16, 17.

MPE sections 16 and MPE-FEC sections 17 are forwarded to buffer 65. Sections 16, 17 having the same burst number 63 are collected and forwarded to the transmitter 7 (Figure 2) as in bursts 19 (step S13).

Referring to Figure 19, the MPE sections 16 carried in first and fourth frame blocks $14_{1,1,1}$, $14_{2,1,1}$ and which include MPE sections 16_1, 16_2, 16_3, 16_4, 16_{a-1}, 16_a, 16_{a+1}, 16_{a+2}, 16_{a+3}, 16_{b-1} (Figure 17) are arranged into a first burst 19_1. The MPE sections 16 carried in second and fifth frame blocks $14_{1,1,2}$, $14_{2,1,2}$ and which include MPE sections 16_b, 16_{b+1}, 16_{c-2}, 16_{c-1}, 16_c, 16_{c+1}, 16_{d-2}, 16_{d-1} (Figure 17) are arranged into a second burst 19_2. The MPE –FEC sections 17 carried in third and sixth frame blocks $14_{1,1,3}$, $14_{2,1,3}$ and which include MPE-FEC sections 17_1, 17_2, 17_{e-3}, 17_{e-2}, 17_{e-1}, 17_e, 17_{e+1}, 17_{f-3}, 17_{f-2}, 17_{f-1} (Figure 17) are arranged into a third burst 19_3. The bursts 19_1, 19_2, 19_3 are each transmitted at a bitrate B_b and have a burst duration B_d.

The last section in each burst 19 is identified as such using burst boundary flag 45 (Figure 13). For example, the burst boundary flag 45 (Figure 13) in section 16_{b-1} is set to '1'. A receiver (not shown) can use the burst boundary flag 45 (Figure 13) to determine when it has received a burst and, thus, when it should 'go to sleep'.

Each section 16, 17 carries a value of a duration of time from time of transmission of the section 16, 17, until time of transmission of the first section 16, 17 in the next burst 19. For example, delta-t $62_{1,1}$ for the first MPE section 16_a indicating the duration of time until MPE section 16_b is transmitted is illustrated. A receiver (not shown) can use the delta-t parameter 62 (Figure 18) to determine when it should 'wake-up' and receive the next burst 19.

The same value of the burst number parameter 63 (Figure 18) is used in sections 16, 17 within the same burst 19. In this example, the bursts are numbered counting down, beginning with a value two and ending at zero. A receiver (not shown) can use the burst number parameter 63 (Figure 18) to determine whether a burst 19 has been lost or whether it has received all the bursts for a given MPE-FEC frame 14.

If three bits are used for the burst number parameter 63, then a burst can start with a burst number up to fifteen. If four bits are units, for example as provided by reserved field 55, 56 (Figure 15) in an MPE section 16 or reserved fields 60, 61 (Figure 16) in an MPE-FEC section 17, a burst can start with a burst number up to thirty-one. The burst number can be cyclical, beginning again at fifteen (or thirty-one) after it has reached zero.

The process of preparing and transmitting MPE-FEC frames continues with the preparation and transmission of third and fourth MPE-FEC frames $14_{1,2}$, $14_{2,2}$, prepared using the first and second coding tables 27_1, 27_2, which are transmitted in fourth, fifth and sixth bursts 19_4, 19_5, 19_6 (step S14) until the datagrams 28_1, 28_2 in the filtered stream 12_1, 12_2 have been transmitted (step S15).

In the example just described, the first and second MPE-FEC frames $14_{1,1}$, $14_{2,1}$ were each divided into three blocks $14_{1,1,1}$, $14_{1,1,2}$, $14_{1,1,3}$, $14_{2,1,1}$, $14_{2,1,2}$, $14_{2,1,3}$. However, the MPE-FEC frames $14_{1,1}$, $14_{2,1}$ can be divided into fewer or more blocks. The blocks may be of equal or unequal sizes.

Referring to Figure 20, the first MPE-FEC frame 14_1 may be divided into four blocks $14_{1,1,1}$', $14_{1,1,2}$', $14_{1,1,3}$', $14_{1,1,4}$' and transmitted in four bursts 19_1', 19_2', 19_3', 19_4'. Similarly, the second MPE-FEC frame 14_1 (Figure 19) may be divided into four blocks (not shown). Furthermore, a block $14_{1,1,3}$' may carry data from both the application data table $32_{1,1}$ and the RS data table $33_{1,2}$, in other words carry MPE sections 16 and MPE-FEC sections 17.

An advantage of distributing data from one MPE-FEC frame between more than one burst is that interleaving length for the frame is increased. If there is 'shot' of noise which affects a burst, the chances of losing all the data from one MPE-FEC frame are decreased. Any errors in the data arising from the shot of noise can be corrected using the FEC parity data.

Additionally or alternatively, larger MPE-FEC frames 14 may be used to help distribute data from one MPE-FEC frame 14 between plural bursts 19, as will now be described in more detail.

Referring to Figure 21, a conventional arrangement for transmitting MPE-FEC frames is shown. In the conventional arrangement, six MPE-FEC frames $66_{1,1}$, $66_{1,2}$, $66_{1,3}$, $66_{1,4}$, $66_{1,5}$, $66_{1,6}$, each having 1024 rows, are transmitted in a respective bursts 67_1, 67_2, 67_3, 67_4, 67_5, 67_6. A drawback of this arrangement is that it has a short interleaving depth 68. As mentioned earlier, if a shot of noise affects one of the bursts, for example the second burst 67_2, then all of the data comprised in the MPE-FEC frame, in this example the second MPE-FEC frame $66_{1,2}$, may be lost.

Referring to Figure 22, an exemplary arrangement for transmitting MPE-FEC frames in accordance with the present invention is shown. In this example, an MPE-FEC frame $14_{1,1}$' has 6×1024 rows. Thus, the frame $14_{1,1}$' can hold 12 Mbits of data. The MPE-FEC frame may have N×M rows, where N = 2, 3, 4 or 5 and M = 1024. N may have a value greater than 6. Furthermore, M need not be equal to 1024. For example, M may be equal to 64, 128, 192, 256, 320, 384, 448, 512, 576, 640, 704, 768, 832, 896 or 960. The MPE-FEC frame $14_{1,1}$' is divided column-wise into six blocks $14_{1,1,1}$'', $14_{1,1,2}$'', $14_{1,1,3}$'', $14_{1,1,4}$'', $14_{1,1,5}$'', $14_{1,1,6}$'' which are transmitted in six respective bursts 19_1'', 19_2'', 19_3'', 19_4'', 19_5'', 19_6''. Each burst 19_1'', 19_2'', 19_3'', 19_4'', 19_5'', 19_6'' comprises 2 Mbits of data. This arrangement has an interleaving depth 68'. Thus, if a shot of noise affects one of the bursts, for example the second burst 19_2', then the data stands a better chance of being recovered using FEC. As will be explained in more detail later, to permit larger MPE-FEC frames, such as MPE-FEC frame $14_{1,1}$', to be received, the mobile terminal (not shown) may include a larger time-slicing buffer 106 (Figure 31).

Thus, increasing the size of the MPE-FEC frame and/or interleaving data from plural MPE-FEC frames helps to increase interleaving length and provide robustness against noise.

In the example described earlier, datagrams 28_1, 28_2 (Figure 6) from two IP streams 9_1, 9_2 (Figure 6) are transmitted in the one set of bursts 19_1, 19_2, 19_3(Figure 19). The same level of coding is used for each IP stream 9_1, 9_2 (Figure 6). In other words, the application data tables 32_1, 32_2 (Figure 7) each have the same size and the RS data tables 33_1, 33_2 (Figure 7) each have the same size.

However, different IP streams 9 may require different coding rates, i.e. different levels of coding. This may arise since IP streams 9 may need to be delivered with different priorities. IP streams encoded to different levels of coding take different amount of time and processing power to decode at a receiver.

Referring to Figure 23, the encoder 13 may be provided with third, fourth and fifth coding tables 27_3, 27_4, 27_5 for third, fourth and fifth filtered streams 12_3, 12_4, 12_5 respectively each comprising respective IP streams 9_3, 9_4, 9_5. The coding tables 27_3, 27_4, 27_5 comprise respective application data tables 32_3, 32_4, 32_5 and RS data tables 33_3, 33_4, 33_5.

For example, video data is transmitted in the third IP stream 9_3, voice data is transmitted in the fourth IP stream 9_4 and related data is transmitted in the fifth IP stream 9_5. It is desired to transmit the video data with a low priority, the related data with a high priority and the voice data at an intermediate priority.

To achieve different priorities, different coding levels are used.

For example, the third coding table 27_3 uses an RS (255, 239, 16) code, the fourth coding table 27_4 uses an RS (255, 223, 32) and the fifth coding table 27_5 uses an RS (255, 191, 64). Thus, the third application data table 32_3 comprises 239 of 255 columns 34_3, the fourth application data table 32_4 comprises 223 of 255 columns 34_4 and the fifth application data table 32_5 comprises 223 of 255 columns 34_5. Instead of using different codes, the coding rate can be decreased by puncturing a number of RS columns and increased by using padding in the application data table.

In this example, the third and fourth coding tables 27_3, 27_4 each comprise 384 rows 34_3, 34_4 and the fifth coding table 27_5 comprises 256 rows34_4. Thus, three MPE-FEC frames $14_{3,1}$, $14_{4,1}$, $14_{5,1}$ can be transmitted in a single 2-Mbit burst 19_7.

The coding tables 27_3, 27_4, 27_5 may each have fewer or more columns 35_3, 35_4, 35_5 and/or fewer or more rows34_3, 34_4, 34_5. A larger or smaller size of burst 19_7 may be used. Nevertheless, it will be appreciated that amount of data which the coding tables 27_3, 27_4, 27_5 can store should be equal to or less than the size of the burst 19_7. Bursts larger than 2 Mbits may be used.

The coding tables 27_3, 27_4, 27_5 are filled with datagrams 28_3, 28_4, 28_5 and RS columns 40_3, 40_4, 40_5 computed in a manner similar to that described earlier to produce MPE-FEC frames $14_{3,1}$, $14_{4,1}$, $14_{5,1}$ (steps S3 to S5).

The MPE-FEC frames $14_{3,1}$, $14_{4,1}$, $14_{5,1}$ are read out from the coding tables 27_3, 27_4, 27_5 and the burst 19_7 prepared in a manner similar to that described earlier. However, interleaving need not be used (steps S6 & S7).

Datagrams 28_3, 28_4, 28_5 and RS columns 40_3, 40_4, 40_5 are encapsulated (step S8). Frame identity and frame counter parameters 41, 42 (Figure 13) are added to the headers of MPE sections 16_h and MPE-FEC sections 17_i (steps S9 & S10).

In the time slicing block 19 (Figure 2), delta-t and burst parameters 62, 63 are added to the headers of MPE sections 16_h and MPE-FEC sections 17_i (steps S11 & 12) and the MPE sections 16_h and MPE-FEC sections 17_i are arranged into a single burst 19_7 (step S13). In this case, the burst number parameter 63 (Figure 18) can be set to burst_no=0. Delta-t is set to indicate arrival of the next burst 19_8, which may comprise the next set of MPE-FEC frames (not shown) prepared using coding table 27_3, 27_4, 27_5.

It will be appreciated that two, three or more MPE-FEC frames 14 can be transmitted in one burst 19 and that at least one of the MPE-FEC frames can have a different coding rate than other MPE-FEC frames.

Referring to Figure 24 and Figures 25 to 27, a method of operating the transmitter will now be described.

Referring in particular to Figure 25, the bursts 19 (Figure 18) in the form of an intermittent stream of MPE sections 16, including MPE sections 16_1, 16_2, 16_3, 16_4, and MPE-FEC sections 17, including MPE-FEC sections 17_{f-2}, 17_{f-1}, is received by the TS stream generating and multiplexing block 23 (Figure 2) and split into section fragments, including fragments 69_1, 69_2, 69_3, 69_4, 69_{g-1}, 69_g. Each fragment 69 is placed into a corresponding TS packet 25_A. For example, fragments 69_1, 69_2, 69_3, 69_4, 69_{g-1}, 69_g are placed into TS packets $25_{A,1}$, $25_{A,2}$, $25_{A,3}$, $25_{A,4}$, $25_{A,g-1}$, $25_{A,g}$ respectively.

Referring to Figure 26, the TS packets 25_A are typically 188 bytes long and are compliant with ISO/IEC Standard 13818-1 "Information Technology-Generic coding of moving pictures and associated audio information: Systems". Each TS packet 25_A comprises a packet header 70 using a packet identifier (PID) 71. The packet identifier 70 can be used to identify contents of a TS packet payload 72.

The TS stream generating and multiplexing block 23 (Figure 2) adds a PID corresponding to a set of bursts carrying MPE sections 16 and MPE-FEC sections 17 for the same filtered stream 12 or set of filtered streams 12 (Figure 2).

Referring to Figure 27, the TS stream generating and multiplexing block 23 (Figure 2) multiplexes the TS packets 25_A carrying MPE sections 16 and MPE-FEC sections 17 with TS packets 25_B carrying SI and PSI tables sections 22 (Figure 2) and TS packets 25_C carrying one or more MPEG-2 TV services 24 (Figure 2) into a common multiplex 25. The SI/PSI table sections 21 (Figure 2) and MPEG-2 TV services 24 (Figure 2) are not time sliced. The multiplex 25 is forwarded to the modulating block 26 for modulation, amplification and transmission as an r.f. signal 8 (Figure 1).

Referring to Figure 2, the MPE encapsulator 6 receives service information data 10 which is used to prepareSI and PSI/SI and SI data, including an IP/MAC Notification Table (INT) (not shown), and transmits the data 21 to receivers (not shown) including the mobile terminal 2 (Figure 1).

The SI/PSI section encapsulating block 20 (Figure 2) segments the INT (not shown) into sections (not shown) and passes the table sections to the TS stream generator and multiplexing means 24 to be mapped into TS packets 25_B having PID = 0x004C and multiplexed into the multiplex 25 (Figure 2). The INT is described in more detail in Clause 7.6 of EN 301 192 *ibid.*.

As briefly mentioned earlier, a data broadcast descriptor in a Service Description Table (SDT) transmitted using service description sections indicates that first, second, third and fourth MAC address fields are used to carry real time parameters, such as delta-t. A broadcast descriptor may indicate that the fifth MAC address field and reserved fields are to be used to carry parameters such a frame identity, frame counter and burst number. The service description sections and data broadcast descriptor are described in more detail in Clauses 6 and 7 of EN 300 468 *ibid.*.

Referring to Figure 28, a time slice and FEC identifier descriptor 73 is used to signal information about MPE-FEC and time slicing for a given elementary stream.

The descriptor 73 is similar to a time slice and FEC identifier descriptor 74 described in Clause 9.5 of EN 301 192 *ibid.* which identifies whether time slicing and/or MPE-FEC is used on a given elementary stream. However, the descriptor 73 includes additional fields including a field 75 for indicating the number of bursts used to transmit a single MPE-FEC frame, a field 76 for indicating the size of MPE-

FEC frame and a field 77 for indicating the number of MPE-FEC frames carried in a single burst. The version number, the type of coding, especially if other than RS(255,191,64), and the maximum frame size, especially if other than maximum burst size, may also be indicated.

Referring to Figure 29, the time slice identifier descriptor 73 is used in a network information table (NIT) 78 having first and second descriptor loops 79, 80.

When located in a first descriptor loop 79, the descriptor 73 applies to all transport streams announced within the table 78. The descriptor 73 applies to all elementary streams having a given stream type field value on any of the transport streams. A stream type field value of 0x0D may be used for elementary streams carrying MPE only streams. A stream type field value of 0x80 may be used for elementary streams carrying MPE and FEC sections. A stream_type field value of between 0x80 and 0xFF may be used for elementary streams carrying only FEC section.

When located in a second descriptor loop 80, the descriptor 73 applies to the transport stream in question, specified in a transport stream field (not shown). The descriptor 73 applies to all elementary streams having a given stream type field value. This descriptor 73 overwrites possible descriptors in the first descriptor loop.

The descriptor 73 may be included in other types of tables, such as in the INT (not shown).

When located in the platform descriptor loop (not shown) of the INT (not shown), the descriptor applies to all elementary streams referred to within the table. This descriptor overwrites possible descriptors in NIT.

When located in the target descriptor loop (not shown) of the INT (not shown), the descriptor applies to all elementary streams referred within the target descriptor loop (not shown) in question after the appearance of the descriptor. This descriptor overwrites possible descriptors in the platform descriptor loop and in NIT. In case an elementary stream is referred from multiple locations within an INT, each contains the same signalling.

The SI/PSI section encapsulating block 20 (Figure 2) segments the NIT 78 into sections (not shown) and passes the sections to the TS stream generator and multiplexing block 24 to be mapped into TS packets 26_B having PID = 0x0010 and multiplexed into the multiplex 26 (Figure 2).

A receiver usually only accesses the NIT 78 when connecting to the network 1 (Figure 1).

A receiver (not shown) may need to read the content of an INT when changing from one transport stream to another (not shown) and usually not more than once. Changes in the INT can be signalled in PSI using a PMT table (not shown), thus ensuring that constant filtering of the INT is not required.

PSI tables, such asPMT (not shown), are usually re-transmitted at least once in every 100 ms. If the duration of a burst is longer than 100 ms, a receiver has access to PMT while receiving a burst. For shorter bursts, a receiver may choose to keep switched on until all required PSI tables are received.

Mobile terminal 2

Referring to Figure 30, a mobile terminal 2 for receiving content from the digital broadcasting network 1 (Figure 1) is shown.

The mobile terminal 2 is in the form of a mobile telephone handset having a multimedia capability. The mobile terminal 2 includes first and second antenna81_1, 81_2, a receiver 82_1 and a transceiver 82_2. In this example, the first antenna 81_1 and receiver 82_1 are used to receive signals from the broadcasting network 1 (Figure 1). The second antenna 81_2 and transceiver 82_2 are used to transmit and receive signals to and from a second communications network (not shown), such as a PLMN. The receiver and transceiver 81_1, 82_2 each include respective r.f. signal processing circuits (not shown) for amplifying and demodulating received signals and respective processors (not shown) for channel decoding and demultiplexing.

The mobile terminal 2 also includes a processor 83, a user interface 84, memory 85, an optional smart card reader 86, an optional smart card 87 received in the smart card reader 86, a coder/decoder (codec) 88, a speaker 89 with corresponding amplifier 90 and a microphone 91 with a corresponding pre-amplifier 92.

The user interface 84 comprises a display 93 and a keypad 94. The display 93 is adapted for displaying images and video by, for instance, being larger and/or having greater resolution than a display of conventional mobile telephone and being capable of colour images. The mobile terminal 2 also includes a battery 95.

The processor 83 manages operation of the mobile terminal 2 under the direction of computer software (not shown) stored in memory 85. For example, the controller 83 provides an output for the display 93 and receives inputs from the keypad 94.

The mobile terminal 2 may be modified providing a single receiver adapted to receive signals from the broadcasting network 1 (Figure 1) and the second communications network (not shown) and a transmitter adapted to transmit signals to the second communications network (not shown). Alternatively, a single transceiver for both communications networks may be provided.

Referring to Figure 31, the receiver 82_1 includes a demodulator 96 for demodulating r.f. signal 8 and outputting TS packets 26 for processing by the processor 83. However, processing need not be performed by processor 83 but may be performed within the receiver 82_1 or by a dedicated digital signal processor (not shown). The processes performed by the processor 83 are illustrated as a functional block diagram in Figure 31.

A TS filtering block 97 receives the TS stream 25', filters TS packets 25_A, 25_B according to PID values 71 (Figure 26) held in the TS packet header 70 (Figure 26) and passes the filtered TS packets 25_A, 25_B to a section parsing block 98. TS packets 25_C carrying MPEG-2 TV can also be filtered and processed in a conventional manner.

The section parsing block 98 decapsulates the payload 72 (Figure 26) of the TS packets 25_A, 25_B and outputs MPE sections 16, MPE-FEC sections 17 and SI/PSI table sections 22. The table sections 21 include sections (not shown) carrying NIT 78 (Figure 29) and INT (not shown).

When the mobile terminal 2 is switched on by the user, the TS filtering block 97 may not know the PID values for TS packets 25_A carrying the filtered streams 12 providing the service(s) which the user wishes to consume. Thus, initially, the TS filtering block 97 may only receive and filter TS packets 25_B carrying the NIT 78 (Figure 29) and INT (not shown) which are used for services discovery, for example as described in EN 301 192 *ibid.* The user is presented with an electronic service guide (not shown) from which he or she can select a service. The processor 83 (Figure 30) looks up the PID for the selected service in the NIT 78 (Figure 29) or INT (not shown) and provide the PID to the TS filtering block 97 so as to filter TS packets 25_A.

The section decapsulating block 99 extracts real time parameters, frame_id and frame_counter parameters from the headers 46, 49 (Figures 13 & 14) of MPE and MPE-FEC sections 16, 17 and provides them to a controller block 100.

The section decapsulating block 99 extracts datagrams and RS columns from payloads 47, 50 (Figures 13 & 14) of MPE and MPE-FEC sections 16, 17 and SI/PSI table sections 21 and forwards them to an MPE-FEC decoding block 102 and an PSI/SI parser 103 respectively. The section decapsulating block 99 also forwards address 43 (Figure 13) to an MPE-FEC decoding block 102.

The controller block 100 analyses real time parameters and generates a control signal 104 for instructing the receiver 82_1 to switch off or conserve power. The controller block 100 may also generate other control signals (not shown) to instruct other processing blocks to switch off or conserve power.

The controller block 100 also analyses the real time parameters and generates a control signal 105 for instructing the MPE-FEC decoding block 102 to begin decoding if an end of a burst is lost.

The MPE-FEC decoding block 102 includes one or more decoding tables 106. As will be explained in more detail later, the number and size of the decoding tables 106 may be determined based on the MPE-FEC frame arrangement.

The MPE-FEC decoding block 102 outputs filtered streams 12 to an IP parsing and filtering block 107 filtering IP streams 9 according to IP address.

Referring to Figures 30, 31 and 32, a method of operating the mobile terminal 2 will now be described.

When the mobile terminal 2 is switched on by the user or at another convenient time, the processor 83 downloads NIT 78 (Figure 29) and INT (not shown) and stores them in memory 85 (steps S18 & S19).

Using the NIT (Figure 29) and INT (not shown), appropriate SI tables (not shown) can be downloaded as-and-when required so as to provide an electronic service guide (ESG) (not shown). A mobile terminal user (not shown) can browse the ESG via display 93 and select a service using keypad 94 (step S19).

The user wishes to consume the service provided by filtered streams 12_1, 12_2 (Figure 4).

Once a service has been selected, the processor 83 searches for the network NIT 78 stored in memory 85 for the corresponding time slice and FEC identifier descriptor 73. The processor 83 examines the time slicing, MPE FEC, maximum burst duration, maximum average rate, burst size and frame size and time slice identity fields (not shown) of the descriptor 73 to determine whether time slicing and MPE-FEC is used and, if so, to acquire time slicing and MPE-FEC parameters.

Additionally, the processor 83 examines burst number field 75, frame size field 76 MPE-FEC frame number field 77 and burst size field to determine the number of bursts used to transmit a single MPE-FEC frame, the size of MPE-FEC frame and the number of MPE-FEC frames carried in a single burst. These parameters are passed to the TS filtering block 97, section demultiplexer 99 and MPE-FEC decoding block 102.

Referring to Figure 33, the MPE-FEC decoding block 102 prepares buffers 106, in this example first and second buffers 106_1, 106_2 which correspond to the first and second coding tables 27_1, 27_2 (Figure 7) and comprise respective application data tables 107_1, 107_2, RS data tables 108_1, 108_2 and have 255 columns 109_1, 109_2 and 1024 rows 110_1, 110_2, each position 111_1, 111_2 within the buffers 106_1, 106_2 holding a byte of data (step S21). Preparing buffers 106 may comprise allocating parts of a single buffer having a size L×2 Mbit, where $L > 1$, to a given MPE-FEC frame.

If the receiver 82_1 is not already switched on, the controller 100 instructs the receiver 82_1 to switch on (step S22).

The receiver 82_1 demodulates the signal 8 and outputs TS stream 25'. The TS stream 25' comprises at least part of the multiplex 25 (Figure 27).

The TS filtering block 97 filters TS packets 25_A (Figure 25) according to the PID 71 (Figure 26) (step S23). The TS filtering block 97 may discard any TS packets 25_A containing errors.

The section parsing block 98 receives the TS packets 25_A, decapsulates section fragments 69 (Figure 25) from the TS packets 25_A and outputs MPE sections 16 and MPE-FEC sections 17, for example similar to those shown in Figure 17 (step S24).

Referring also to Figure 34, the section decapsulating block 99 receives the MPE sections 16 and MPE-FEC sections 17, decapsulates the datagrams 28 and RS columns 40 from their payloads 47, 50 from the MPE and MPE-FEC sections 16, 17 (step S25) and extracts real time parameters including address (step S26), frame identity and frame counter parameters (step S27) and burst number (step S28) from the headers 46, 49.

Referring to Figure 35, the MPE-FEC decoding block 102 receives datagrams 28_1, 28_2, for example including datagrams $28_{1,1}$, $28_{1,2}$, $28_{2,1}$, $28_{2,2}$, $28_{2,3}$, $28_{2,4}$, and RS columns 40_1, 40_2, together with corresponding frame identity and frame counter parameter 41, 42, address data 43, table flag 44, burst end flag 45, and burst counter 60.

Based on the frame identity parameter 41, the MPE-FEC decoding block 106 channels datagrams 28 and RS columns 40 to the first and second buffers 106_1, 106_2 and places them in the first and second buffers 106_1, 106_2 according to the address data 43 (step S29).

The MPE-FEC decoding block 102 checks whether the end of the burst has been reached (step S30). This comprises checking the burst end field in the real time parameter field 54, 59 (Figures 15 & 16) and determining whether the burst end field is equal to '1', where '1' indicates end of the burst. If the end of the burst has not been reached, then processing of TS packets 25_A and sections 16, 17 continues (steps S23 to S30).

If the end of the burst is reached, then the MPE-FEC decoding block 102 checks whether further bursts carrying more data from the same MPE-FEC frame are expected (step S31). This comprises checking the burst counter 60 and determining whether the burst counter is equal to '0'. This can also be used to check whether a burst is a single burst comprises plural whole MPE-FEC frames.

Referring to Figure 36, if no further bursts carrying more data from the same MPE-FEC frame are expected whether because the burst is the last in a series carrying one or more MPE-FEC frames or whether the burst comprises plural whole MPE-FEC frames, then the or each MPE-FEC frame 14_1, 14_2 can be assumed to have been received.

The MPE-FEC decoding block 102 need not receive or may ignore RS columns 40_1, 40_2.

Referring to Figure 37, MPE-FEC decoding block 102 decodes the or each MPE-FEC frame 14_1, 14_2 (step S31). This comprises using RS codewords 38_1, 38_2 to check for and correct errors, such as erroneous byte $112_{1,1}$.

The MPE-FEC decoding block 102 need not decode the or each MPE-FEC frame 14_1, 14_2.

MPE-FEC decoding block 102 reads out datagrams 28_1, 28_2 from the buffer 106_1, 106_2 (step S33).

The filtering block 107 filters datagrams 28_1, 28_2 according to their IP address and passes them on to an application (not shown) or memory for storage, further processing, rendering or other use (step S33). If the service has been delivered or is no longer required, then reception and processing of TS packets 25_A for the service can cease (step S35).

If further bursts are expected, then the controller 100 instructs the receiver 82_1 to switch off (step S36), waits delta-t (step S37), preferably using the value received in the last section of the burst and instructs the receiver 82_1 to switch on to receive the next burst (step S22).

Referring to Figure 38, if an MPE-FEC frame larger than 2 Mbits is to be received, for example MPE-FEC frame $14_{1,1}$' (Figure 22), then the decoding table 106_1' which is larger than a conventional time-slicing buffer buffer, in other words larger than 2 Mbits, can be prepared.

Referring to Figure 39, if plural MPE-FEC frames are to be received in a single burst, for MPE-FEC frame $14_{3,1}$, $14_{4,1}$, $14_{5,1}$, then respective decoding tables 106_3, 106_4, 106_5 can be prepared.

It will be appreciated that many modifications may be made to the embodiments hereinbefore described. For example, the mobile terminal 2 may be a personal data assistant (PDA) or other mobile terminal capable of at least of receiving signals via the first communications network 1. The mobile terminal may also be semi-fixed or semi-portable such as a terminal carried in vehicle, such as a car.

2005283852 20 Jan 2010

The claims defining the invention are as follows:

1. A method comprising:

providing a first data frame, the data frame comprising data and forward error correction data;

forming a sequence of transmissions; and

dividing the first data frame between said transmissions, the data being divided between at least two transmissions.

2. A method according to claim 1, wherein at least one transmission does not include forward error correction data.

3. A method according to claim 1, further comprising:

providing a second data frame, the second data frame comprising data and forward error correction data; and

dividing the data and the forward error correction data in the second data frame between the plurality of transmissions.

4. A method according to claim 3, comprising:

dividing the first data frame into a first set of data frame blocks;

dividing the second data frame into a second set of data frame blocks;

interleaving the first and second sets of data frame blocks; and

sequentially placing the interleaved data frame blocks into the plurality of transmissions.

5. A method according to claim 1, further comprising:

providing each data frame with a respective label for identifying an origin of the data.

6. A method according to claim 1, further comprising:

providing each data frame with a respective label for locating the data frame in a sequence of data frames.

7. A method according to claim 1, further comprising:

providing each transmission with a respective label for identifying the transmission within the plurality of transmissions.

8. A method according to claim 1, wherein providing the first data frame comprises:

providing a first array comprising first and second portions;

filling at least a part of the first array-portion with the data;

determining forward error correction data in dependence upon the data in the first array-portion; and

placing said forward error correction data in the second array-portion.

9. A method according to claim 1, comprising:

encapsulating the data into a first set of multiprotocol encapsulation sections; and

encapsulating said corresponding forward error correction data into a second set of multiprotocol encapsulation sections.

10. A method according to claim 9, wherein forming said plurality of transmissions comprises:

arranging said first and second sets of multiprotocol encapsulation sections temporally-offset groups.

11. A method according to claim 1, wherein said first data frame is a multiprotocol encapsulation-forward error correction frame.

12. A method comprising:

providing a first data frame, said first data frame comprising data and forward error correction data;

providing a second data frame, said second data frame comprising data and forward error correction data; and

forming a transmission comprising said first and second data frames.

13. A method comprising:

receiving a first transmission, said transmission including data for a data frame;

placing said data in a data frame;

extracting, from said first transmission, an indication that a second transmission in a sequence of transmissions which includes said first transmission will follow;

receiving said second transmission, said second transmission including further data for said data frame; and

placing said further data in said data frame.

14. A method comprising:

receiving a transmission, said transmission including data for a plurality of data frames;

extracting sets of data from said transmission together with indications to which data frame said sets of data belong; and

placing each set of data in a corresponding data frame.

15. A computer program comprising instructions for causing data processing apparatus:

to provide a first data frame, the data frame comprising data and forward error correction data,

to form a sequence of transmissions; and

to divide the first data frame between said transmissions, the data being divided between at least two transmissions.

16. A computer program comprising instructions for causing data processing apparatus:

to provide a first data frame, said first data frame comprising data and forward error correction data;

to provide a second data frame, said second data frame comprising data and forward error correction data; and

to form a transmission comprising said first and second data frames.

17. A computer program comprising instructions for causing data processing apparatus to:

to receive a first transmission, said transmission including data for a data frame;

to place said data in a data frame;

to extract, from said first transmission, an indication that a second transmission in a sequence of transmissions which includes said first transmission will follow;

to receive said second transmission, said second transmission including further data for said data frame; and

to place said further data in said data frame.

18. A computer program comprising instructions for causing data processing apparatus:

to receive a transmission, said transmission including data for a plurality of data frames;

to extract sets of data from said transmission together with indications to which data frame said sets of data belong; and

to place each set of data in a corresponding data frame.

19. A device configured:

to provide a first data frame, the first data frame comprising data and forward error correction data;

to form a sequence of transmissions; and

to divide the first data frame between said transmissions, the data being divided between at least two transmissions.

20. A network element configured:

to provide a first data frame, said first data frame comprising data and forward error correction data;

to provide a second data frame, said second data frame comprising data and forward error correction data; and

to form a transmission comprising said first and second data frames.

21. A device according to claim 20, which is a multiprotocol encapsulation encapsulator.

22. A device configured:

to receive a first transmission, said transmission including data for a data frame;

to place said data in a data frame;

to extract, from said first transmission, an indication that a second transmission in a sequence of transmissions which includes said first transmission will follow;

to receive said second transmission, said second transmission including further data for said data frame; and

to place said further data in said data frame.

23. A device configured:

to receive a transmission, said transmission including data for a plurality of data frames;

to extract sets of data from said transmission together with indications to which data frame said sets of data belong; and

to place said data in a corresponding data frame.

24. A method according to claim 1, wherein the transmission is a burst.

25. A method of transmitting in a digital broadcasting network, comprising a method according to claim 1.

26. A method according claim 25, wherein said digital broadcasting network is a digital video broadcasting network.

2005283852 20 Jan 2010

DATED this Twentieth Day of January, 2010

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Patent Attorneys for the Applicant

SPRUSON & FERGUSON

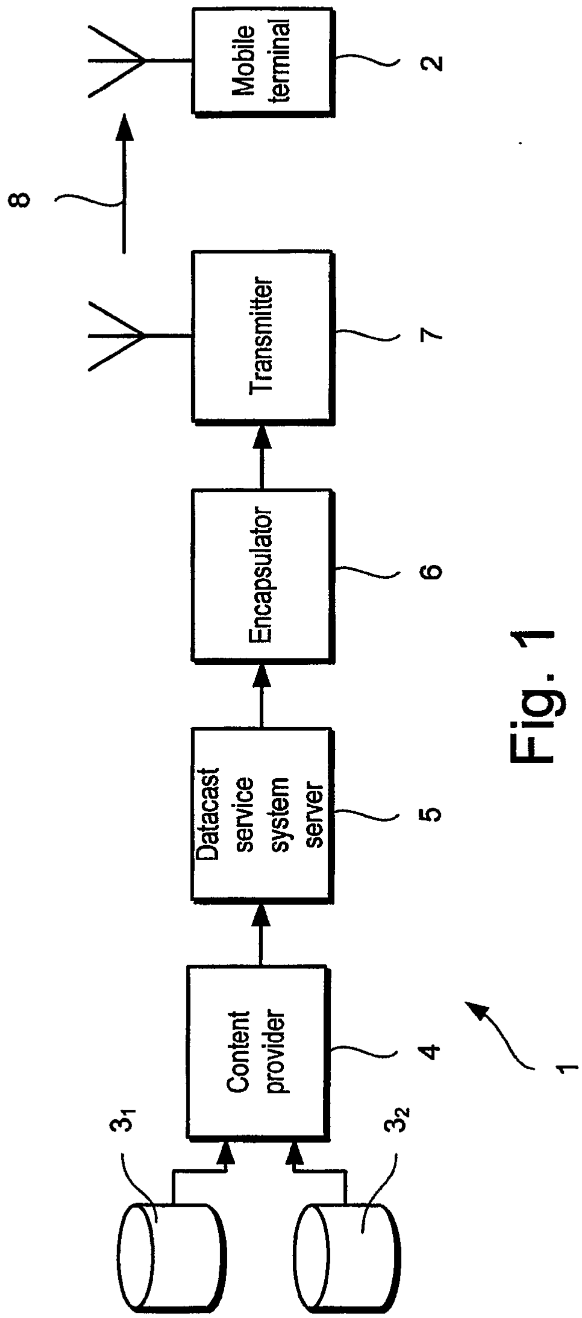

Mobile terminal
2
8
Transmiter
7
Encapsulator
6
Datacast service system server
5
Content provider
4
1
31
32

Fig. 1

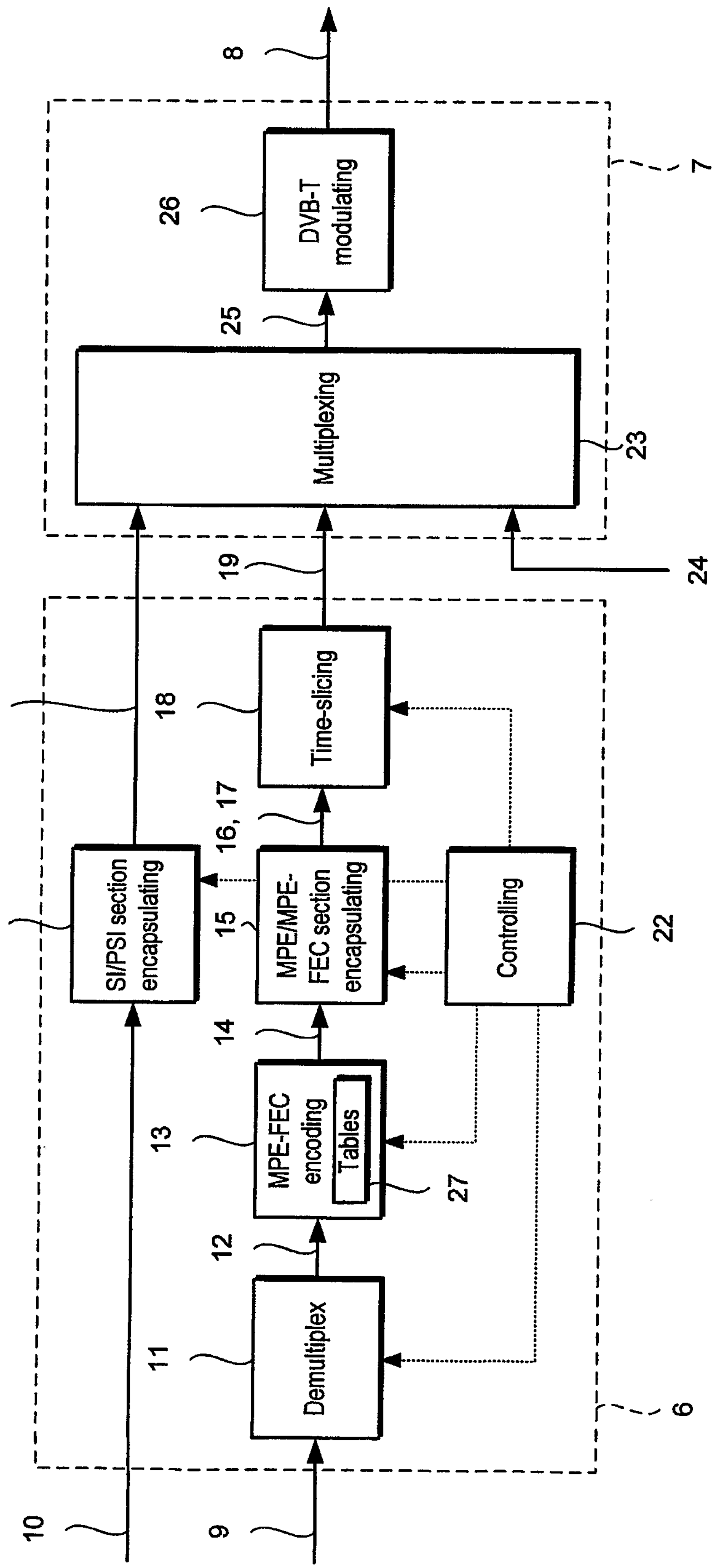

DVB-T modulating
Multiplexing
SI/PSI section encapsulating
MPE/MPE-FEC section encapsulating
Time-slicing
Controlling
MPE-FEC encoding
Tables
Demultiplex
8
7
26
25
23
24
19
21
18
16, 17
20
15
22
14
13
27
12
11
6
10
9

Fig. 2

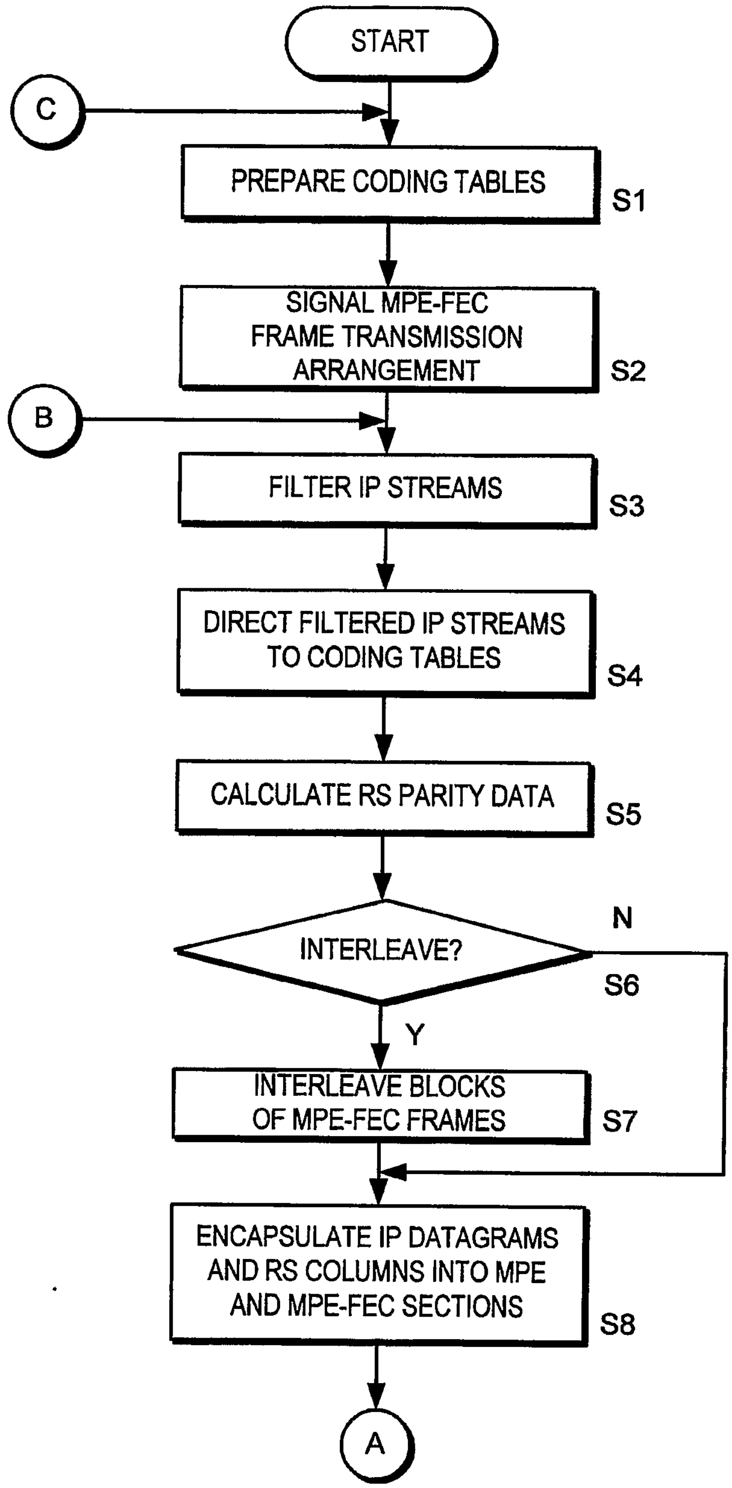

START
C
PREPARE CODING TABLES
S1
SIGNAL MPE-FEC FRAME TRANSMISSION ARRANGEMENT
S2
B
FILTER IP STREAMS
S3
DIRECT FILTERED IP STREAMS TO CODING TABLES
S4
CALCULATE RS PARITY DATA
S5
INTERLEAVE?
N
S6
Y
INTERLEAVE BLOCKS OF MPE-FEC FRAMES
S7
ENCAPSULATE IP DATAGRAMS AND RS COLUMNS INTO MPE AND MPE-FEC SECTIONS
S8
A

Fig. 3

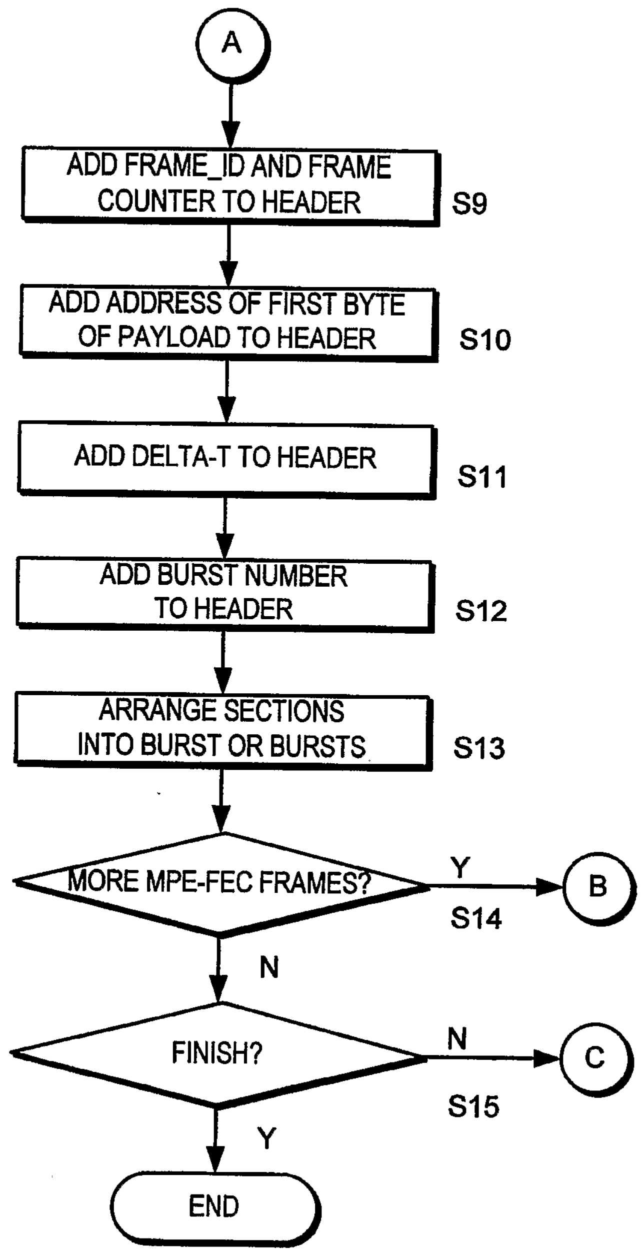

A
ADD FRAME_ID AND FRAME COUNTER TO HEADER
S9
ADD ADDRESS OF FIRST BYTE OF PAYLOAD TO HEADER
S10
ADD DELTA-T TO HEADER
S11
ADD BURST NUMBER TO HEADER
S12
ARRANGE SECTIONS INTO BURST OR BURSTS
S13
MORE MPE-FEC FRAMES?
Y
B
S14
N
FINISH?
N
C
S15
Y
END

Fig. 3

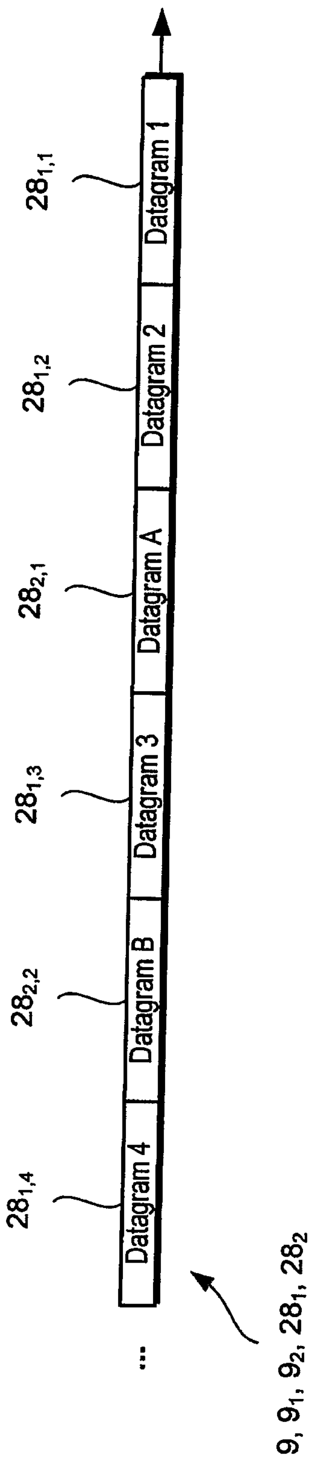


Fig. 4

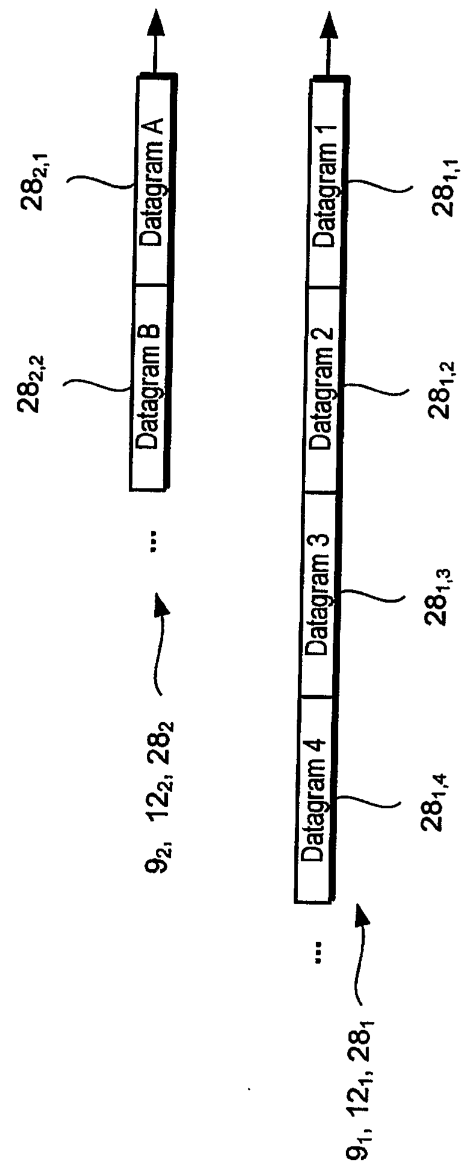


Fig. 6

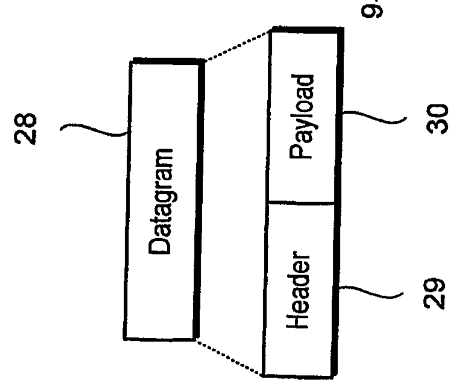


Fig. 5

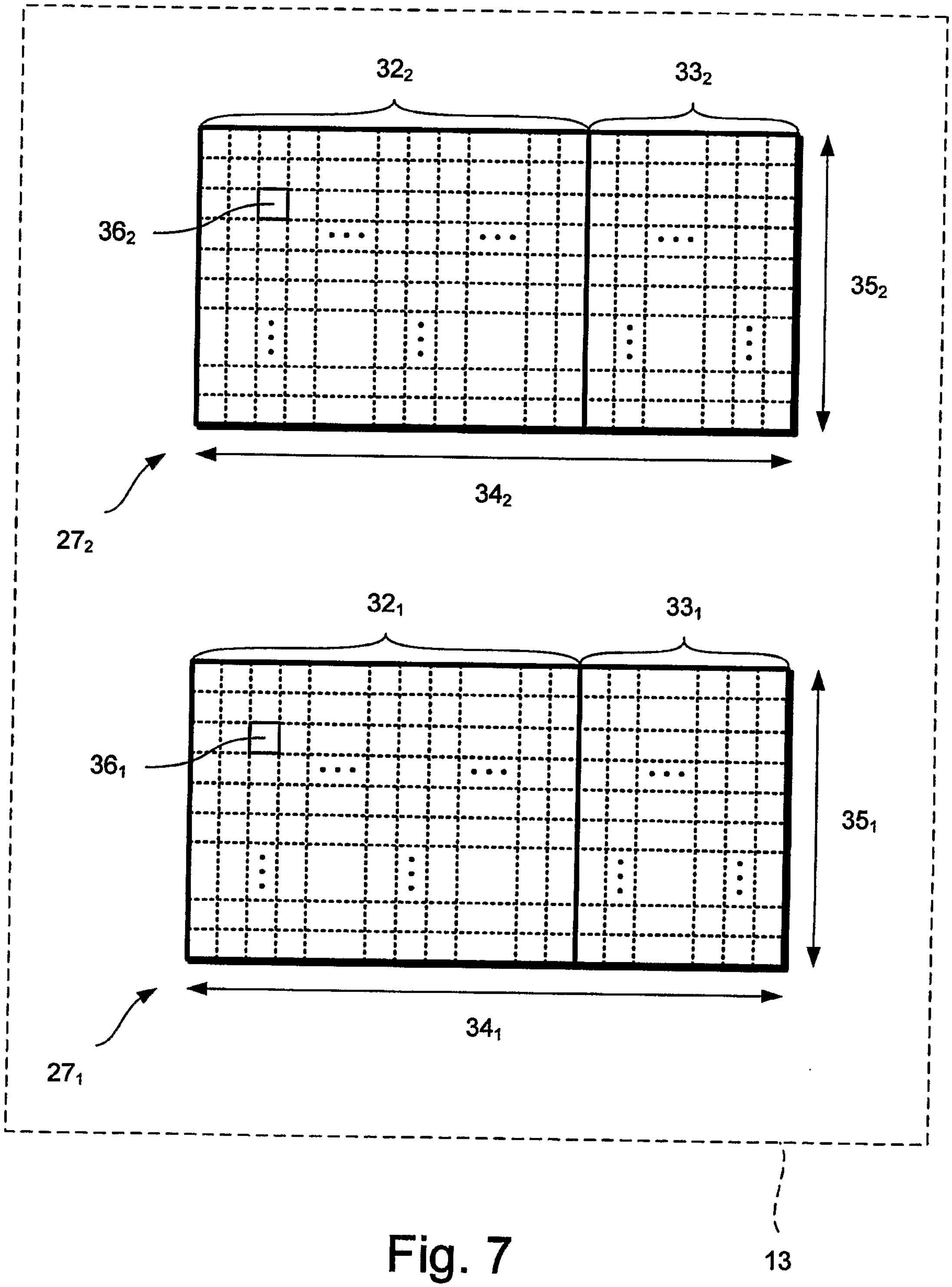


Fig. 7

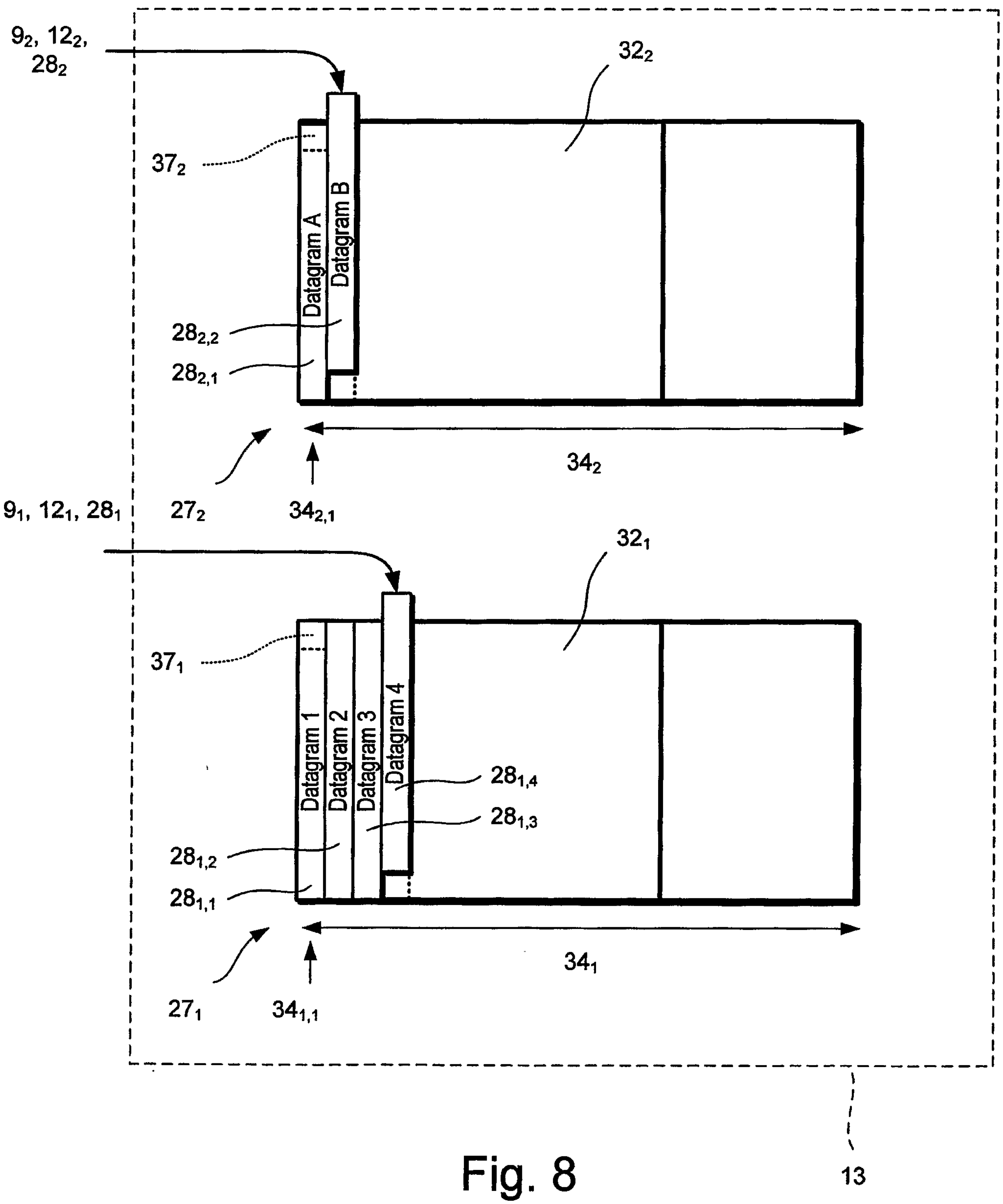
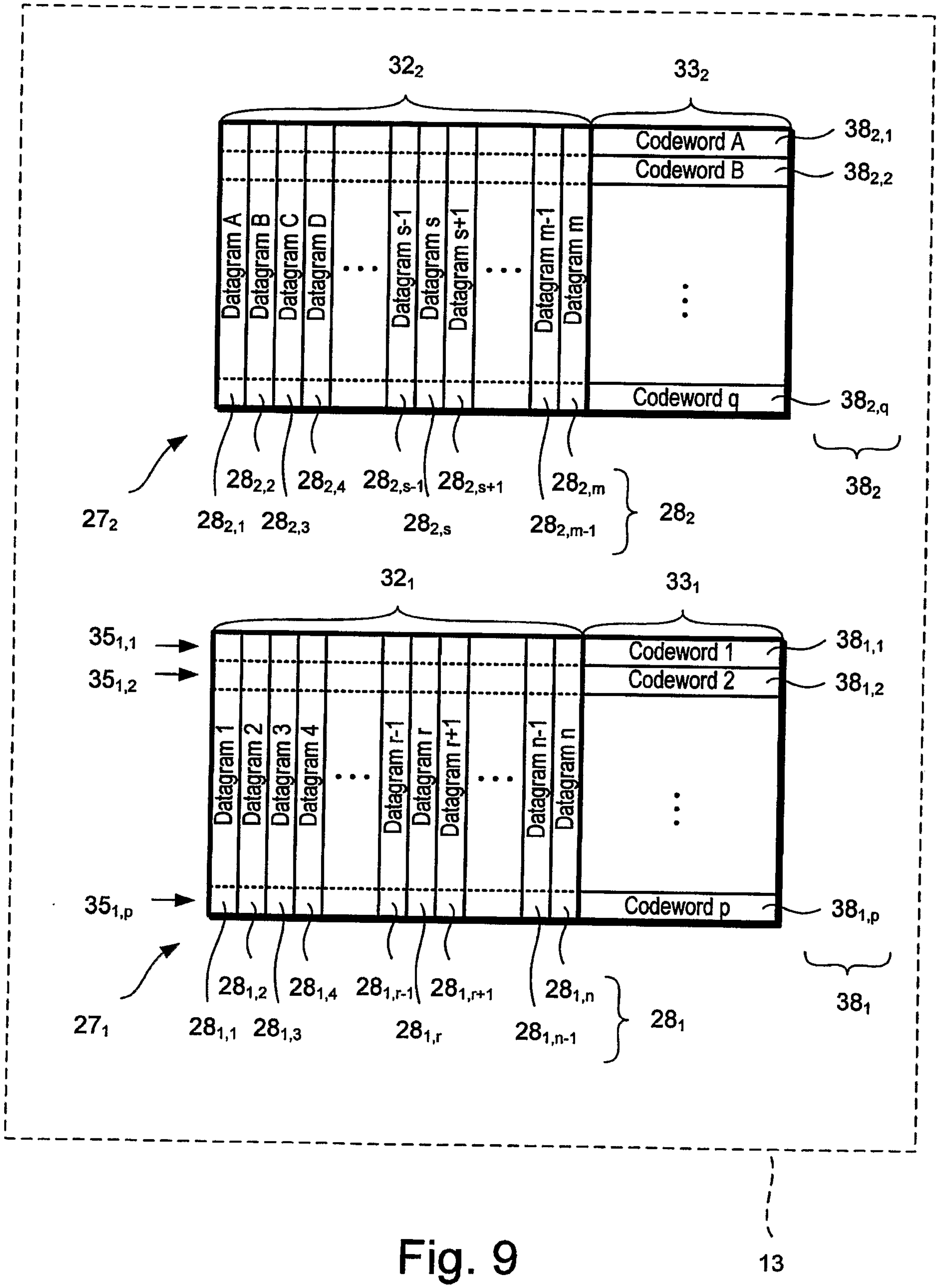
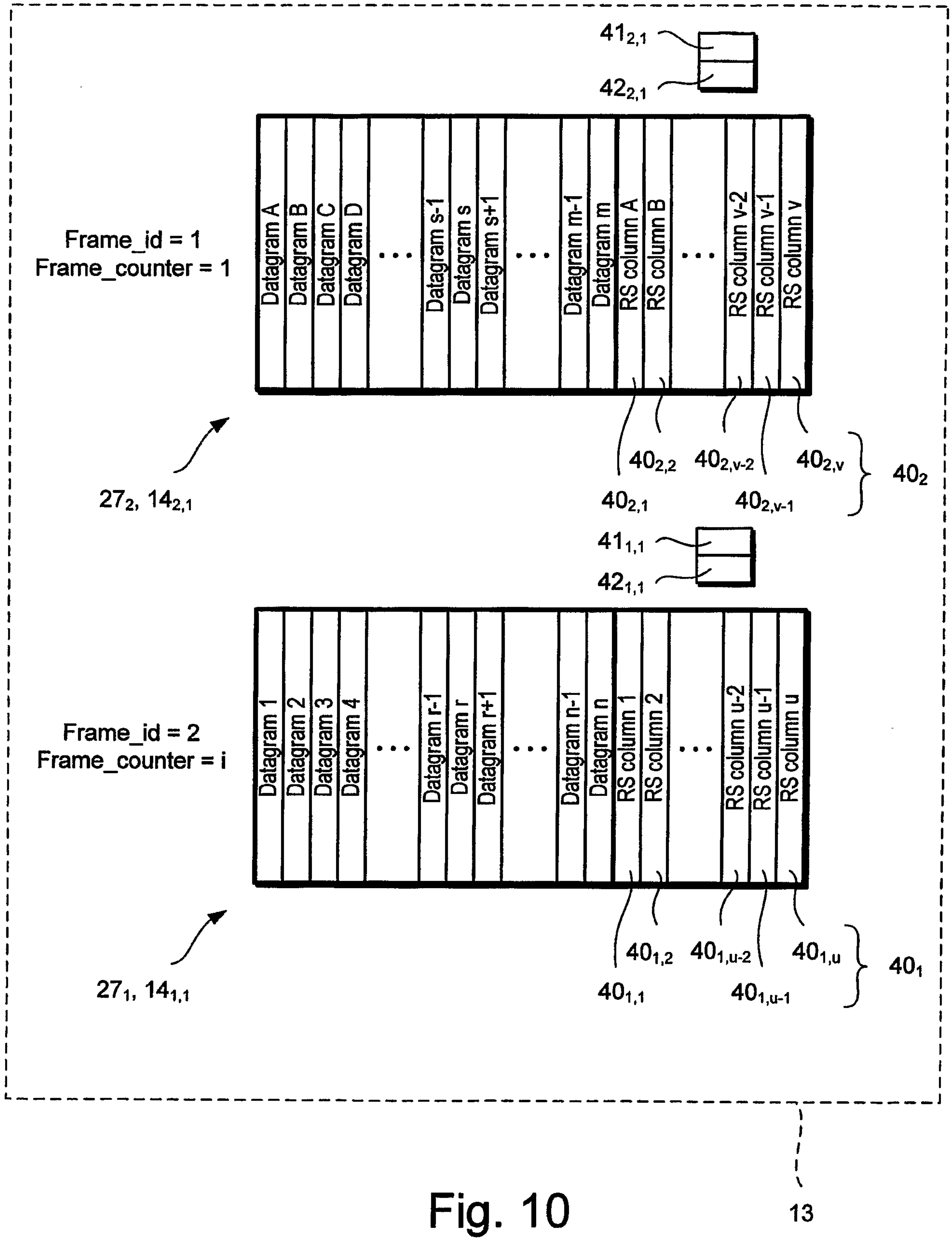

9₂, 12₂, 28₂
32₂
37₂
Datagram A
Datagram B
28₂,₂
28₂,₁
34₂
27₂
34₂,₁
9₁, 12₁, 28₁
32₁
37₁
Datagram 1
Datagram 2
Datagram 3
Datagram 4
28₁,₄
28₁,₃
28₁,₂
28₁,₁
34₁
27₁
34₁,₁
13

Fig. 8



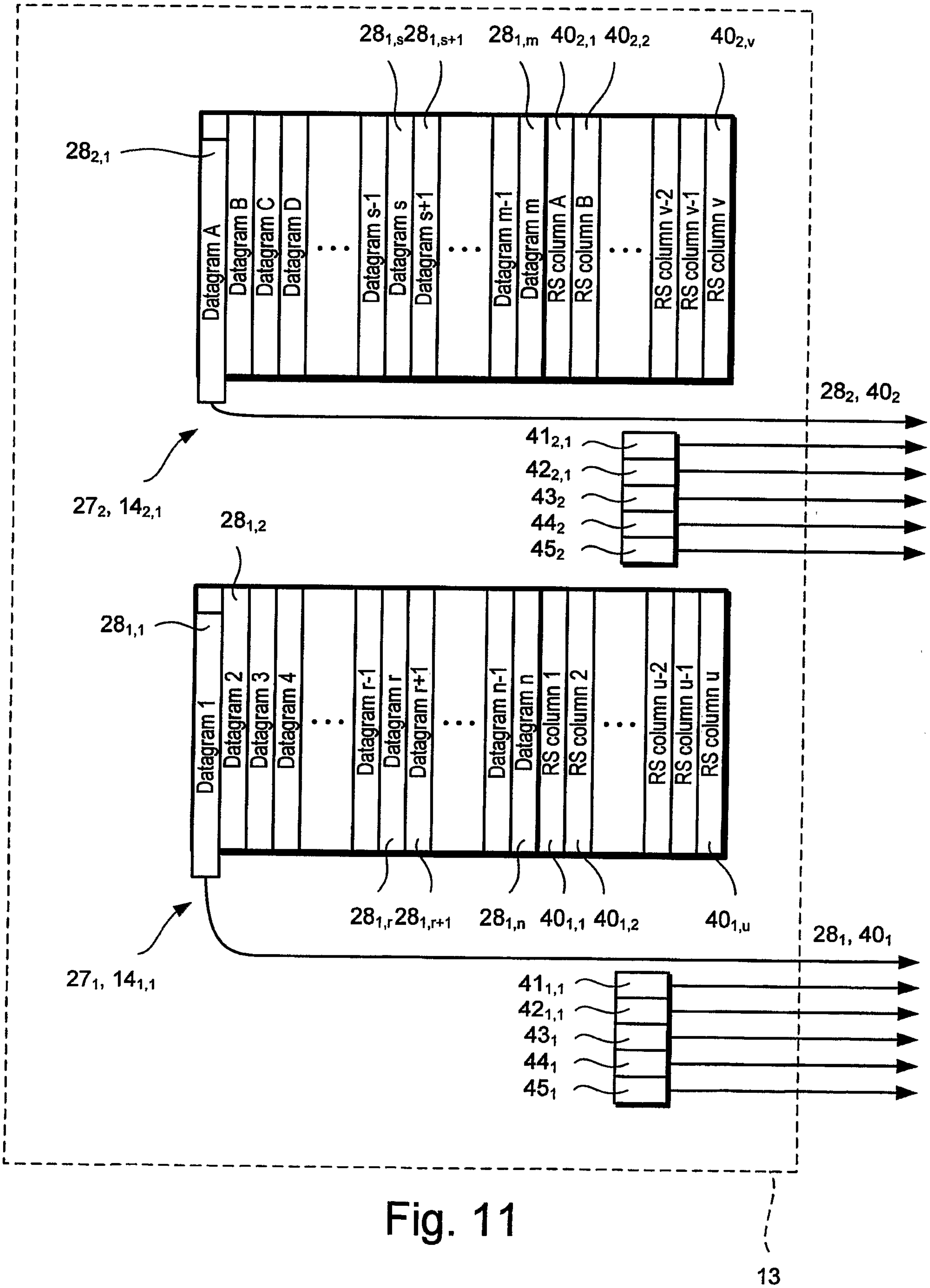
32₂
33₂
Codeword A
Codeword B
Codeword q
38₂,₁
38₂,₂
38₂,q
38₂
Datagram A
Datagram B
Datagram C
Datagram D
Datagram s-1
Datagram s
Datagram s+1
Datagram m-1
Datagram m
27₂
28₂,₁
28₂,₂
28₂,₃
28₂,₄
28₂,s-1
28₂,s
28₂,s+1
28₂,m-1
28₂,m
28₂
32₁
33₁
35₁,₁
35₁,₂
35₁,p
Codeword 1
Codeword 2
Codeword p
38₁,₁
38₁,₂
38₁,p
38₁
Datagram 1
Datagram 2
Datagram 3
Datagram 4
Datagram r-1
Datagram r
Datagram r+1
Datagram n-1
Datagram n
27₁
28₁,₁
28₁,₂
28₁,₃
28₁,₄
28₁,r-1
28₁,r
28₁,r+1
28₁,n-1
28₁,n
28₁
13

Fig. 9



$41_{2,1}$
$42_{2,1}$
Frame_id = 1
Frame_counter = 1
Datagram A
Datagram B
Datagram C
Datagram D
Datagram s-1
Datagram s
Datagram s+1
Datagram m-1
Datagram m
RS column A
RS column B
RS column v-2
RS column v-1
RS column v
27_2, $14_{2,1}$
$40_{2,1}$
$40_{2,2}$
$40_{2,v-2}$
$40_{2,v-1}$
$40_{2,v}$
40_2
$41_{1,1}$
$42_{1,1}$
Frame_id = 2
Frame_counter = i
Datagram 1
Datagram 2
Datagram 3
Datagram 4
Datagram r-1
Datagram r
Datagram r+1
Datagram n-1
Datagram n
RS column 1
RS column 2
RS column u-2
RS column u-1
RS column u
27_1, $14_{1,1}$
$40_{1,1}$
$40_{1,2}$
$40_{1,u-2}$
$40_{1,u-1}$
$40_{1,u}$
40_1
13

Fig. 10



28_{1,s} 28_{1,s+1}
28_{1,m}
40_{2,1} 40_{2,2}
40_{2,v}
28_{2,1}
Datagram A
Datagram B
Datagram C
Datagram D
Datagram s-1
Datagram s
Datagram s+1
Datagram m-1
Datagram m
RS column A
RS column B
RS column v-2
RS column v-1
RS column v
28_2, 40_2
41_{2,1}
42_{2,1}
43_2
44_2
45_2
27_2, 14_{2,1}
28_{1,2}
28_{1,1}
Datagram 1
Datagram 2
Datagram 3
Datagram 4
Datagram r-1
Datagram r
Datagram r+1
Datagram n-1
Datagram n
RS column 1
RS column 2
RS column u-2
RS column u-1
RS column u
28_{1,r} 28_{1,r+1}
28_{1,n}
40_{1,1} 40_{1,2}
40_{1,u}
28_1, 40_1
27_1, 14_{1,1}
41_{1,1}
42_{1,1}
43_1
44_1
45_1
13

Fig. 11

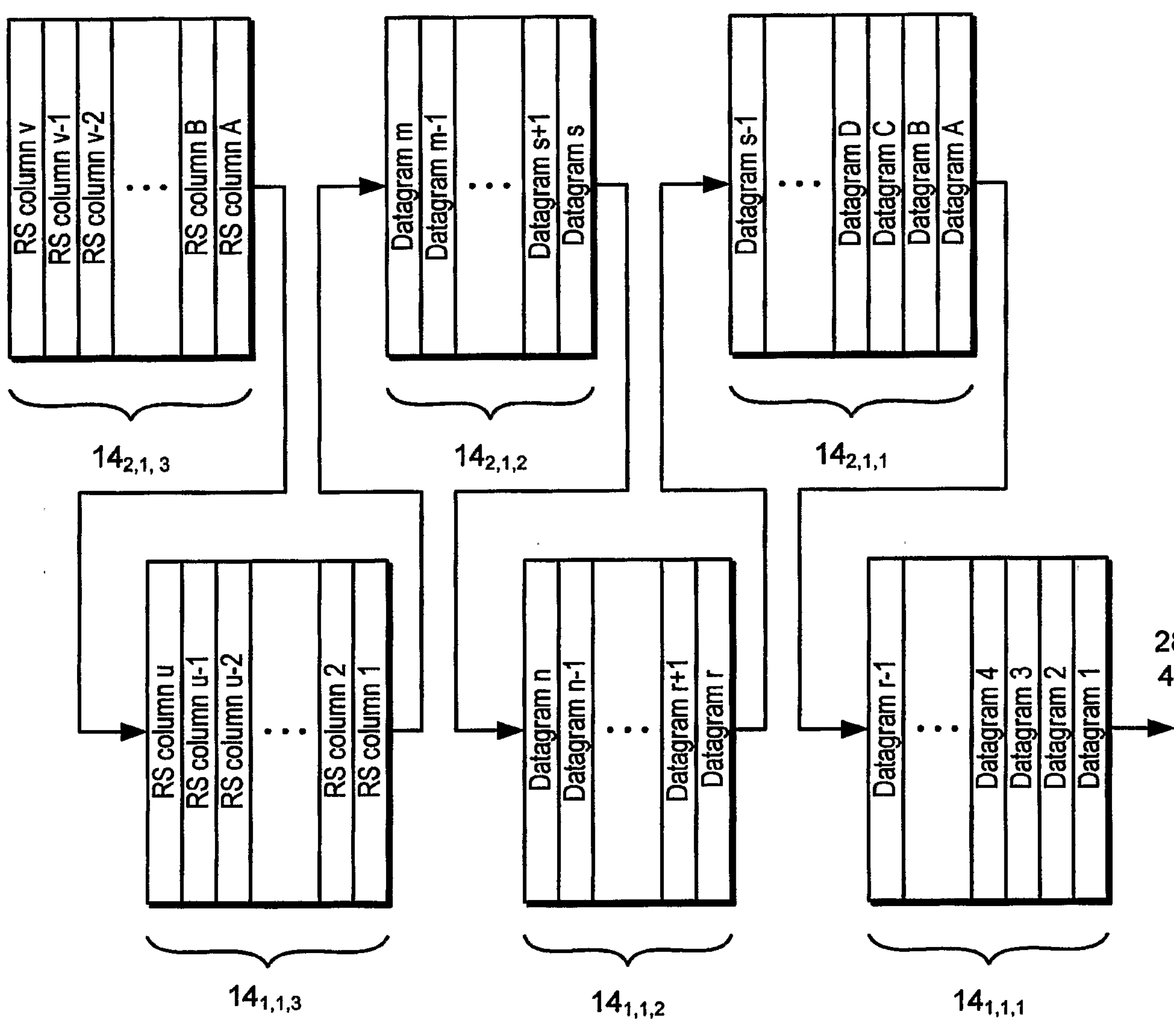

RS column v
RS column v-1
RS column v-2
RS column B
RS column A
Datagram m
Datagram m-1
Datagram s+1
Datagram s
Datagram s-1
Datagram D
Datagram C
Datagram B
Datagram A
$14_{2,1,3}$
$14_{2,1,2}$
$14_{2,1,1}$
RS column u
RS column u-1
RS column u-2
RS column 2
RS column 1
Datagram n
Datagram n-1
Datagram r+1
Datagram r
Datagram r-1
Datagram 4
Datagram 3
Datagram 2
Datagram 1
28,
40
$14_{1,1,3}$
$14_{1,1,2}$
$14_{1,1,1}$

Fig. 12

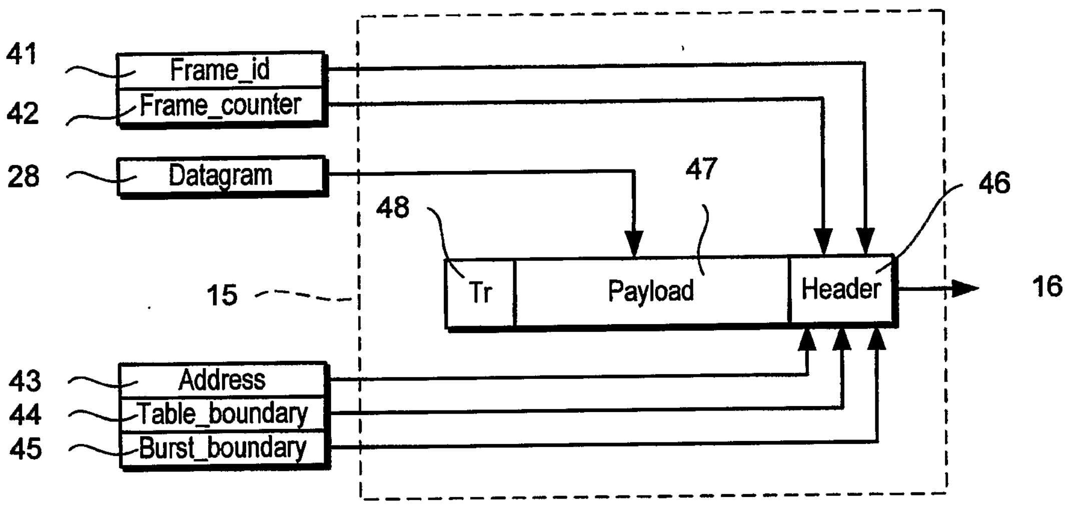

41
42
28
Frame_id
Frame_counter
Datagram
47
48
46
Tr
Payload
Header
15
16
43
44
45
Address
Table_boundary
Burst_boundary

Fig. 13

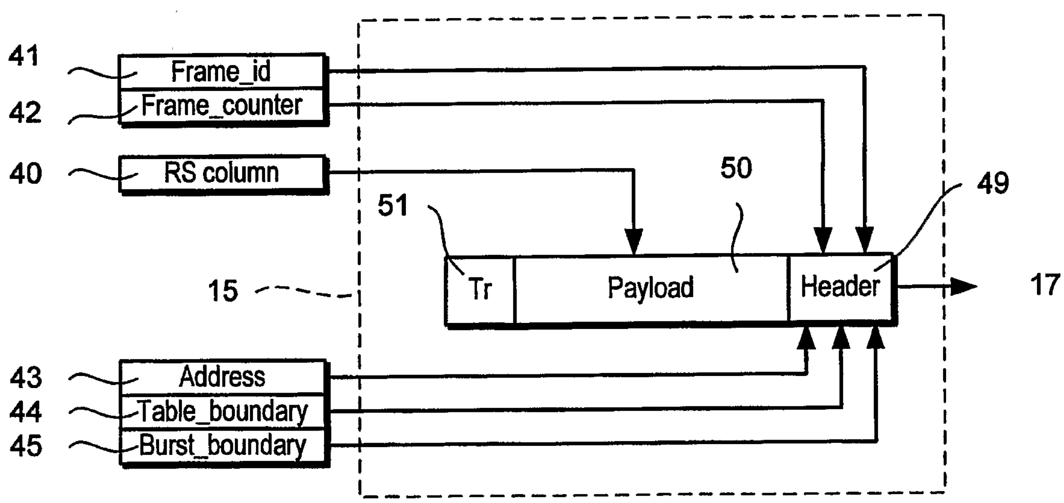

41
42
40
Frame_id
Frame_counter
RS column
50
51
49
Tr
Payload
Header
15
17
43
44
45
Address
Table_boundary
Burst_boundary

Fig. 14

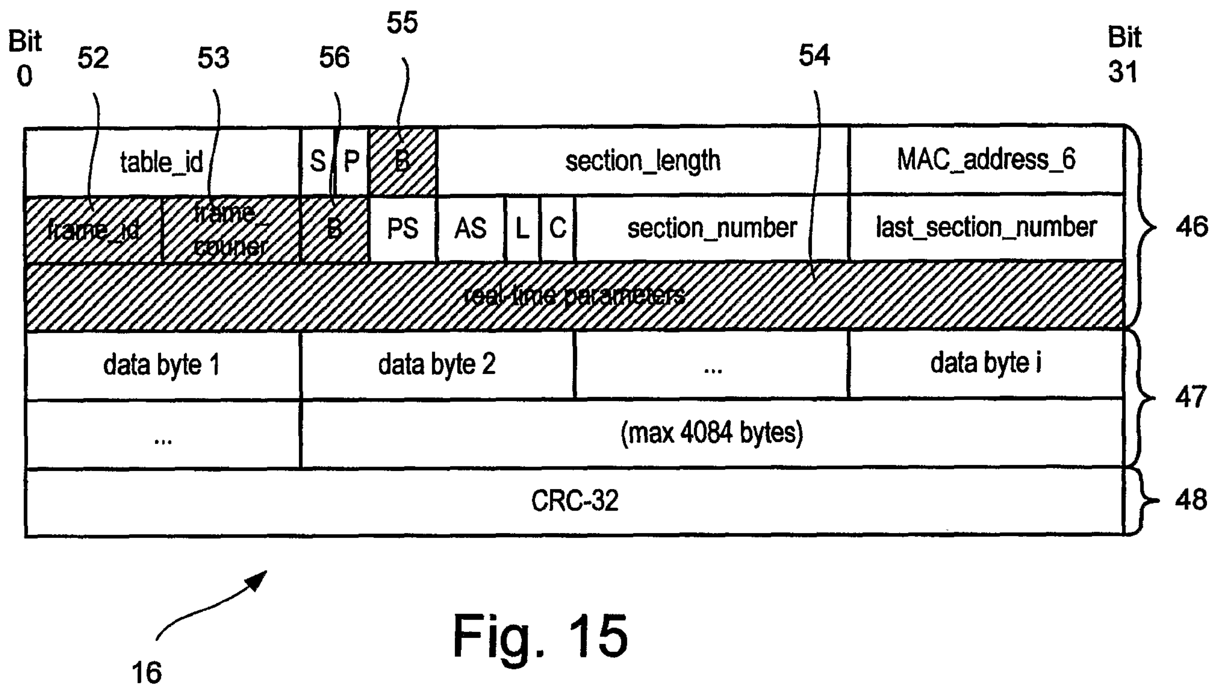

55
Bit 0
52
53
56
54
Bit 31
table_id
S
P
B
section_length
MAC_address_6
frame_id
frame_ couner
B
PS
AS
L
C
section_number
last_section_number
46
real-time parameters
data byte 1
data byte 2
...
data byte i
47
...
(max 4084 bytes)
CRC-32
48
16

Fig. 15

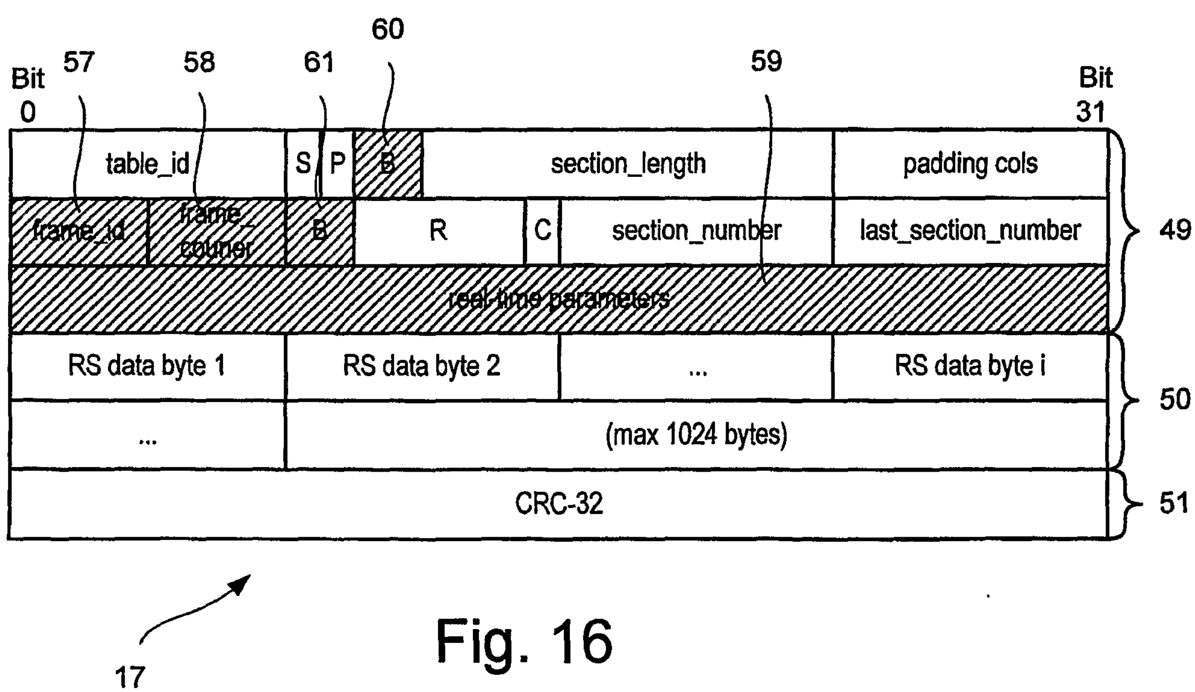

60
Bit 0
57
58
61
59
Bit 31
table_id
S
P
B
section_length
padding cols
frame_id
frame_ couner
B
R
C
section_number
last_section_number
49
real-time parameters
RS data byte 1
RS data byte 2
...
RS data byte i
50
...
(max 1024 bytes)
CRC-32
51
17

Fig. 16

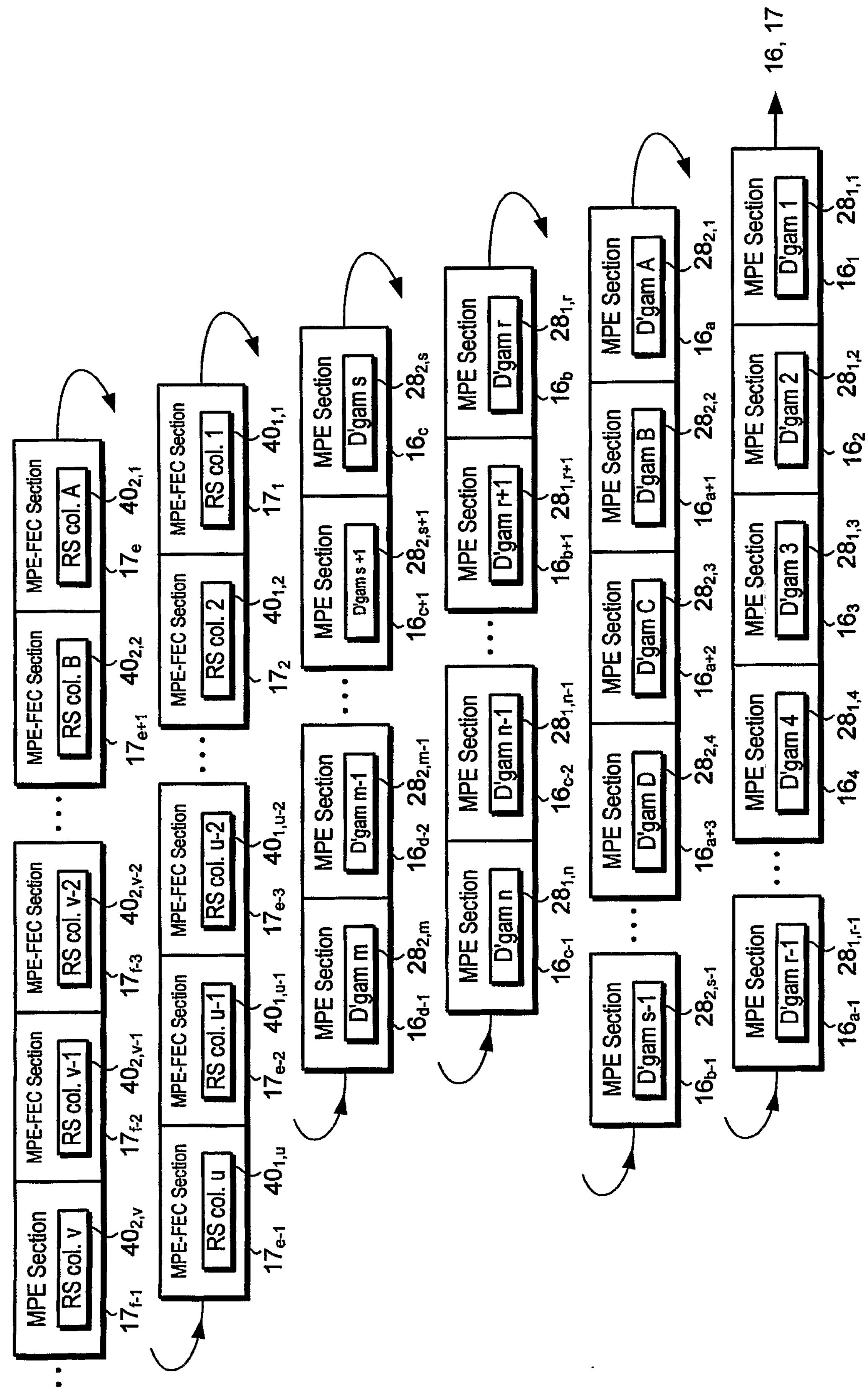

16, 17
MPE Section
D'gam 1
D'gam 2
D'gam 3
D'gam 4
D'gam r-1
D'gam A
D'gam B
D'gam C
D'gam D
D'gam s-1
D'gam r
D'gam r+1
D'gam n-1
D'gam n
D'gam s
D'gam s +1
D'gam m-1
D'gam m
MPE-FEC Section
RS col. 1
RS col. 2
RS col. u-2
RS col. u-1
RS col. u
RS col. A
RS col. B
RS col. v-2
RS col. v-1
RS col. v

Fig. 17

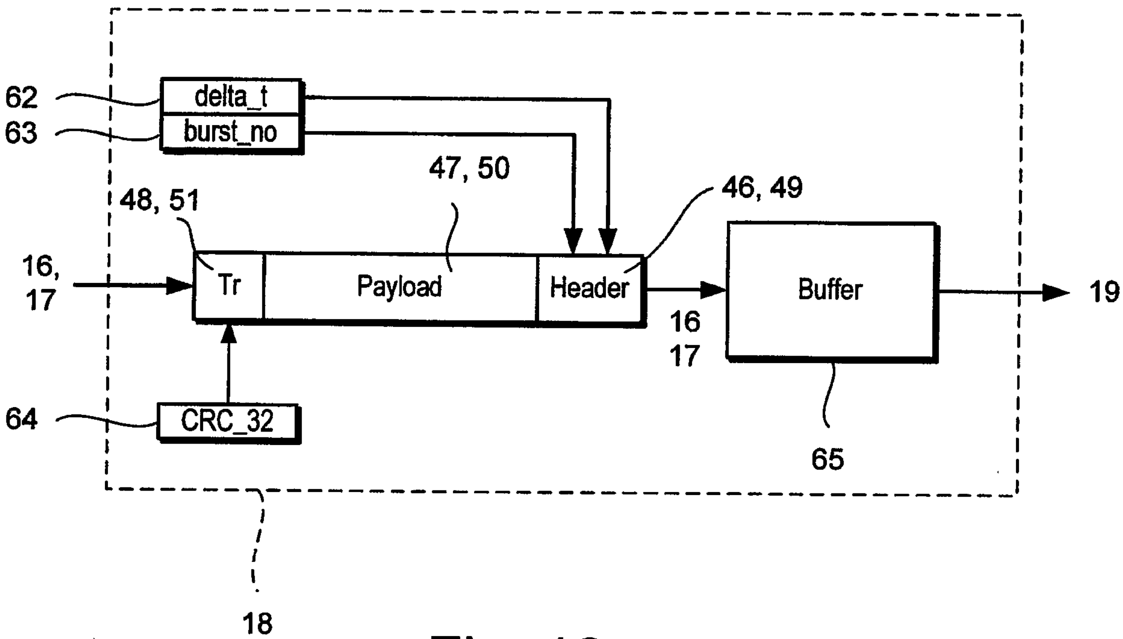

62
63
delta_t
burst_no
47, 50
48, 51
46, 49
16,
17
Tr
Payload
Header
Buffer
19
16
17
64
CRC_32
65
18

Fig. 18

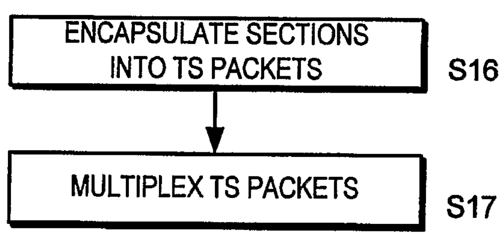

ENCAPSULATE SECTIONS INTO TS PACKETS
S16
MULTIPLEX TS PACKETS
S17

Fig. 24

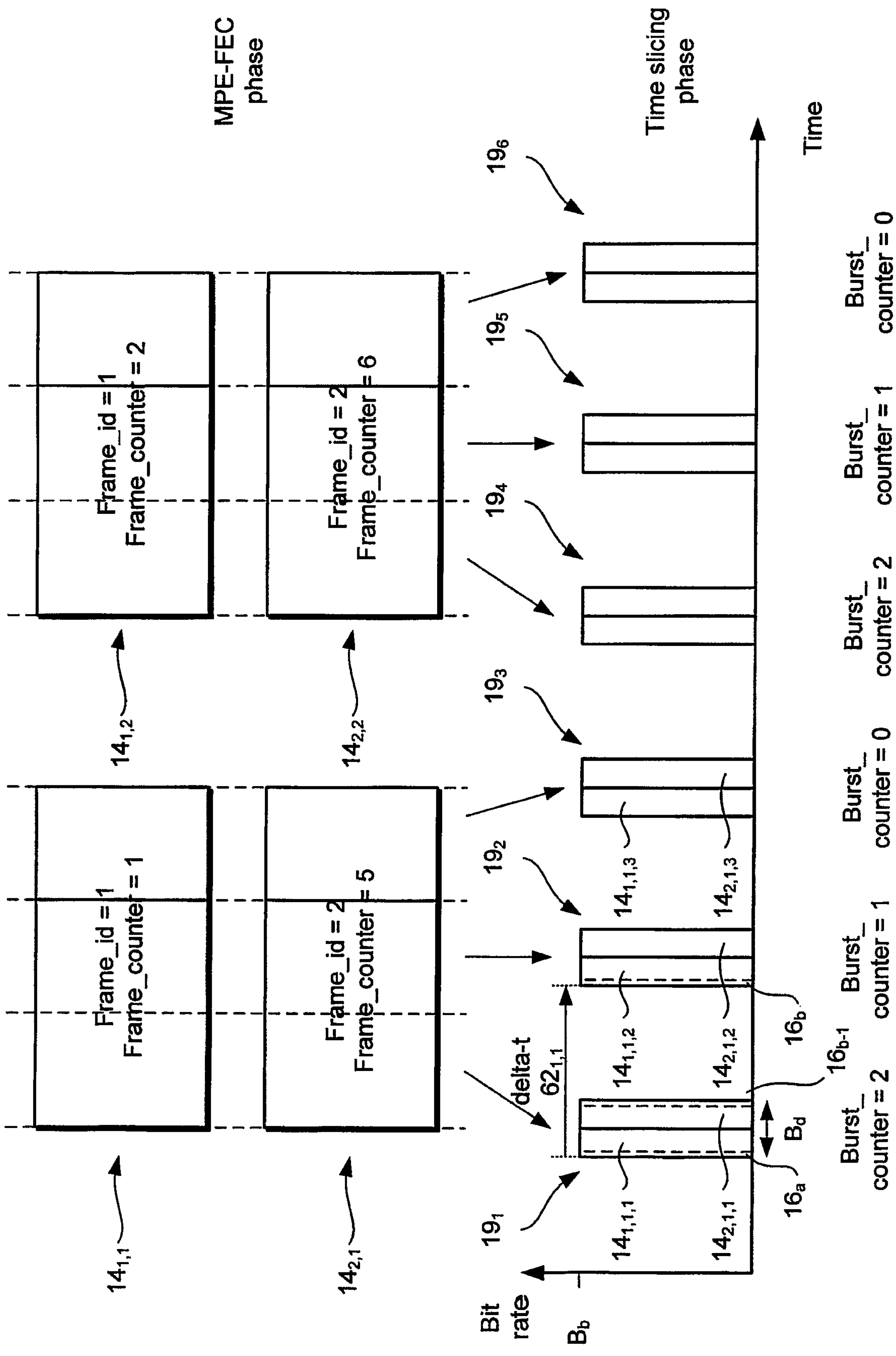

MPE-FEC phase
Time slicing phase
Time
Bit rate
B_b
Frame_id = 1
Frame_counter = 1
Frame_id = 2
Frame_counter = 5
Frame_id = 1
Frame_counter = 2
Frame_id = 2
Frame_counter = 6
$14_{1,1}$
$14_{2,1}$
$14_{1,2}$
$14_{2,2}$
19_1
19_2
19_3
19_4
19_5
19_6
delta-t
$62_{1,1}$
$14_{1,1,1}$
$14_{2,1,1}$
$14_{1,1,2}$
$14_{2,1,2}$
$14_{1,1,3}$
$14_{2,1,3}$
B_d
16_a
16_{b-1}
16_b
Burst_counter = 2
Burst_counter = 1
Burst_counter = 0
Burst_counter = 2
Burst_counter = 1
Burst_counter = 0

Fig. 19

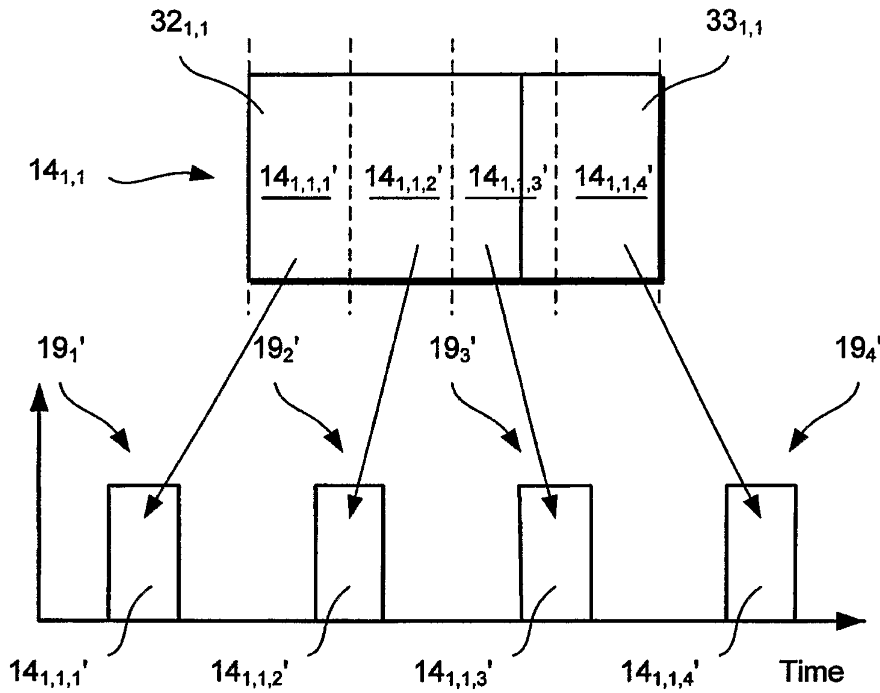


Fig. 20

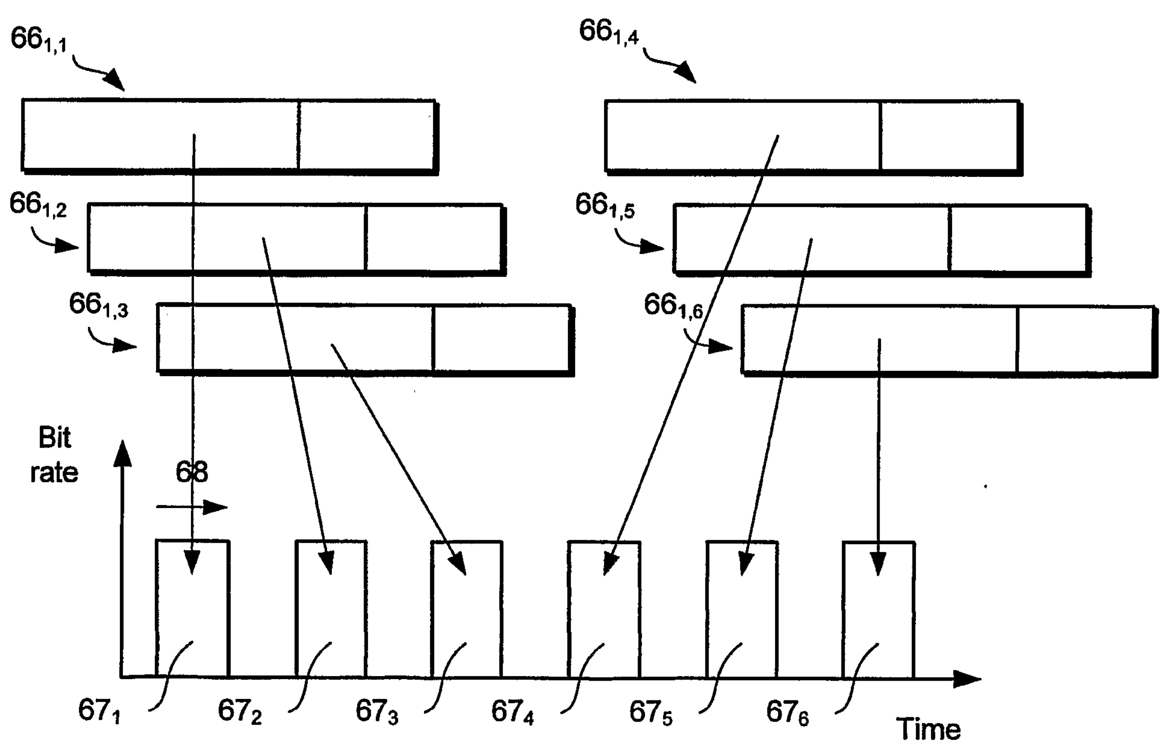


Fig. 21 (Prior art)

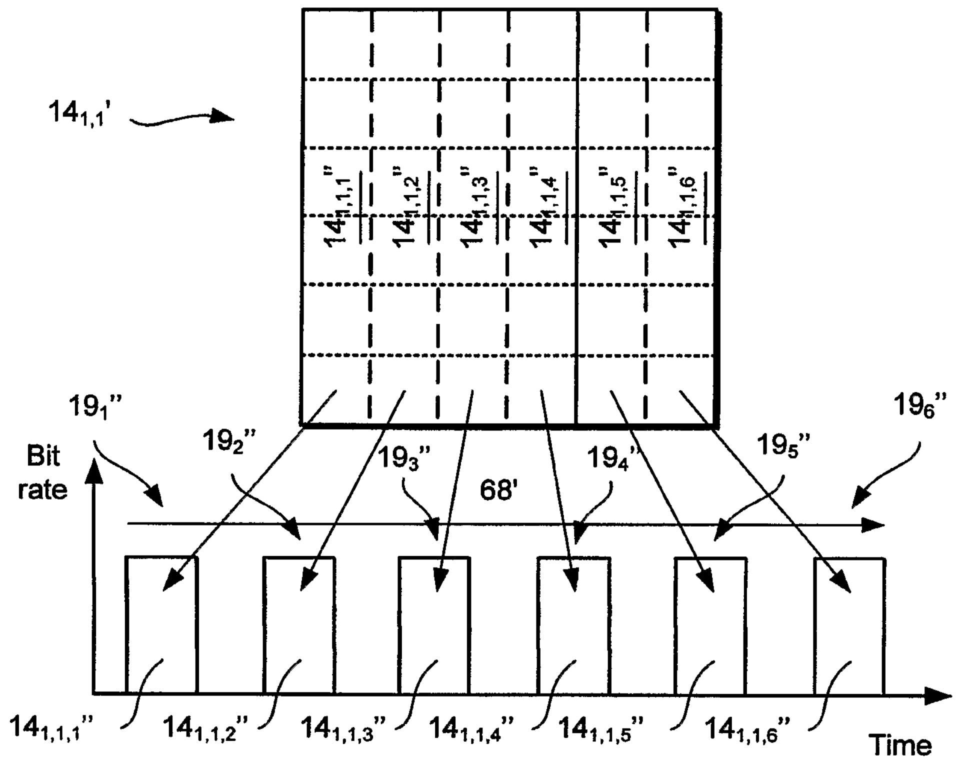

14_{1,1}'
14_{1,1,1}"
14_{1,1,2}"
14_{1,1,3}"
14_{1,1,4}"
14_{1,1,5}"
14_{1,1,6}"
19_1"
19_2"
19_3"
19_4"
19_5"
19_6"
68'
Bit rate
Time

Fig. 22

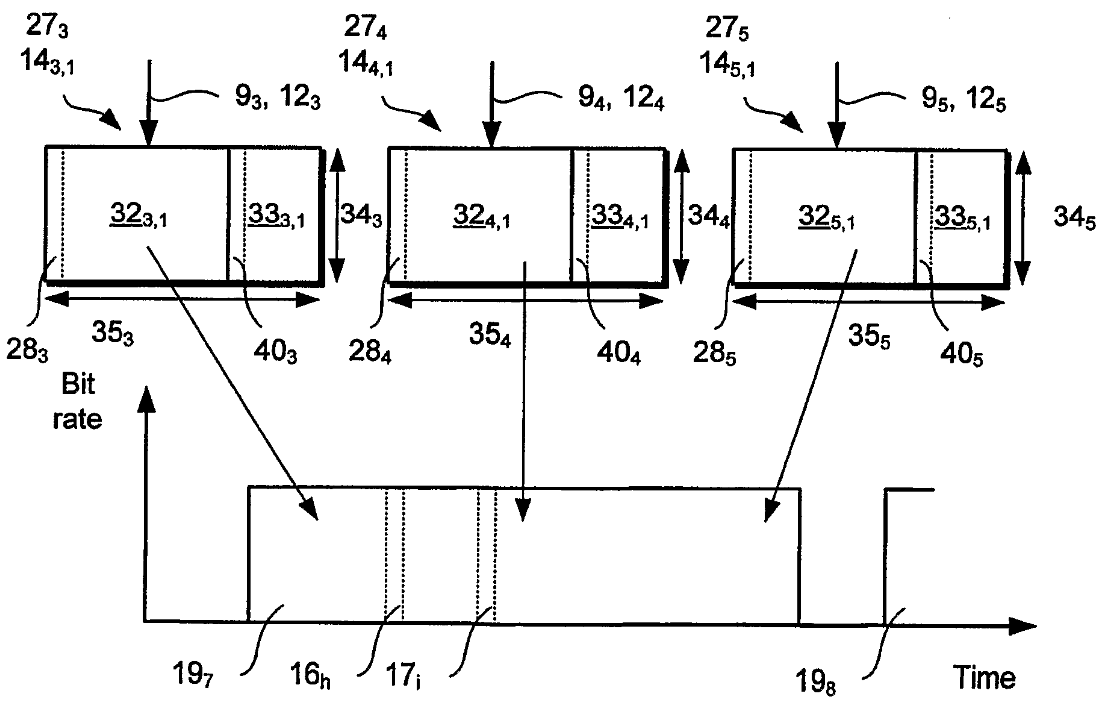

27_3 14_{3,1}
27_4 14_{4,1}
27_5 14_{5,1}
9_3, 12_3
9_4, 12_4
9_5, 12_5
32_{3,1}
33_{3,1}
32_{4,1}
33_{4,1}
32_{5,1}
33_{5,1}
34_3
34_4
34_5
28_3
35_3
40_3
28_4
35_4
40_4
28_5
35_5
40_5
Bit rate
19_7
16_h
17_i
19_8
Time

Fig. 23

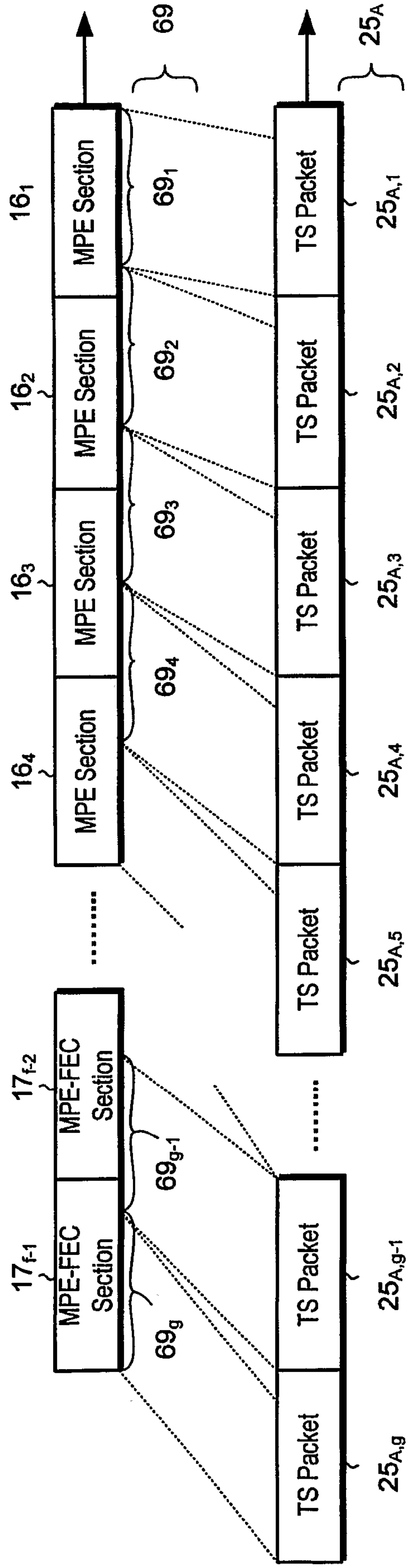


Fig. 25

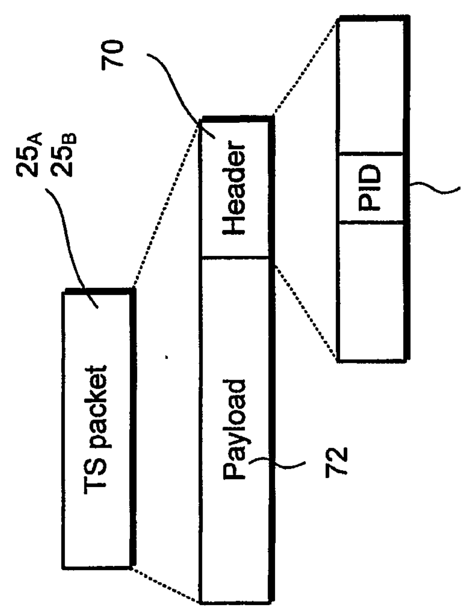


Fig. 26

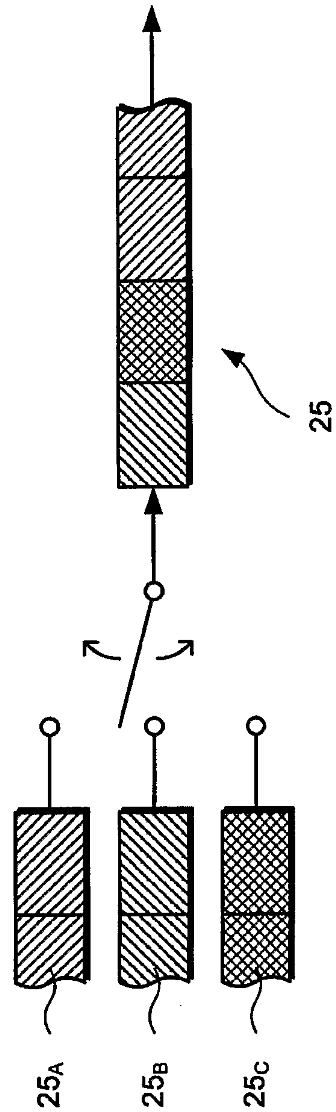


Fig. 27

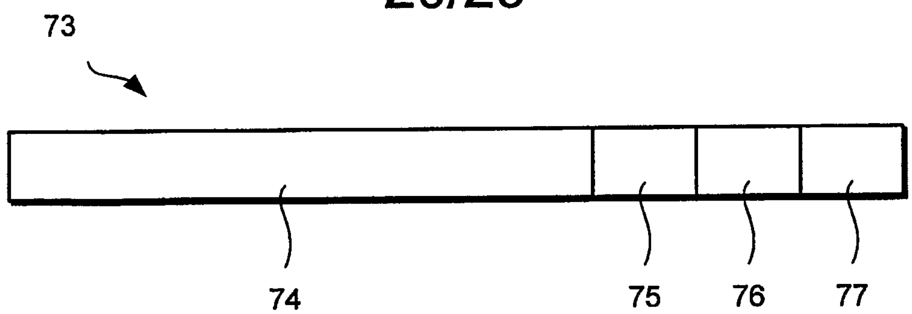


Fig. 28

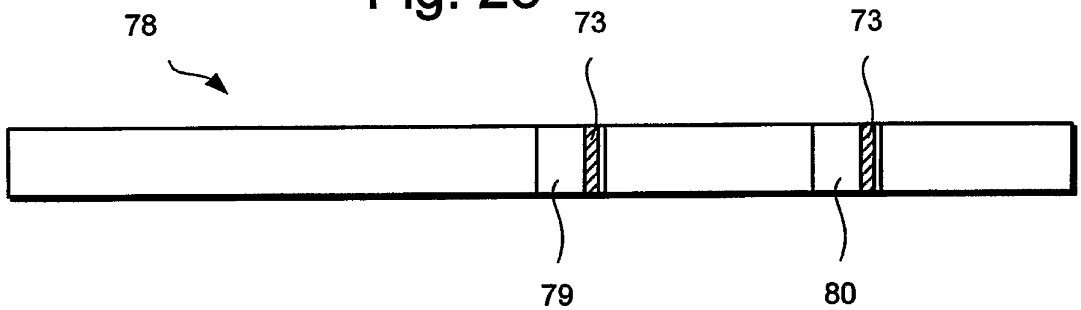


Fig. 29

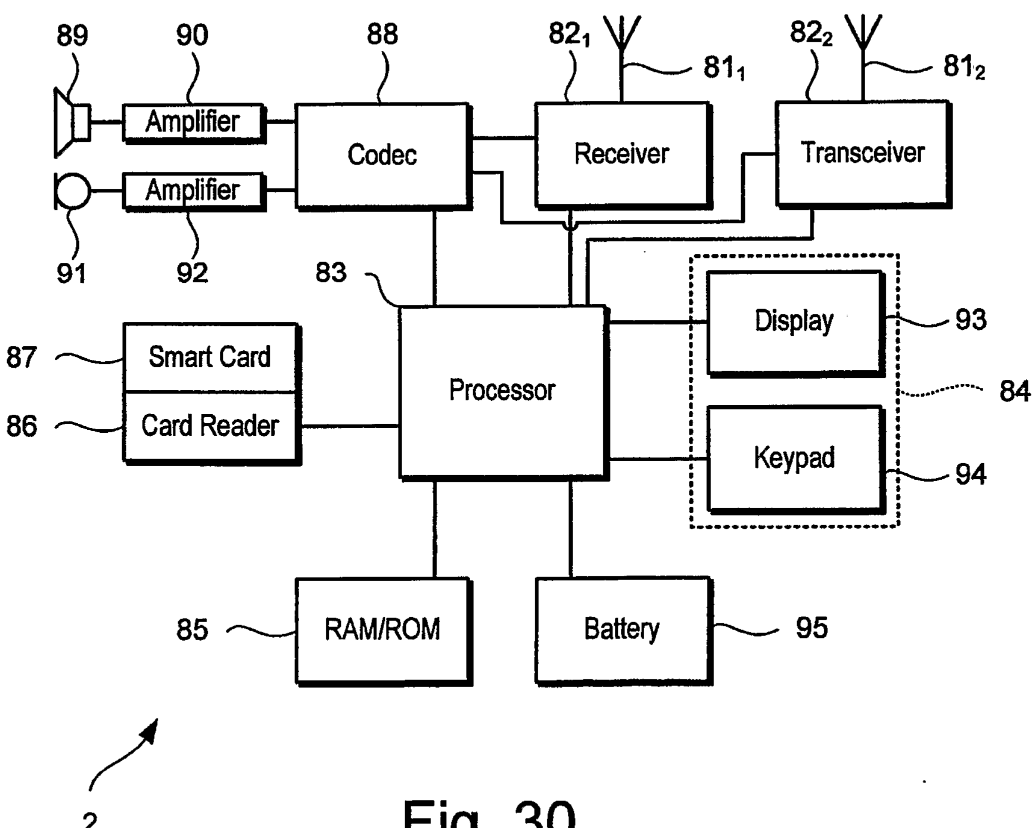


Fig. 30

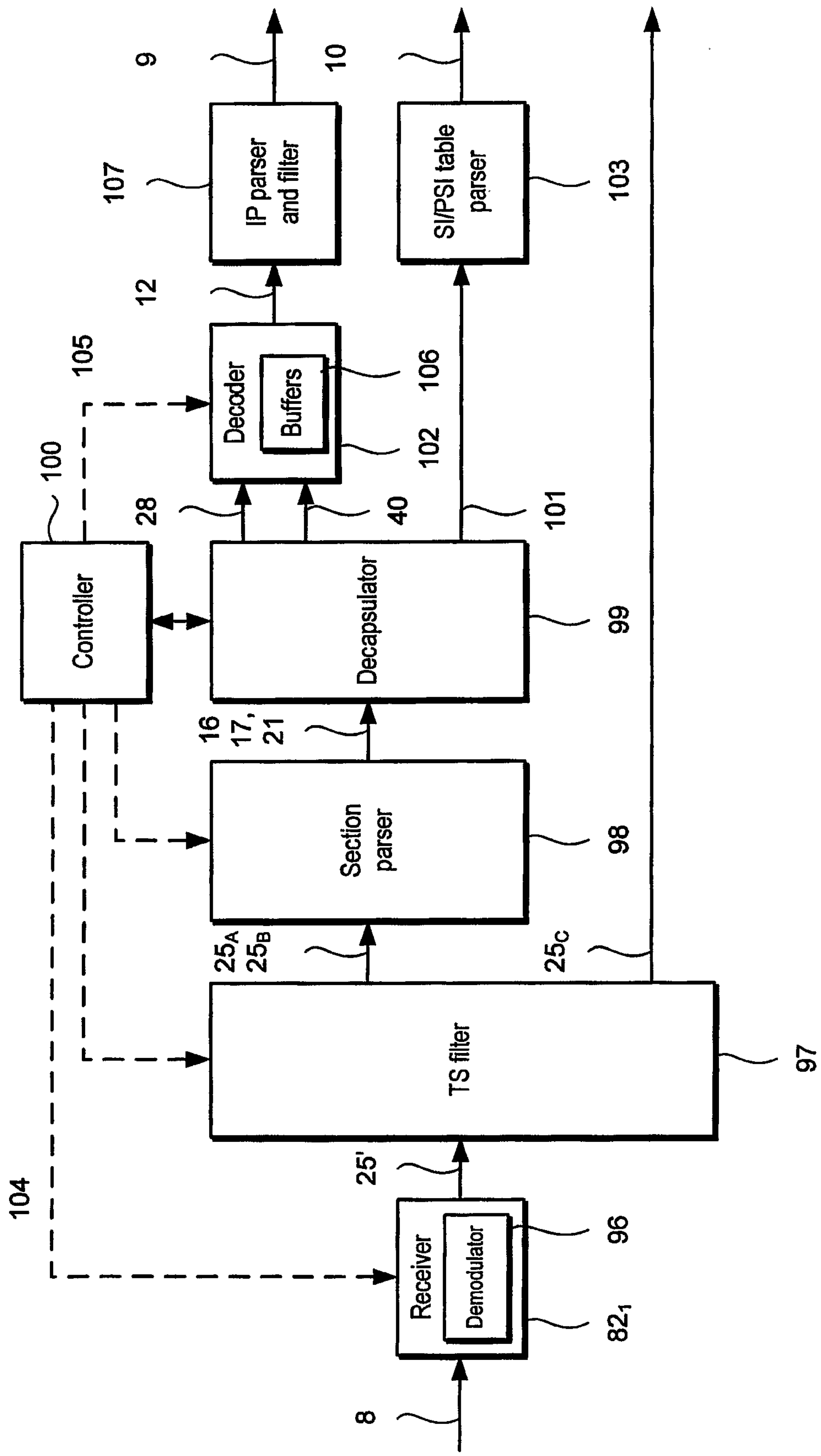

IP parser and filter
SI/PSI table parser
Decoder
Buffers
Controller
Decapsulator
Section parser
TS filter
Receiver
Demodulator
9
10
107
103
12
105
106
100
102
28
40
101
99
16
17,
21
98
25A
25B
25C
97
104
25'
96
82₁
8

Fig. 31

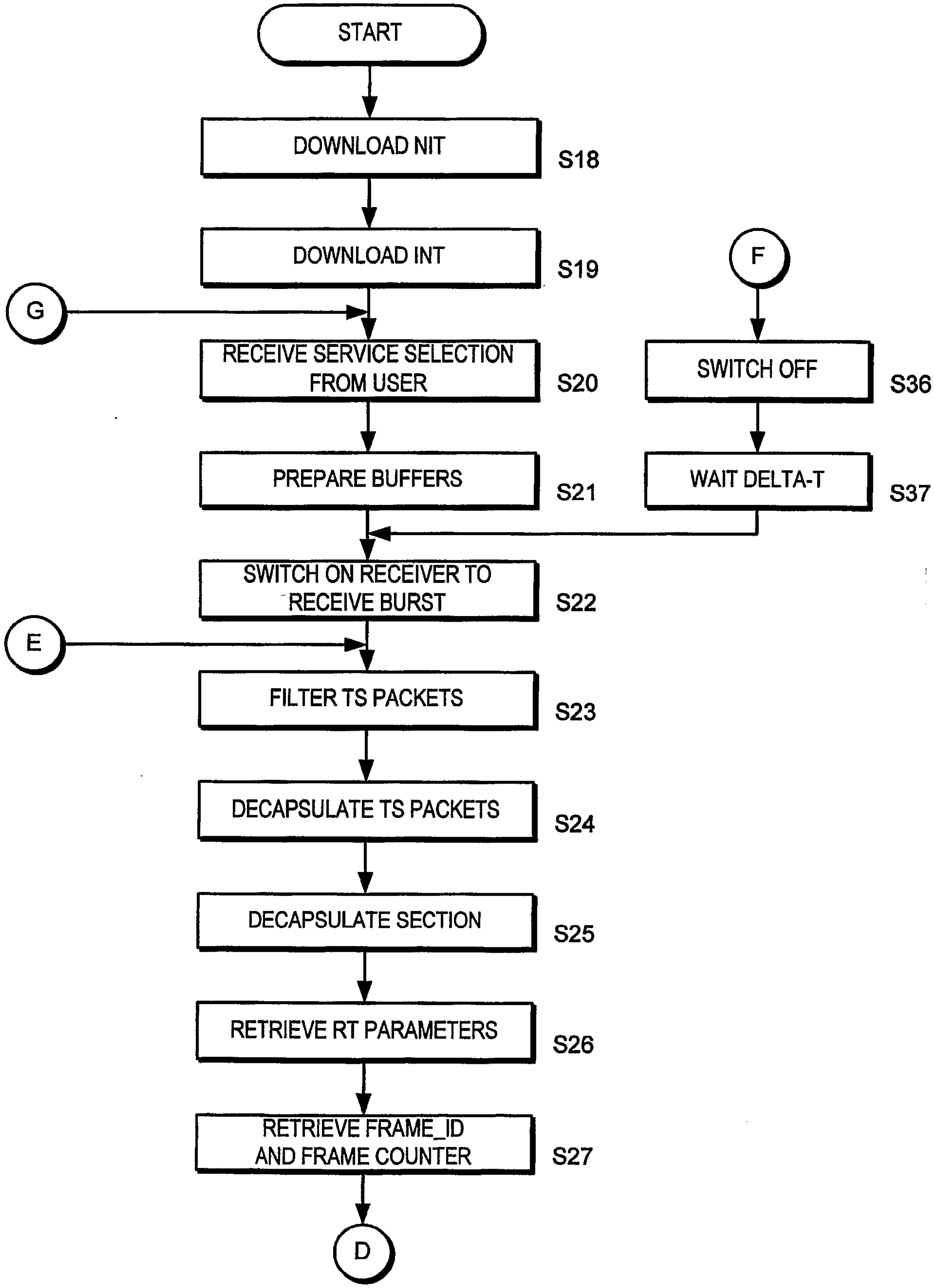

START
DOWNLOAD NIT
S18
DOWNLOAD INT
S19
F
G
RECEIVE SERVICE SELECTION FROM USER
S20
SWITCH OFF
S36
PREPARE BUFFERS
S21
WAIT DELTA-T
S37
SWITCH ON RECEIVER TO RECEIVE BURST
S22
E
FILTER TS PACKETS
S23
DECAPSULATE TS PACKETS
S24
DECAPSULATE SECTION
S25
RETRIEVE RT PARAMETERS
S26
RETRIEVE FRAME_ID AND FRAME COUNTER
S27
D

Fig. 32

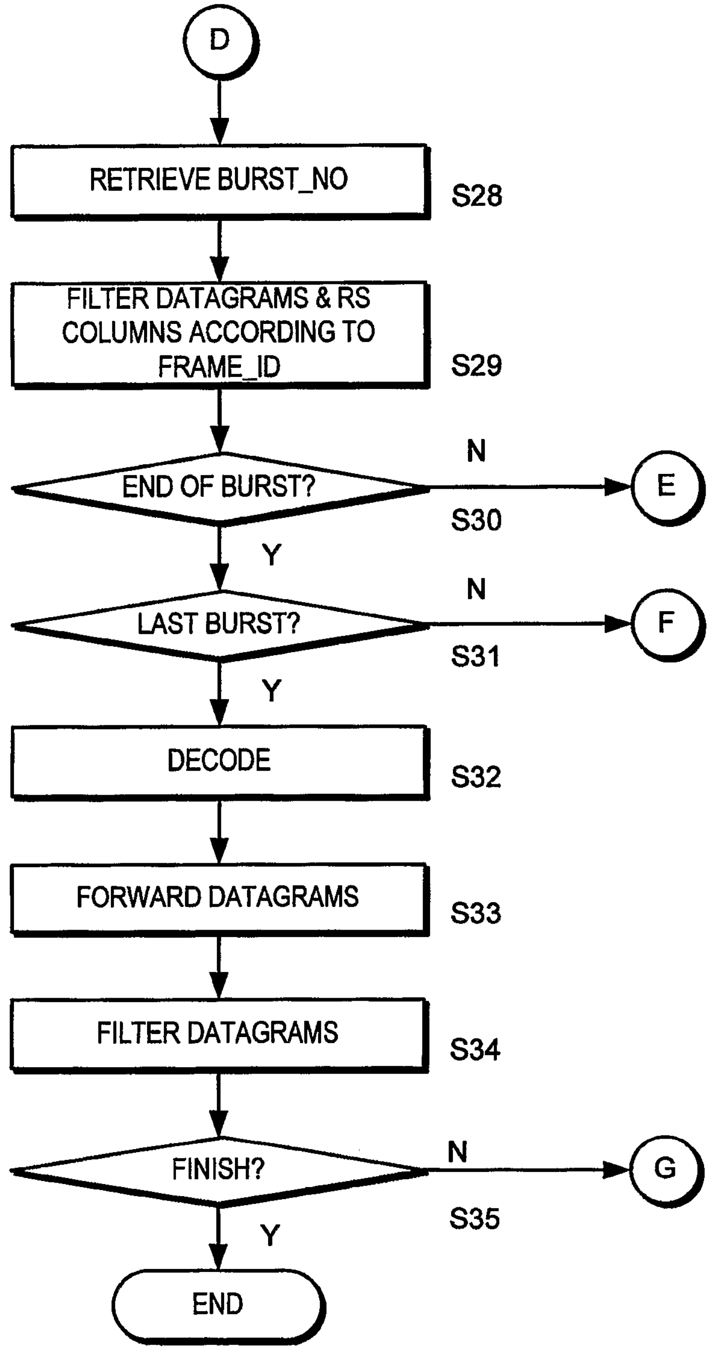

D
RETRIEVE BURST_NO
S28
FILTER DATAGRAMS & RS COLUMNS ACCORDING TO FRAME_ID
S29
END OF BURST?
N
E
S30
Y
LAST BURST?
N
F
S31
Y
DECODE
S32
FORWARD DATAGRAMS
S33
FILTER DATAGRAMS
S34
FINISH?
N
G
S35
Y
END

Fig. 32

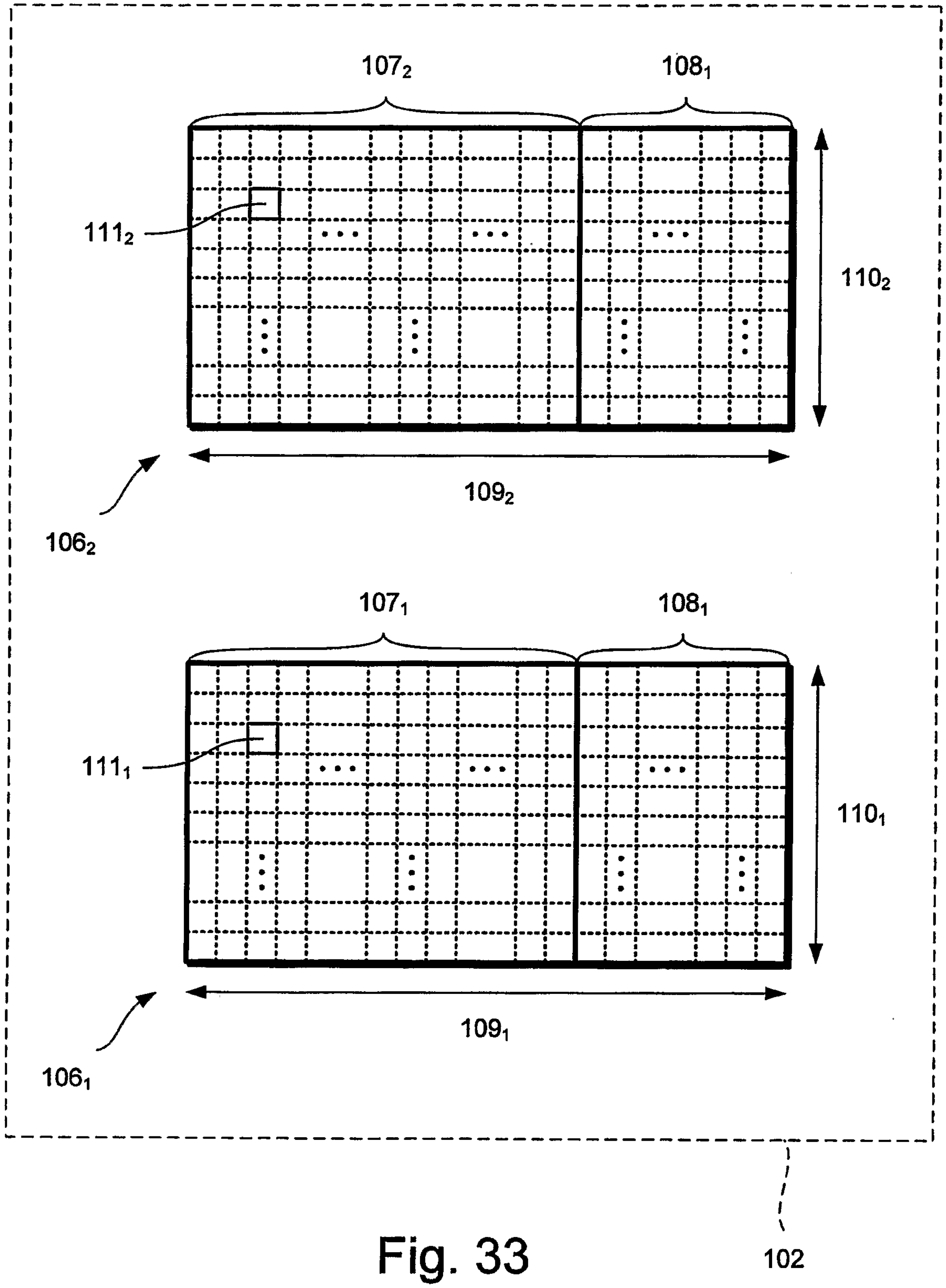

107₂
108₁
111₂
110₂
109₂
106₂
107₁
108₁
111₁
110₁
109₁
106₁
102

Fig. 33

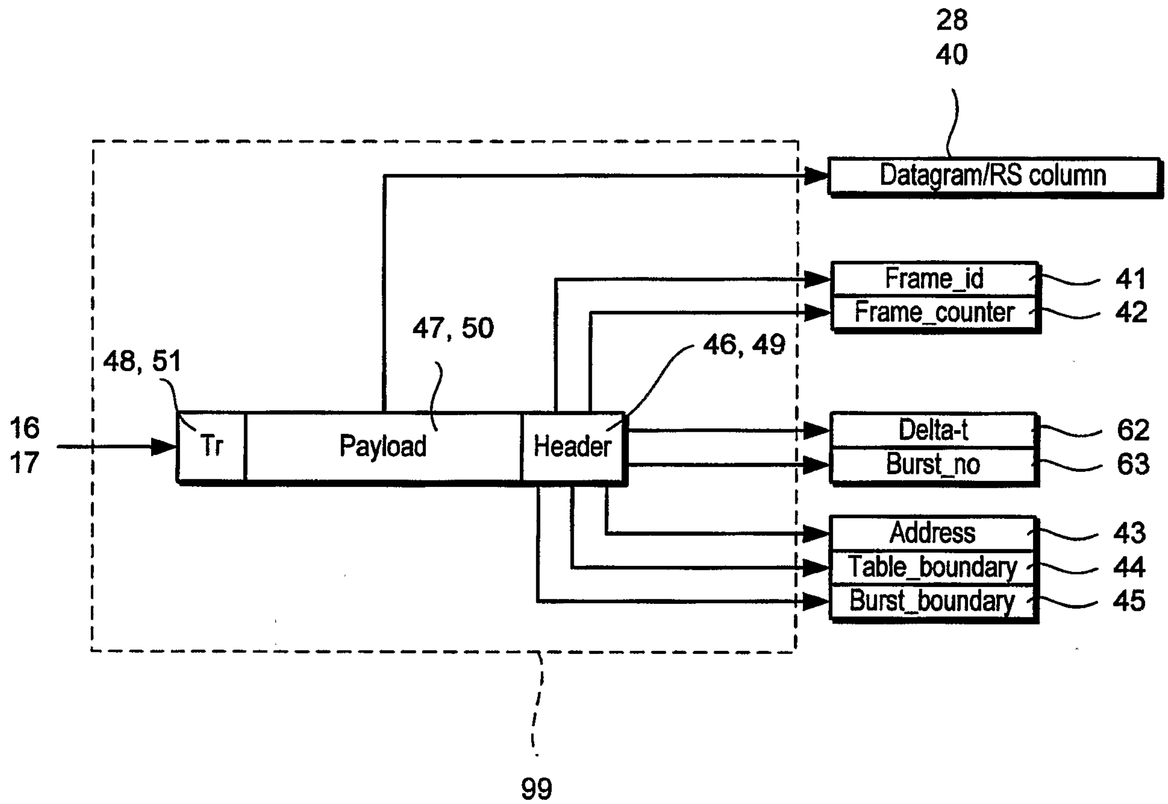
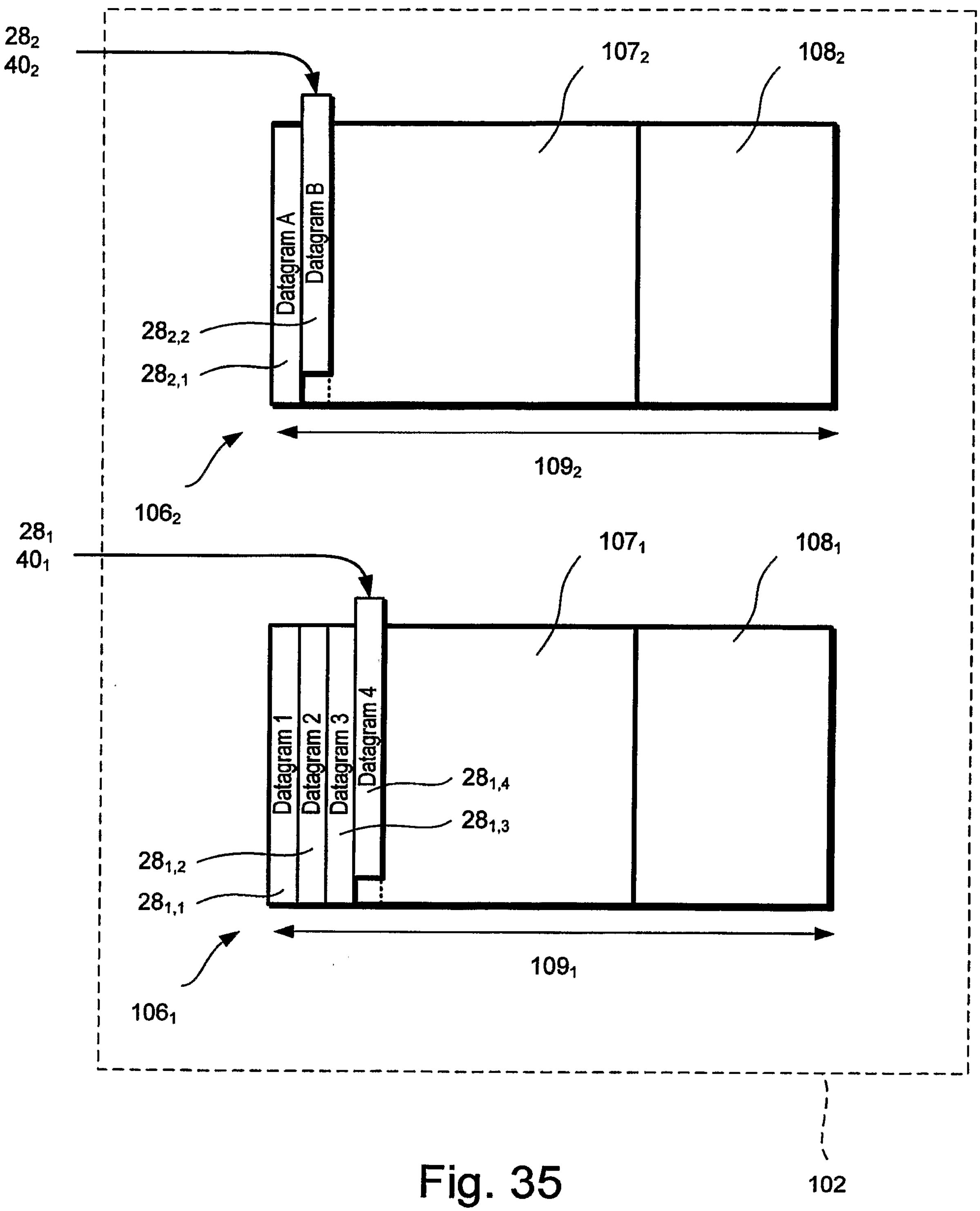

28
40
Datagram/RS column
Frame_id
Frame_counter
41
42
47, 50
48, 51
46, 49
16
17
Tr
Payload
Header
Delta-t
Burst_no
62
63
Address
Table_boundary
Burst_boundary
43
44
45
99

Fig. 34



28_2
40_2
107_2
108_2
Datagram A
Datagram B
$28_{2,2}$
$28_{2,1}$
109_2
106_2
28_1
40_1
107_1
108_1
Datagram 1
Datagram 2
Datagram 3
Datagram 4
$28_{1,4}$
$28_{1,3}$
$28_{1,2}$
$28_{1,1}$
109_1
106_1
102

Fig. 35

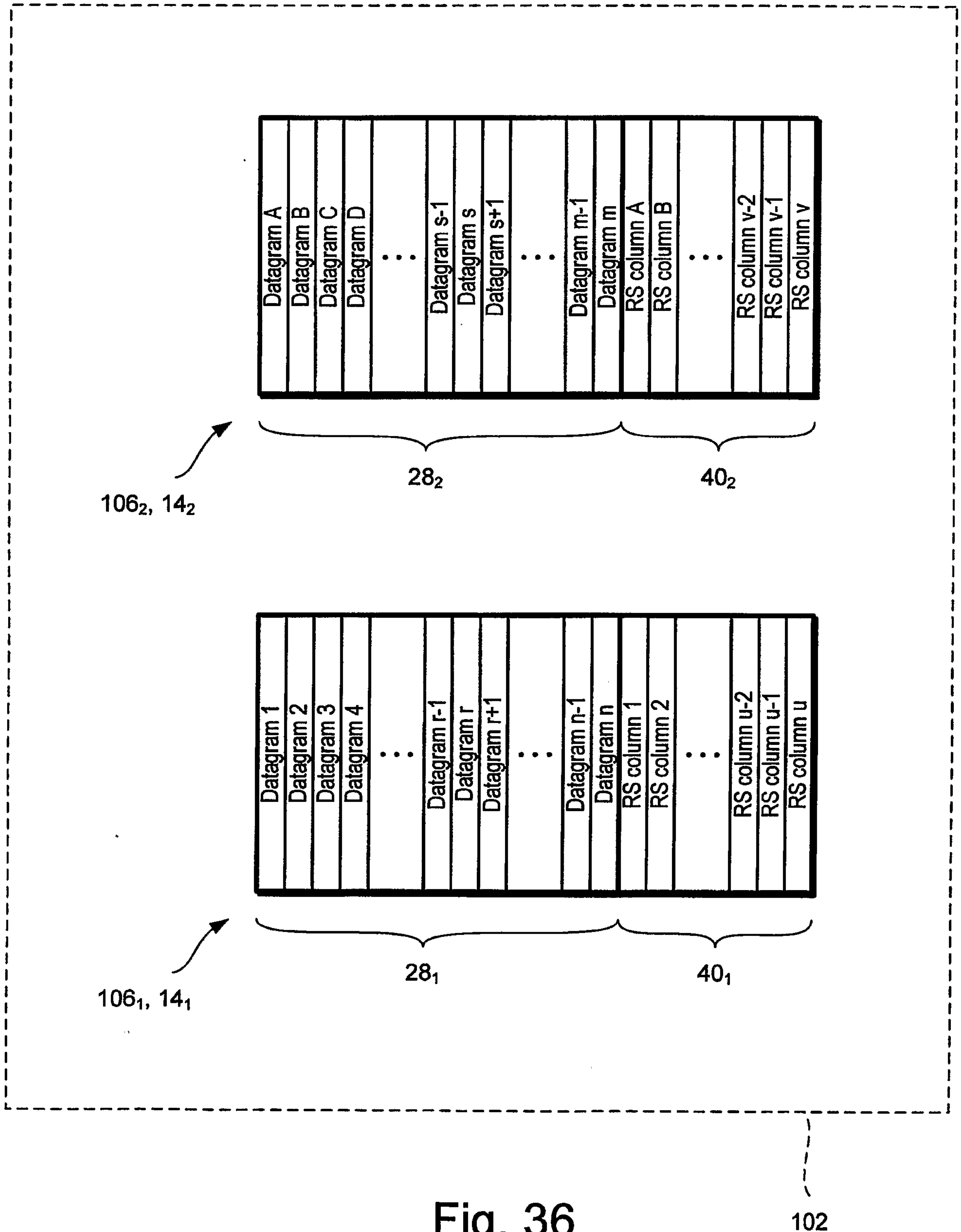

Datagram A
Datagram B
Datagram C
Datagram D
...
Datagram s-1
Datagram s
Datagram s+1
...
Datagram m-1
Datagram m
RS column A
RS column B
...
RS column v-2
RS column v-1
RS column v
28₂
40₂
106₂, 14₂
Datagram 1
Datagram 2
Datagram 3
Datagram 4
...
Datagram r-1
Datagram r
Datagram r+1
...
Datagram n-1
Datagram n
RS column 1
RS column 2
...
RS column u-2
RS column u-1
RS column u
28₁
40₁
106₁, 14₁
102

Fig. 36

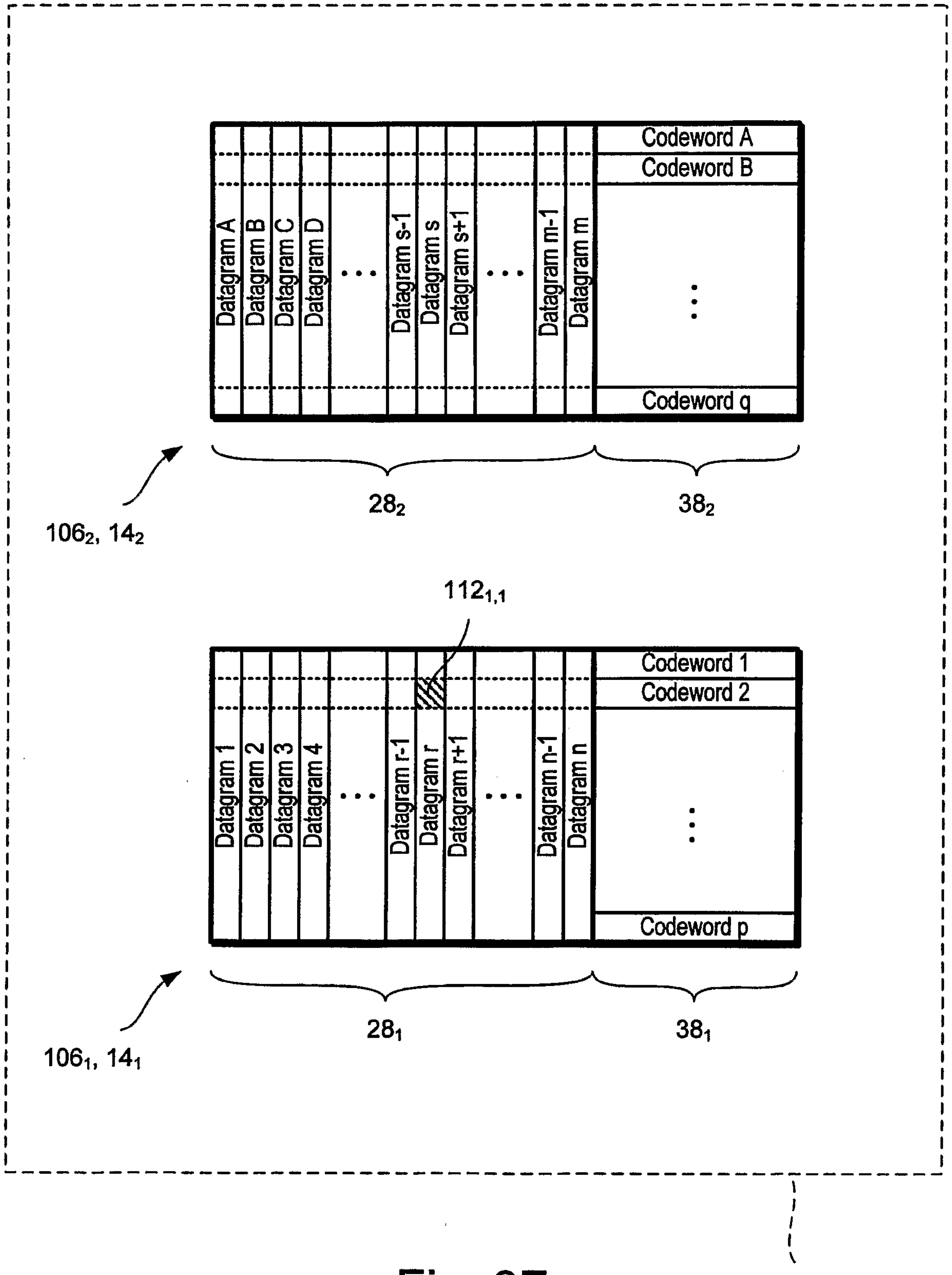

Codeword A
Codeword B
Datagram A
Datagram B
Datagram C
Datagram D
Datagram s-1
Datagram s
Datagram s+1
Datagram m-1
Datagram m
Codeword q
28₂
38₂
106₂, 14₂
112₁,₁
Codeword 1
Codeword 2
Datagram 1
Datagram 2
Datagram 3
Datagram 4
Datagram r-1
Datagram r
Datagram r+1
Datagram n-1
Datagram n
Codeword p
28₁
38₁
106₁, 14₁
102

Fig. 37

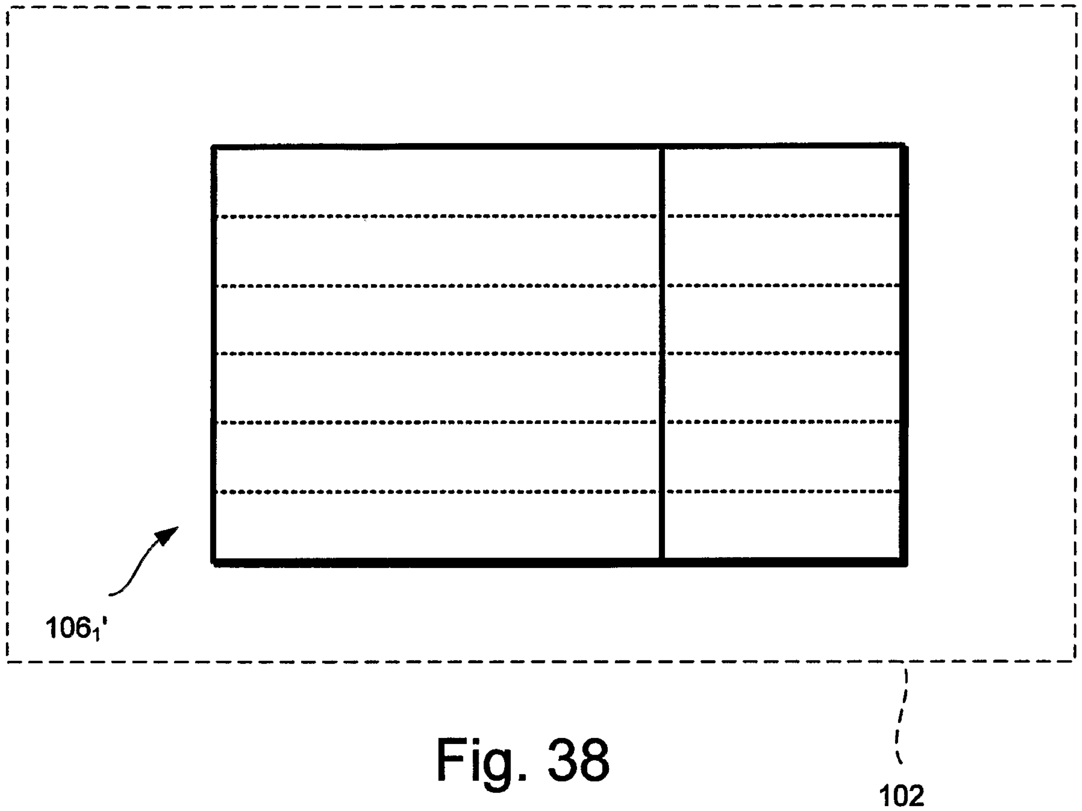


Fig. 38

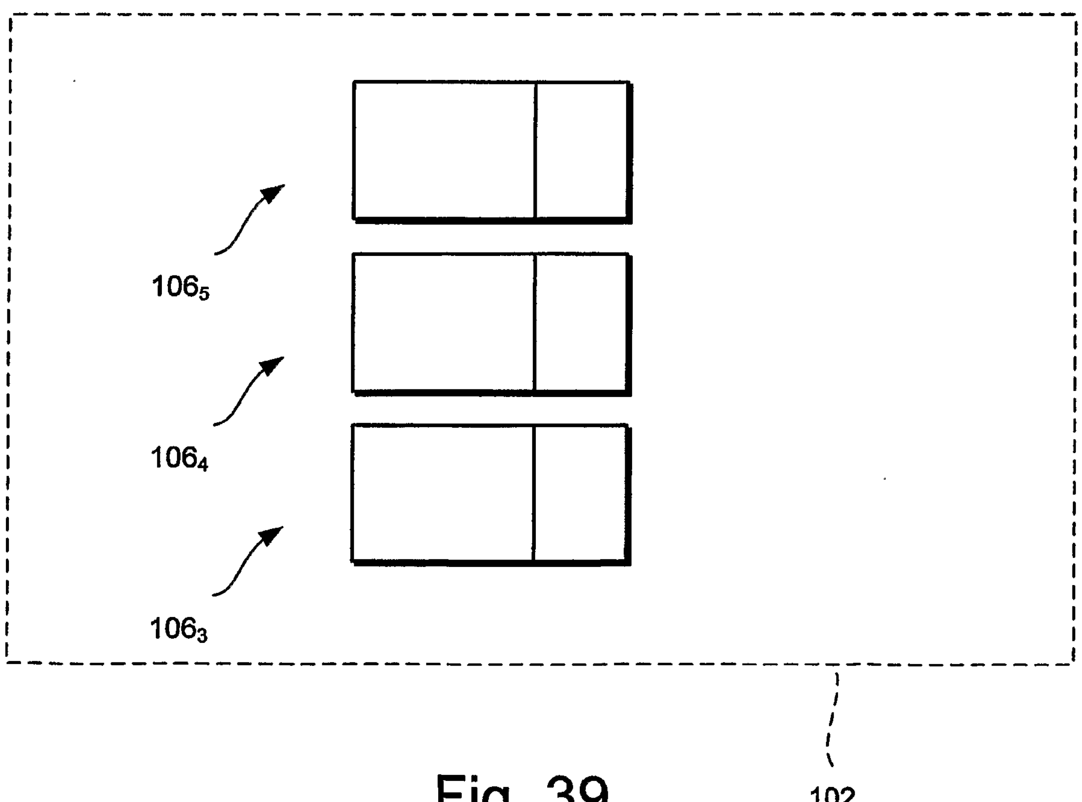


Fig. 39