

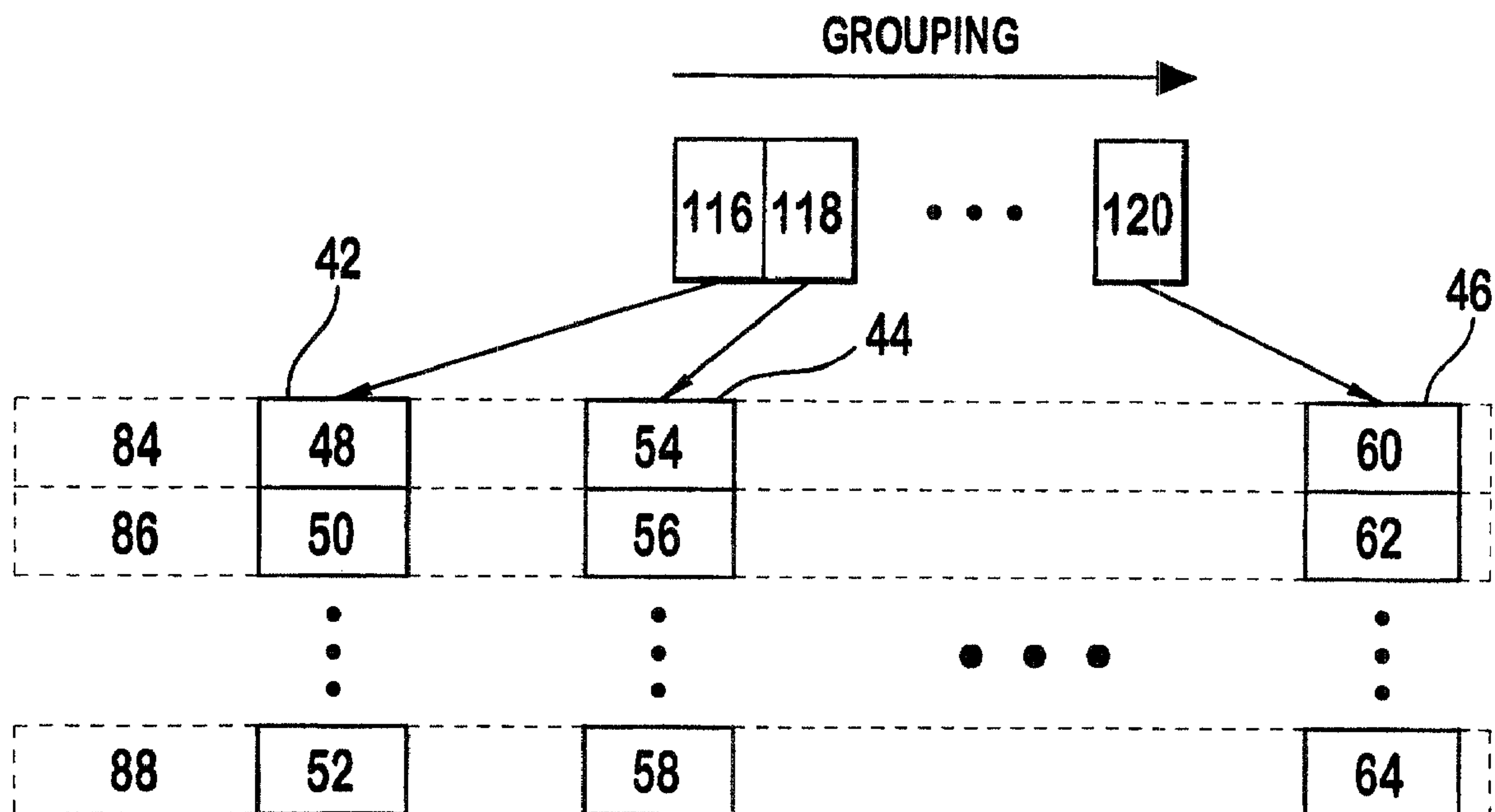


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(54) Title: CHANNEL ASSIGNMENT IN A SPREAD SPECTRUM CDMA COMMUNICATION SYSTEM



(57) **Abrégé/Abstract:**

A selected user equipment transmits a signature in a selected one of the common packet channel's time slots. The base station, in response to receiving the transmitted signature, selects a currently unused code, if available, out of a plurality of code associated with the access opportunity defined by the selected signature and selected time slot. The base station transmits an acknowledgment signal comprising an identifier of the selected code. The selected user equipment receives the acknowledgment signal. The selected user equipment and the base station communicate using the selected code.



ABSTRACT

A selected user equipment transmits a signature in a selected one of the common packet channel's time slots. The base station, in response to receiving the transmitted signature, selects a currently unused code, if available, out of a plurality of code associated with the access opportunity defined by the selected signature and selected time slot. The base station transmits an acknowledgment signal comprising an identifier of the selected code. The selected user equipment receives the acknowledgment signal. The selected user equipment and the base station communicate using the selected code.

TITLE OF THE INVENTION

CHANNEL ASSIGNMENT IN A SPREAD SPECTRUM CDMA COMMUNICATION SYSTEM

This application is a divisional of Canadian patent application Serial No. 2,371,482 filed internationally on May 19, 2000 and entered nationally on November 16, 2001.

BACKGROUND OF THE INVENTION

The invention relates generally to resource allocation in a wireless code
5 division multiple access communication system. More specifically, the invention relates to assigning uplink and downlink channels in response to access requests of user equipment.

Figure 1 depicts a wireless spread spectrum Code Division Multiple Access (CDMA) communication system **18**. A base station **20** communicates with user
10 equipment (UE) **22- 26** in its operating area. In a spread spectrum CDMA system **18**, data signals are communicated between UEs **22-26** and the base station **20** over the same spread bandwidth. Each data signal in the shared bandwidth is spread with a unique chip code sequence. Upon reception, using a replica of the chip code sequence, a particular data signal is recovered.

15 Since signals are distinguished by their chip code sequences (code), separate dedicated communication channels are created using different codes. Signals from the base station **20** to the UEs **22-26** are sent on downlink channels and signals from the UEs **22-26** to the base station **20** are sent on uplink channels. For coherent detection

of downlink transmissions by the UEs 22-26, pilot signals are transmitted to all the UEs 22-26 within the base station's operating range. The UEs 22-26 condition their receivers based on the pilot signals to enable data reception.

In many CDMA systems, a common packet channel (CPCH) is used for uplink transmissions. A CPCH is capable of carrying packets of data from different UEs 22-26. Each packet is distinguishable by its code. For detection by the base station 20, the packets have a preamble which also distinguishes it from other packets. The CPCH is typically used to carry infrequently communicated data at high rates.

Figure 2 depicts a CPCH access scheme 28. The CPCH access scheme 28 is time divided into intervals having time slots 30-34, such as 8 time slots proposed for the Third Generation Mobile Telecommunications System (IMT-2000). A group of predetermined signatures 36-40 are assigned to the time slots 30-34 to allow more than one UE 22-26 to use the same time slot 30-34. A particular signature used within a particular time slot is referred to as an access opportunity 66-82. For instance, for each of the 8 time slots in the proposal for IMT-2000, one out of 16 signatures is available to be chosen, resulting in 128 access opportunities. Each signature 36-40 is preassigned a virtual channel. A virtual channel uniquely defines operating parameters for both the uplink and downlink, i.e., an uplink spreading factor and a unique code for the downlink.

Broadcast from the base station 20 to each UE 22-26 is the availability of each virtual channel over an acknowledge indication channel (AICH). The UE 22-26 monitors the AICH to determine the availability of each virtual channel. Based on the operating parameters required by the UE 22-26 and the availability of the virtual

channels, the UE determines the access opportunity to select. Upon identifying a particular access opportunity, the base station **20** sends out an acknowledgment message (ACK) if the corresponding downlink channel is still available. In the proposal for IMT-2000, the ACK simply repeats the signatures **36-40** associated with the access attempt. If the downlink channel is not available, a negative acknowledge (NAK) is sent.

After receiving a corresponding acknowledgment, the UEs **22-26** determine the proper code to recover communications on the downlink channel based on the access opportunity **66-82** used to send the UEs' packet. Either stored in the UEs **22-26** or transmitted on a Base Station's Broadcast Channel is a list of the code assigned to each access opportunity **66-82**. This scheme severely increases the packet collision probability and therefore the packet delay which is undesirable.

In some situations, monitoring the AICH is not desirable. At a particular moment, some UEs **22-26** will be operating in a "sleep" mode. In the "sleep" mode, the UE **22-26** only runs when there is a need to send data. Monitoring the AICH during "sleep" mode will both reduce battery life and introduce a delay in the transmission of the first packet. Additionally, when a UE **22-26** borders between two base station's operating areas, monitoring multiple AICHs further exacerbates these drawbacks.

Monitoring creates other problems. It further complicates the UE's receiving circuitry, making the UE **22-26** more expensive.

Monitoring results in a suboptimum use of the CPCH. AICH monitoring provides information when a channel becomes busy. The time at which the channel becomes free is deduced on a worst case maximum packet length. If a packet is not

maximum length, the channel will be idle while the UEs 22-26 are waiting to transmit. On the other hand, if monitoring is not performed in such a system, channel availability information is unavailable. The UE 22-26 may randomly choose a busy virtual channel increasing the packet delay by causing a collision. Accordingly, it would be desirable to allow the UEs 22-26 to wait a period shorter than the maximum packet length and provide for some other collision reducing mechanism.

One technique to reduce the possibility of collision is to raise the number of codes, for instance to 128 different codes. In the proposal for IMT-2000 the 128 sequences represent approximately half of the sequences available at the base station 20. Accordingly, this solution is undesirable. Additionally, since monitoring the AICH complicates the UE receiver circuitry increasing its cost, it is undesirable.

WO 9849857 discloses a system for transmitting random access packets from mobile stations to a base station. A preamble signature is added to each packet to be transmitted by the mobile station in a time slot of repeating frames. The signature is a short spreading code which is concatenated with a unique long spreading code. The packet including the preamble are received by the base station. The preamble facilitates recovery of data from the packet.

TIA/EIA-95-B, "Mobile Station-Base Station Systems" discloses an approach for channel assignment in a code division multiple access system. A channel assignment message is sent to a mobile station. The message indicates information regarding a channel, such as its spreading code. Accordingly, an alternate approach to assign virtual channels is desirable.

SUMMARY OF THE INVENTION

A selected user equipment transmits a signature in a selected one of the common packet channel's time slots. The base station, in response to receiving the transmitted signature, selects a currently unused code, if available, out of a plurality of code associated with the access opportunity defined by the selected signature and selected time slot. The base station transmits an acknowledgment signal comprising an identifier of the selected code. The selected user equipment receives the acknowledgment signal. The selected user equipment and the base station.

According to one aspect, the invention provides a method for sending data in a wireless spread spectrum code division multiple access communication system between a selected user equipment out of a plurality of user equipments and a base station, the system having a common packet channel defined by a predetermined set of codes, the common packet channel having a plurality of access opportunities, each defined by a time slot and signature, the selected user equipment transmitting a signature in a selected one of the common packet channel time slots, the method comprising:

in response to receiving the transmitted signature at the base station, selecting a currently unused code, if available, based on a code association with the access opportunity defined by the selected signature and selected time slot;

transmitting from the base station an identifier of the selected code;

receiving the identifier at the selected user equipment; and

communicating data between the selected user equipment and the base station using the selected code.

According to another aspect, the invention provides a base station for a wireless spread spectrum code division multiple access communication system comprising a receiver for receiving access opportunities and packet data over a common packet channel, the common packet channel defined by a predetermined set of codes and having a plurality of access opportunities, each access opportunity defined by a time slot and a signature, the base station characterized by:

a code selection controller associated with said receiver for selecting a currently unused code based on a code association with a received access opportunity, such that a code, if available, is selected in response to receiving a signature in one of said time slots from a user equipment, the access opportunity defined by the received signature and said one time slot; and

a transmitter associated with said controller which transmits to the user equipment an identifier of the selected available code, whereby said transmitter sends communications to the user equipment encoded with said selected code.

According to yet another aspect, the invention provides a wireless spread spectrum code division multiple access communication system having a base station and a plurality of user equipments, the system using a common packet channel for communication, the common packet channel defined by a predetermined set of codes and having a plurality of access opportunities, each access opportunity defined by a time slot and signature, the system comprising the plurality of user equipments, each having means for transmitting a signature in a selected one of the common packet channel time slots; the system characterized by:

each of the plurality of user equipments further having:

means for receiving an identifier, the identifier indicating a selected code; and

means for communicating with the base station using the selected code;

and

5 the base station having:

means, in response to receiving the transmitted signature, for determining the selected code by selecting a currently unused code, if available, based on a code association with the access opportunity defined by the selected signature and selected time slot;

10 means for transmitting the identifier of the selected code; and

means for communicating with the user equipment using the selected code.

BRIEF DESCRIPTION OF THE DRAWINGS

15 **Figure 1** is an illustration of a typical wireless spread spectrum CDMA communication system.

Figure 2 is an illustration of a common packet channel access scheme.

Figure 3 is an illustration assigning virtual channels.

20 **Figure 4** is a graph of the probability of a collision versus demand for the prior art and the virtual channel assignment.

Figure 5 illustrates a simplified base station and user equipment.

Figure 6 is an identifier transmitter circuit.

Figure 7 is an identifier receiver circuit.

Figure 8 is a table of an assignment of Golay sequences.

Figure 9 is a circuit for detecting the Golay sequences of **Figure 8**.

Figure 10 is an assignment table for a system having physical channels with two
5 time slots.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments will be described with reference to the drawing
figures where like numerals represent like elements throughout. **Figure 3** illustrates
10 a virtual channel assignment scheme. Each virtual channel **48-64** is defined by its
operating parameters, such as uplink spreading factor and down link code.
Additionally, instead of assigning virtual channels **48-64**, the same principles may be
applied to assigning physical channels which are defined by their downlink code.

To reduce the number of used physical channels and increase the power level
15 of each channel, each physical channel may be multiplexed, such as by using two time
slots. Using two time slots will increase the channel's effective data rate, such as from
8 Kbps to 16 Kbps. In such a system, the virtual channel **48-64** also defines which
multiplexed signal is assigned to the UE **22-26**.

Instead of assigning a single virtual channel for each signature **36-40** as in the
20 prior art, a set **42-46** of virtual channels are assigned for each grouping **116-120** of
access opportunities. A grouping may contain all of the channels in one group or as
few as 2 or 3 channels. One possible virtual channel grouping may group all virtual
channels with the same data rate for the uplink. For groups having the same uplink data

rate, the UE **22-26** selects an access opportunity out of the groups having the UE's desired uplink data rate. Another grouping may be formed based on the access opportunities' signature **36-40**. Based on the selected access request and the UE's priority, one of the virtual channels **48-64** assigned to the group **116-120** associated with the access attempt is used for the UE if available. Once the virtual channel is assigned, it will not be assigned again until the particular UE's transaction is complete. Additionally, a receiving circuit at the base station **20** with the proper data rate is assigned to the UE **22-26**.

In the prior art system, the UEs **22-26** determine which channel is assigned to the downlink based on the access opportunity **66-82**. Virtual channel assignment transmits a channel identifier **84-88**, preferably along with the ACK, indicating which of the set **42-46** of channels assigned to the group **116-120** is selected. When all of the virtual channels are in the same group, the identifier **84-88** indicates the selected virtual channel. If no channel is available out of the set **42-46**, a no channel is available (NAK) identifier is sent. Since more than one virtual channel is potentially assigned to a particular access attempt, the probability of UE collisions is reduced.

Figure 4 is a graph **91** depicting the probability of a collision (Collisions) versus the number of UEs **22-26** requesting access (Demand). As shown, the collisions using 2 or 3 virtual channels per group (2 states/AP or 3 states/AP) is lower than the prior art (AICH monitor) regardless of demand.

Figure 5 illustrates a simplified base station **20** and a UE **22** for use in implementing channel assignment. The UE **22** has a controller **144** for determining the code of the uplink and downlink communications. A UE transmitter **140** sends

communications, such as access opportunities and uplink packet signals, to the base station **20**. A UE receiver **142** receives communications, such as ACK messages, NAK messages and downlink signals.

The base station **20** has a controller **134** for determining the code of uplink and downlink communications as well as determining channel availability. A base station transmitter **136** sends communications, such as ACK messages, NAK messages and downlink signals, to the UE **22**. The base station receiver **138** receives communications, such as access opportunities and uplink packet signals.

Techniques for sending the identifiers are to attach extra bits to the ACK or to change the phase of the ACK to indicate the selected identifier. For a system using a single group of virtual channels, the extra bits identify the selected virtual channel. Circuits for sending the identifiers by phase shifting the ACK are depicted in **Figures 6 and 7**. The circuits are capable of sending up to four channel identifiers without a NAK identifier or three channel identifiers with a NAK identifier. In the transmitter circuit **92** of **Figure 6**, the ACK sequence is generated by a sequence generator **94**. The sequence itself is associated with the preamble access opportunity and is unique to the access attempt. Several such sequences may be transmitted to several users at the same time. The ACK sequence is passed through a mixer **96** which multiplies the signal with either +1 or -1. The mixed signal is subsequently passed through another mixer **98** where the signal is mixed with an in-phase carrier ($\cos \omega t$) or a quadrature carrier ($\sin \omega t$). As a result of the two mixers **96, 98**, the transmitted ACK is at one of four phases 0° , 90° , 180° or 270° . Each identifier **84-88** is preassigned to one of the phases.

The receiver circuit **14** of **Figure 7** is used to determine the phase of the ACK sent

by the transmitter circuit **92** of **Figure 6**. The ACK is mixed with both an in-phase carrier by mixer **100** and a quadrature carrier by mixer **102**. Each of the mixed signals are correlated with a replica of the ACK's sequence by sequence correlators **104, 106**. The in-phase and quadrature correlation signals are each negated by mixers **108, 110** by multiplying the correlation signals by -1. The two correlated signals and the two negated signals are supplied to an identifier circuit **112**. The identifier circuit **112** determines which of the four phased versions of the correlated signal has the highest magnitude. Since the downlink transmissions from the base station are synchronized and their phase is known, the identifier circuit **112** determines which identifier **84-88** was sent based on the phase of the ACK. A list stored either in the UEs **22-26** or transmitted on a Base Station's Broadcast Channel is used to determine the virtual channel **48-64** associated with the identifier **84-88** and the group **116-120** of the UE's access request. Using the determined virtual channel **48-64**, transmissions sent by the base station **20** using the selected downlink channel's code are recovered at the UE **22-26**.

Another technique for sending the identifier **84-88** is to use the ACK and a collision resolution signal (CR). After a collision between UEs **22-26** is detected at a base station **20**, in many spread spectrum systems the base station **20** sends a CR directed to the colliding UEs. The CR has a sequence which is associated with a specific UE **22** for detection by the UE **22**. By inverting the ACK and CR, an identifier **84-88** is sent to the specific UE **22**. An inverted ACK indicates a NAK. By inverting

the CR, one virtual channel is assigned to +CR a second virtual channel is assigned to -CR. Accordingly, using the ACK and CR an identifier indicating either a NAK or one of two channels is sent. Additionally, using a CR with multiple states, such as three, one of multiple channels is assigned to the CR.

5 Alternatively, the identifier is sent with a signal using a Golay sequence. A Golay sequence is constructed out of short sequences, such as X and Y. By inverting the shorter sequences and changing their order many unique longer sequences may be constructed as shown in table 122 of **Figure 8**. To reduce the size of the table 122, only half of the possible sequences are shown. By negating each sequence, another
10 unique Golay sequence results. As shown in **Figure 8**, each UE 22-26 is assigned a unique set of Golay sequences, such as 4. For instance, user 0 is assigned four sequences, the top two sequences and the negation of those sequences. By assigning each of the Golay sequences a virtual channel, upon reception, the receiving UE 22-26 determines the code of the downlink transmission.

15 A Golay sequence detector is shown in **Figure 9**. The received signal is correlated with a Golay Correlator 123 and interleaved by an interleaver 124 to detect the short codes. The arrangement of the short codes for two assigned sequences within the long codes is shown as Signature 0 and 1. Using mixers 125, 126, the signatures are mixed with the detected short codes. Adders 127, 128 are coupled to the mixer and
20 also to delay devices 129, 130. The delay devices 129, 130 take the output of the adders 127, 128 and feed them back to those adders 127, 128 for correlation with the next short sequence. The output of each adder 127, 128 determines the Golay sequence of the received signal.

Figure 10 illustrates an assignment scheme for a system using two time slot multiplexing for the physical channels. In table 132, each of the sixteen different signatures is assigned a downlink code and one of two time slots. The selected time slot is indicated by the transmitted identifier.

WHAT IS CLAIMED IS:

1. A user equipment comprising:

a transmitter for transmitting a selected preamble out of a set of preambles in a slot out of a plurality of slots divided by time of a common packet channel, the common packet channel using a predetermined set of codes; and

a receiver for receiving a combined collision signal and channel indicator, the channel indicator indicating a selected code out of the predetermined set of codes, the channel indicator being associated with the selected preamble; and

wherein the user equipment communicates using the selected code.

2. The user equipment of claim 1 wherein the combined collision signal and channel indicator distinguishes between codes using an inversion.

3. A user equipment comprising:

means for transmitting a selected preamble out of a set of preambles in a slot out of a plurality of slots divided by time of a common packet channel, the common packet channel using a predetermined set of codes;

means for receiving a combined collision signal and channel indicator, the channel indicator indicating a selected code out of the predetermined set of codes, the channel indicator being associated with the selected preamble; and

means for communicating using the selected code.

4. The user equipment of claim 3 wherein the combined collision signal and channel indicator distinguishes between codes using an inversion.

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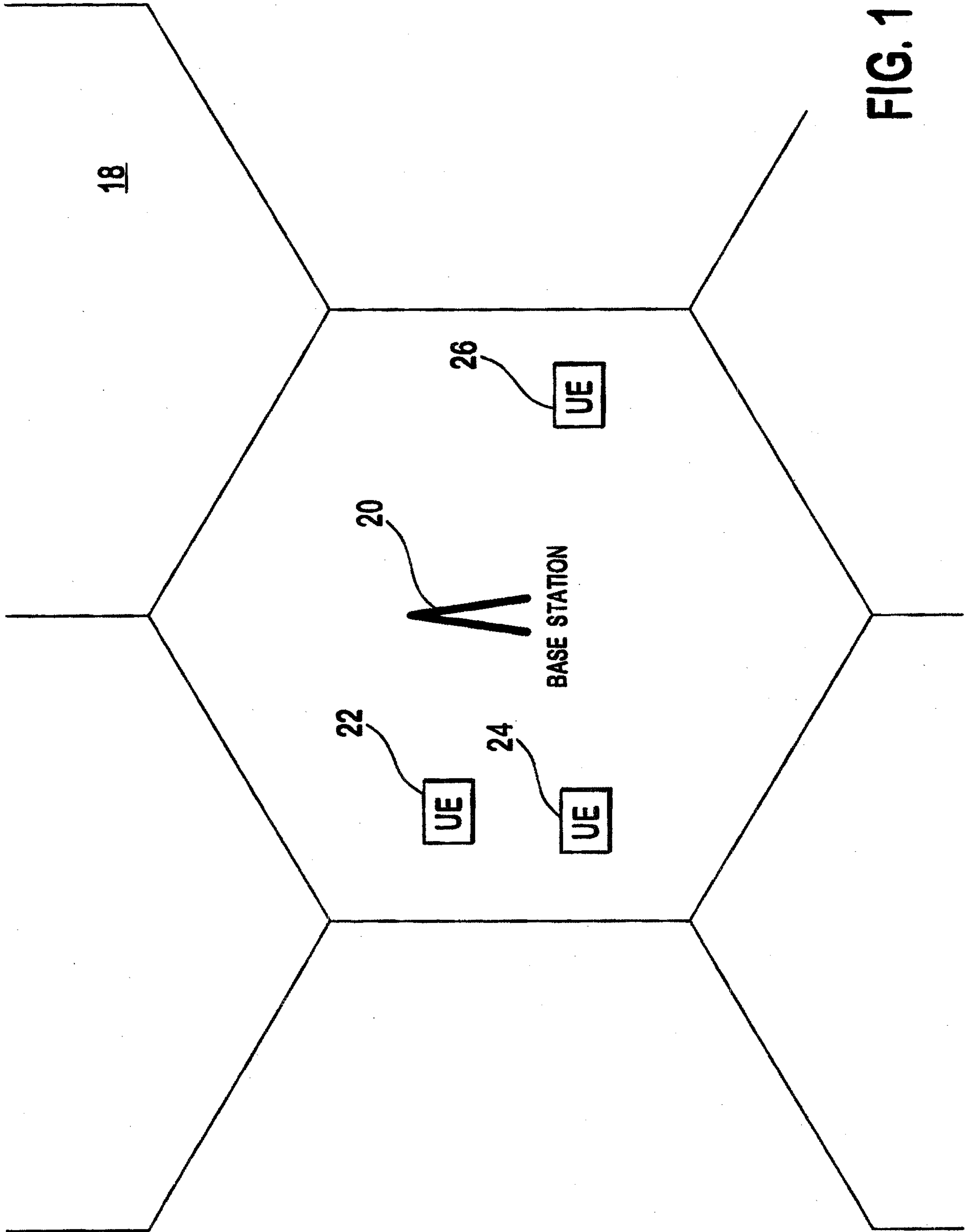


FIG. 1

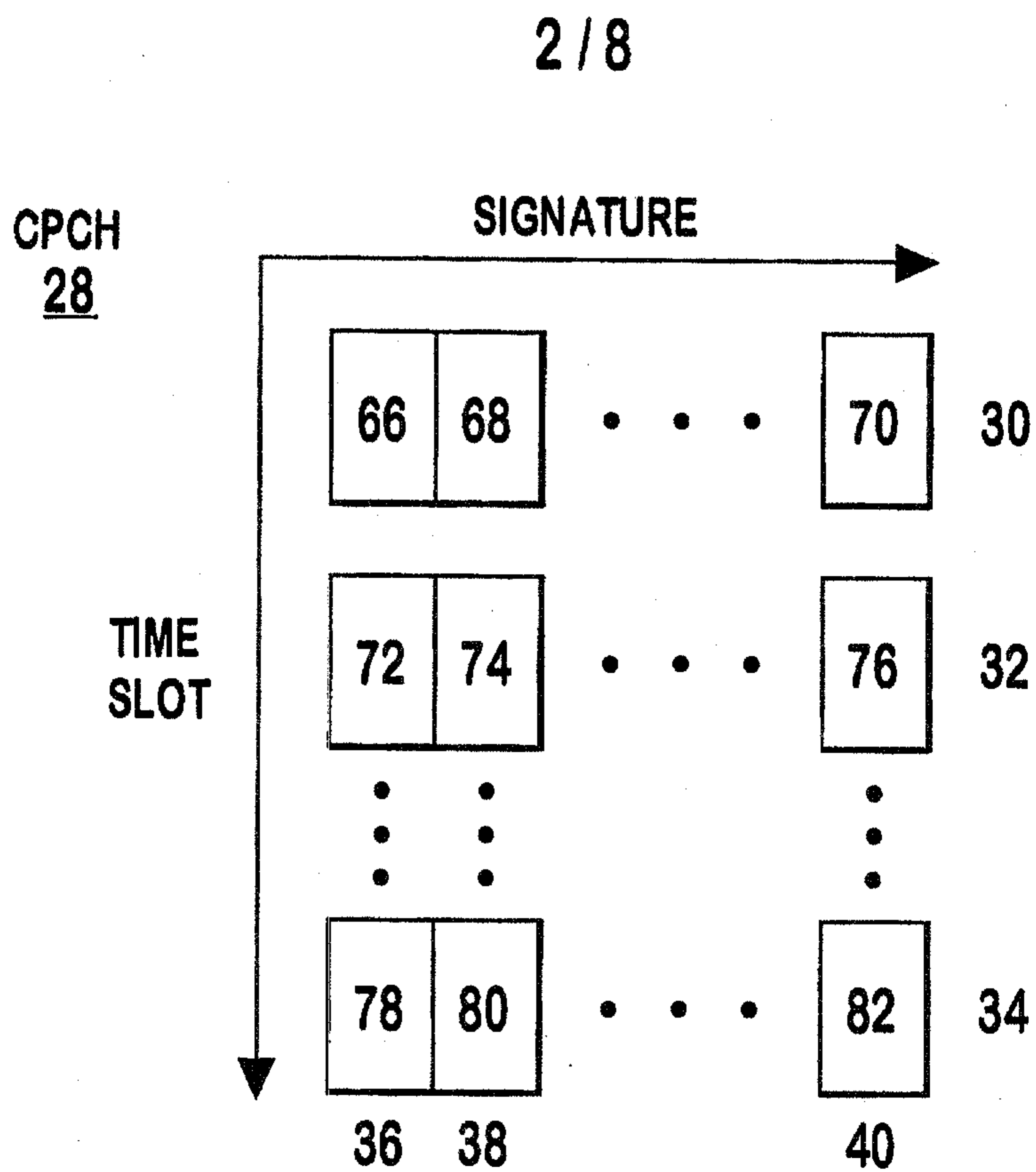


FIG. 2

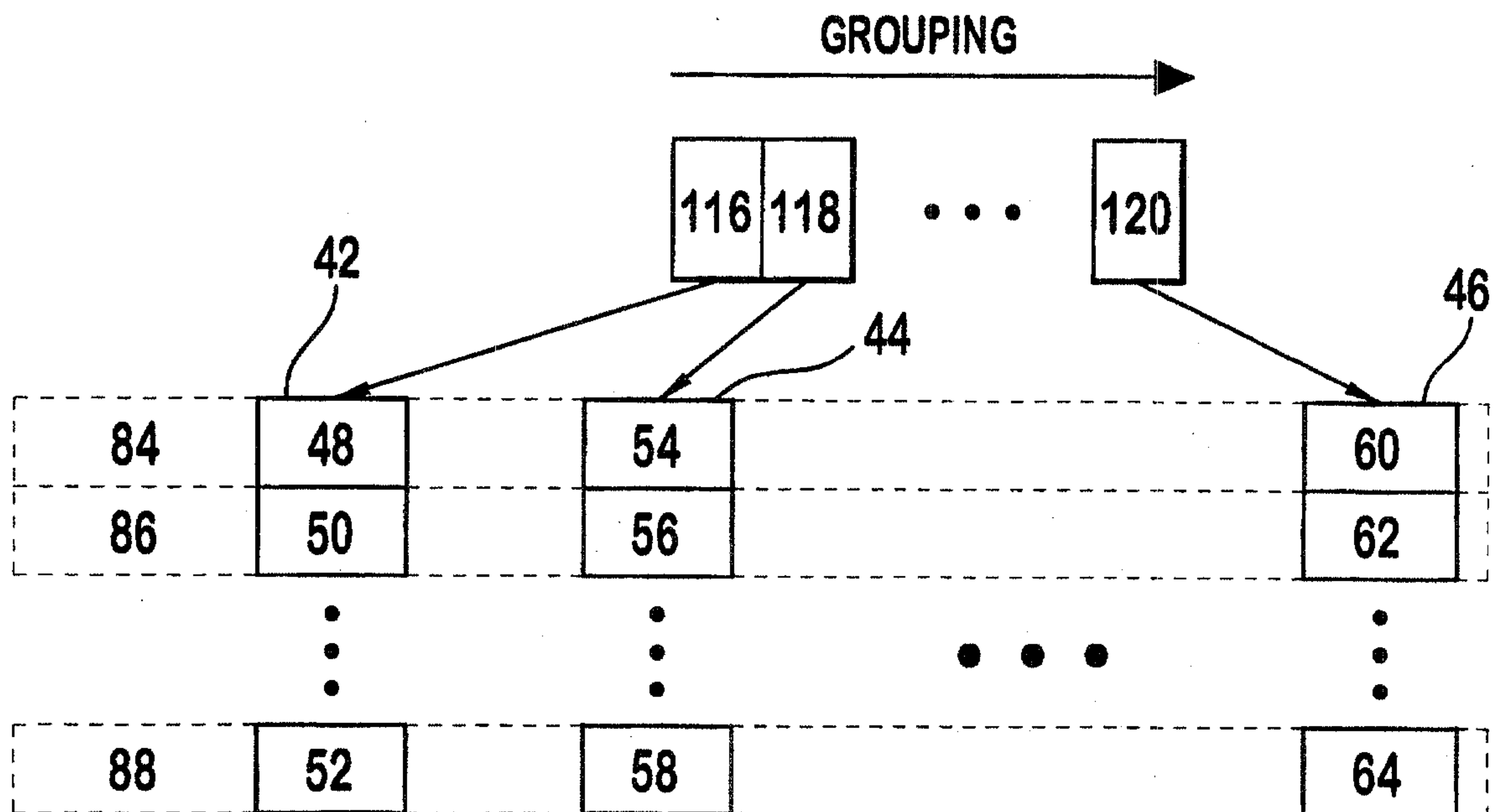


FIG. 3

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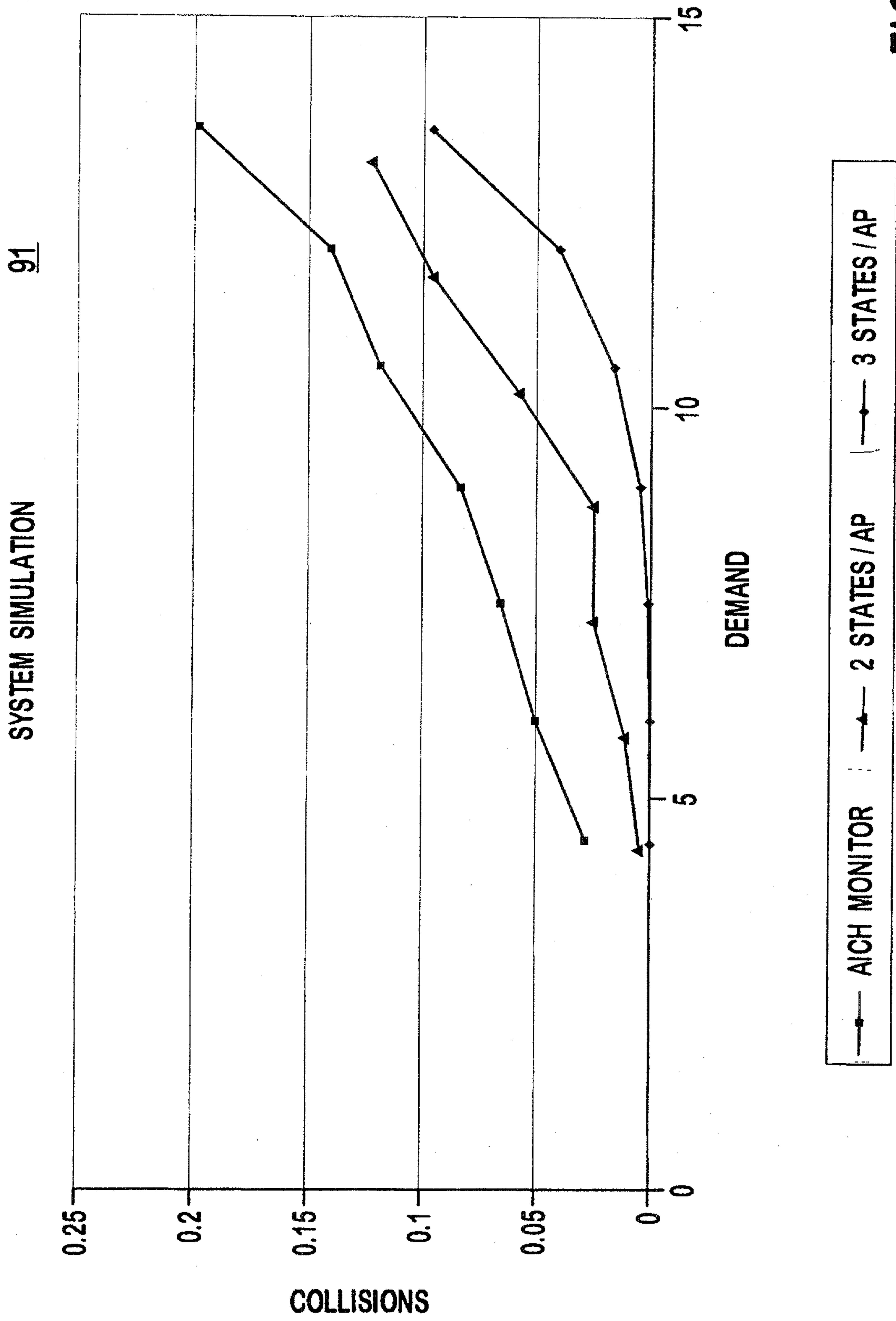


FIG. 4

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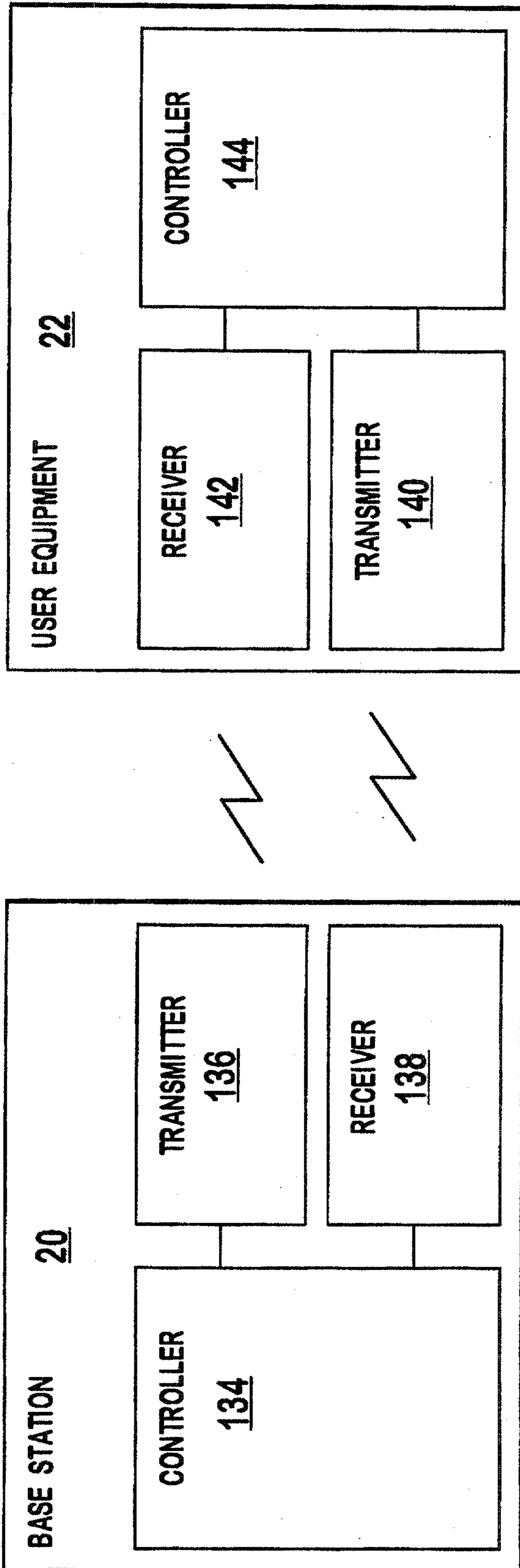


FIG. 5

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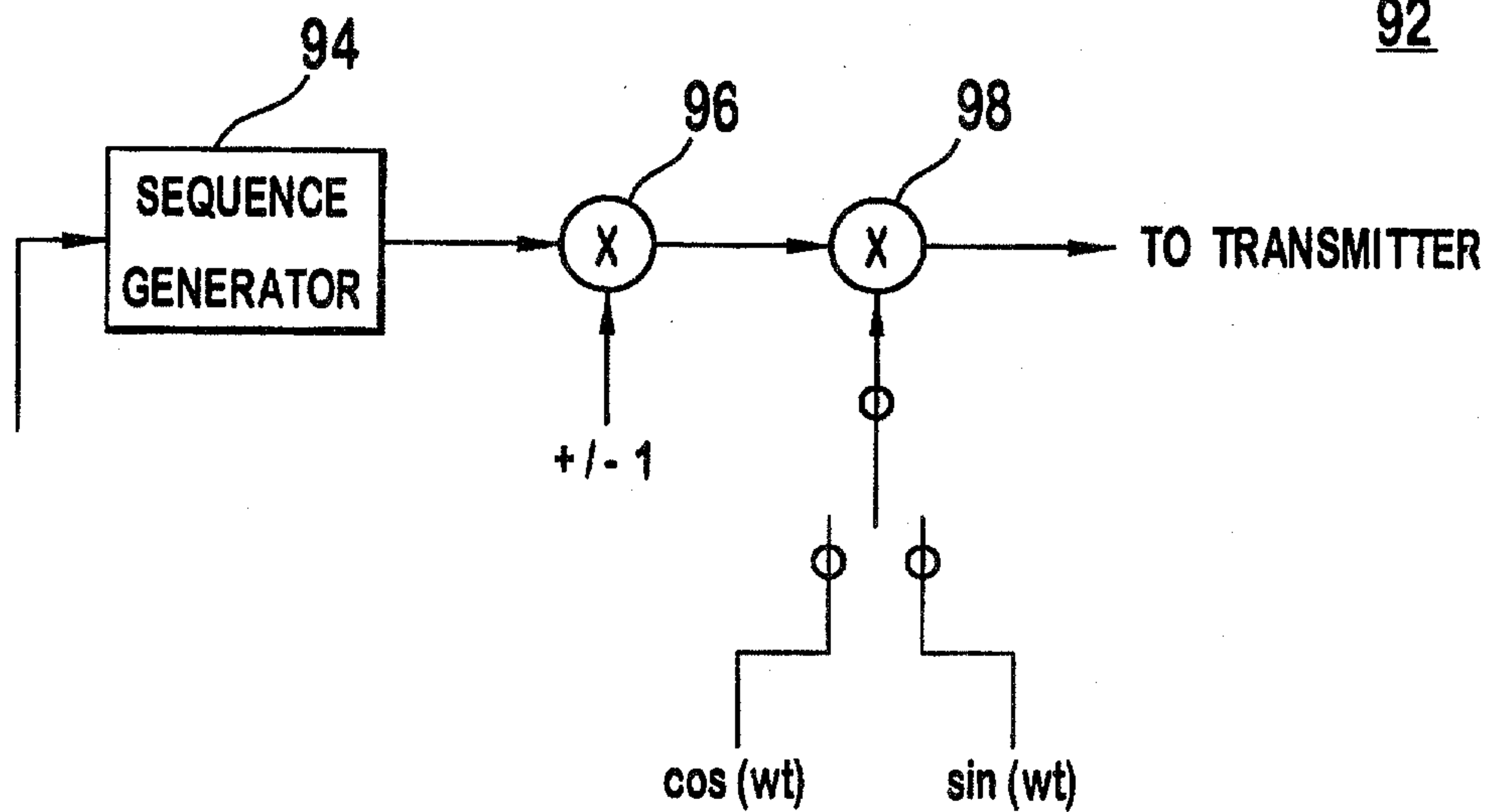
92

FIG. 6

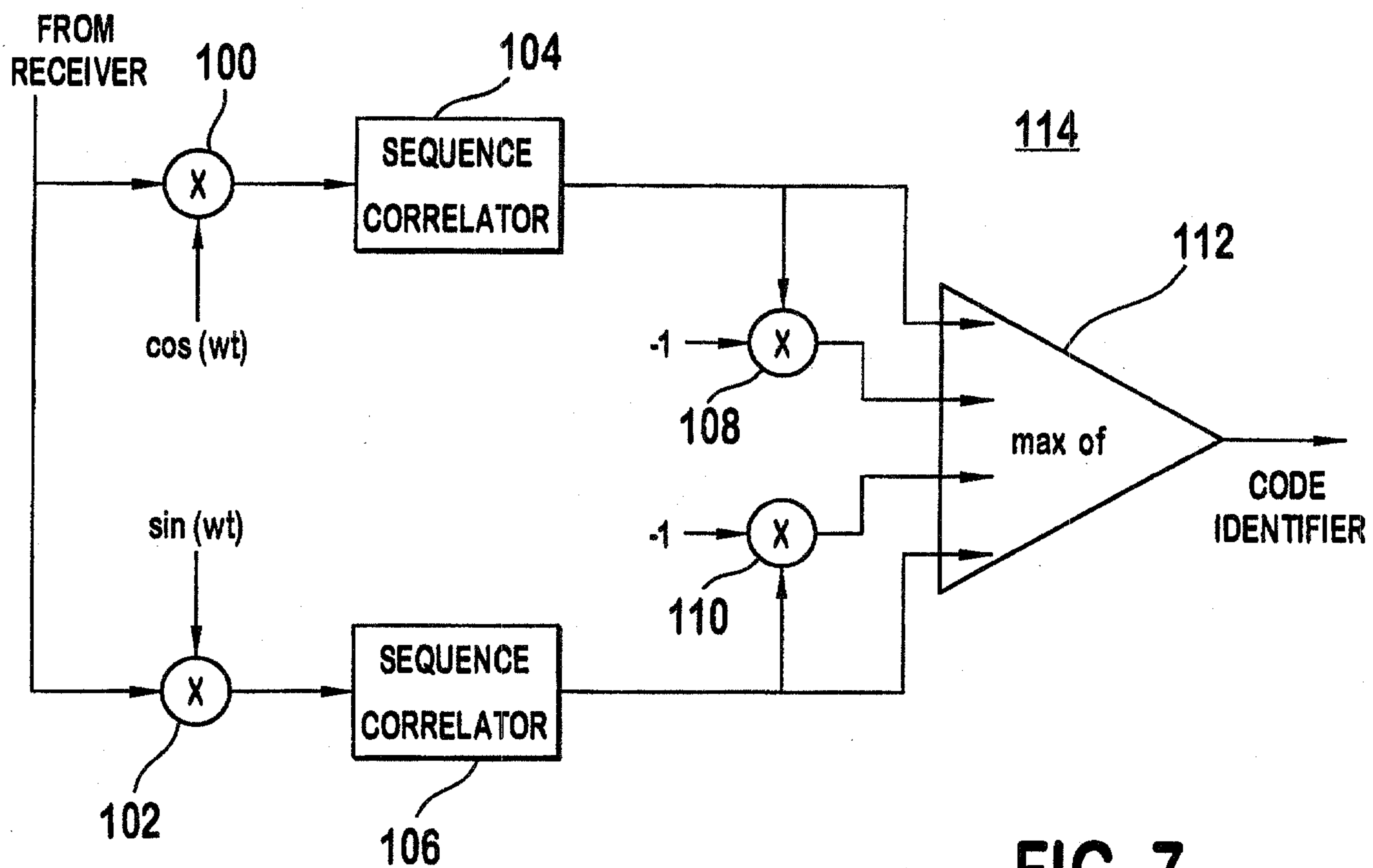


FIG. 7

ASSIGNMENT OF GOLAY SEQUENCES 122

USER	STATES	LONG GOLAY SEQUENCES COMPOSED OF SHORTER X, Y GOLAY SEQUENCES															
		Y	Y	X	X	Y	Y	-Y	X	-X	Y	-Y	Y	-X	X	-X	-X
0	0, 1	Y	Y	X	X	Y	Y	-Y	X	-X	Y	-Y	Y	-X	X	-X	-X
0	2, 3	Y	Y	X	X	Y	Y	-Y	X	-X	Y	-Y	Y	-X	X	-X	-X
1	0, 1	Y	-Y	X	-X	Y	Y	Y	X	-X	Y	Y	Y	X	-X	-X	X
1	2, 3	Y	-Y	X	-X	Y	Y	Y	X	-X	Y	Y	Y	X	-X	-X	X
2	0, 1	Y	Y	X	X	-Y	Y	-Y	X	X	-Y	-Y	-Y	-X	X	X	-X
2	2, 3	Y	Y	X	X	-Y	Y	-Y	X	X	-Y	-Y	-Y	-X	X	X	-X
3	0, 1	Y	-Y	X	-X	-Y	Y	Y	X	-X	-Y	Y	Y	X	-X	-X	-X
3	2, 3	Y	-Y	X	-X	-Y	Y	Y	X	-X	-Y	Y	Y	X	-X	-X	-X
4	0, 1	Y	Y	-X	-X	Y	Y	-Y	-X	X	Y	-Y	Y	-X	X	X	X
4	2, 3	Y	Y	-X	-X	Y	Y	-Y	-X	X	Y	-Y	Y	-X	X	X	X
5	0, 1	Y	-Y	-X	-X	Y	Y	Y	X	-X	-Y	Y	Y	-X	X	-X	-X
5	2, 3	Y	-Y	-X	-X	Y	Y	Y	X	-X	-Y	Y	Y	-X	X	-X	-X
6	0, 1	Y	Y	-X	-X	Y	Y	-Y	-X	X	-Y	-Y	Y	-X	X	-X	-X
6	2, 3	Y	Y	-X	-X	Y	Y	-Y	-X	X	-Y	-Y	Y	-X	X	-X	-X
7	0, 1	Y	-Y	-X	-X	-Y	-Y	Y	-X	X	Y	-Y	Y	-X	X	-X	X
7	2, 3	Y	-Y	-X	-X	-Y	-Y	Y	-X	X	Y	-Y	Y	-X	X	-X	X
8	0, 1	X	X	Y	Y	X	X	-X	Y	-Y	-X	X	X	-Y	Y	-Y	-Y
8	2, 3	X	X	Y	Y	X	X	-X	Y	-Y	-X	X	X	-Y	Y	-Y	-Y
9	0, 1	X	-X	Y	-Y	X	X	X	-Y	-Y	-X	X	X	Y	-X	-X	Y
9	2, 3	X	-X	Y	-Y	X	X	X	-Y	-Y	-X	X	X	Y	-X	-X	Y
10	0, 1	X	X	Y	Y	-X	-X	-X	-Y	-Y	-X	-X	-X	-Y	-Y	-Y	-Y
10	2, 3	X	X	Y	Y	-X	-X	-X	-Y	-Y	-X	-X	-X	-Y	-Y	-Y	-Y
11	0, 1	X	-X	Y	-Y	-X	-X	-X	Y	-Y	-X	X	-X	-Y	-Y	-Y	-Y
11	2, 3	X	-X	Y	-Y	-X	-X	-X	Y	-Y	-X	X	-X	-Y	-Y	-Y	-Y
12	0, 1	X	X	-Y	-Y	X	X	-X	-Y	-Y	Y	Y	X	Y	-Y	Y	Y
12	2, 3	X	X	-Y	-Y	X	X	-X	-Y	-Y	Y	Y	X	Y	-Y	Y	Y
13	0, 1	X	-X	-Y	-Y	X	X	X	Y	-Y	-Y	-Y	-X	-Y	-Y	-Y	-Y
13	2, 3	X	-X	-Y	-Y	X	X	X	Y	-Y	-Y	-Y	-X	-Y	-Y	-Y	-Y
14	0, 1	X	X	-Y	-Y	-X	-X	-X	Y	-Y	-Y	Y	-X	Y	-Y	-Y	-Y
14	2, 3	X	X	-Y	-Y	-X	-X	-X	Y	-Y	-Y	Y	-X	Y	-Y	-Y	-Y
15	0, 1	X	-X	Y	Y	-X	-X	X	-Y	-Y	-X	X	-X	-Y	-Y	-Y	-Y
15	2, 3	X	-X	Y	Y	-X	-X	X	-Y	-Y	-X	X	-X	-Y	-Y	-Y	-Y

FIG. 8

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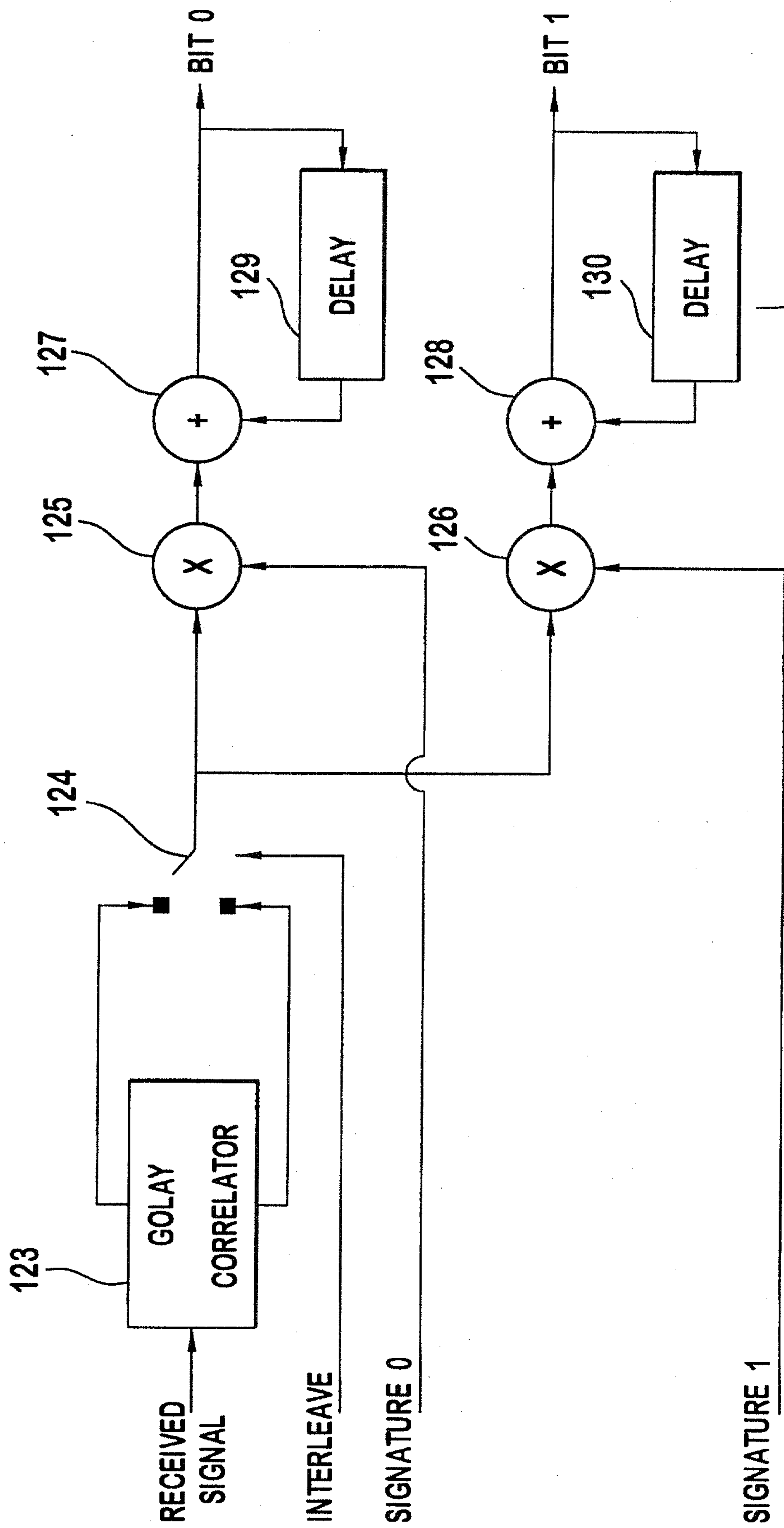


FIG. 9

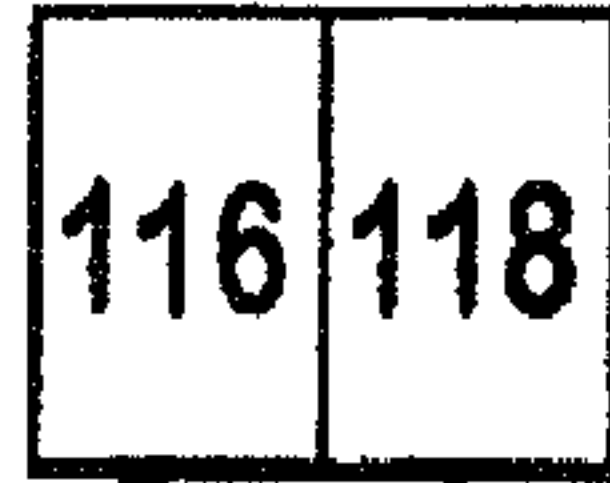
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132

PREAMBLE	DOWNLINK CODE	DOWNLINK SLOTS
1	1	1, 2
2	1	1, 2
3	1	1, 2
4	1	1, 2
5	2	1, 2
6	2	1, 2
7	3	1, 2
8	3	1, 2
9	3	1, 2
10	4	1, 2
11	4	1, 2
12	5	1, 2
13	5	1, 2
14	5	1, 2
15	5	1, 2
16	5	1, 2

FIG. 10

GROUPING



...



42

44

46

84	48	54		60
86	50	56		62

⋮

⋮

...

⋮

88	52	58		64
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