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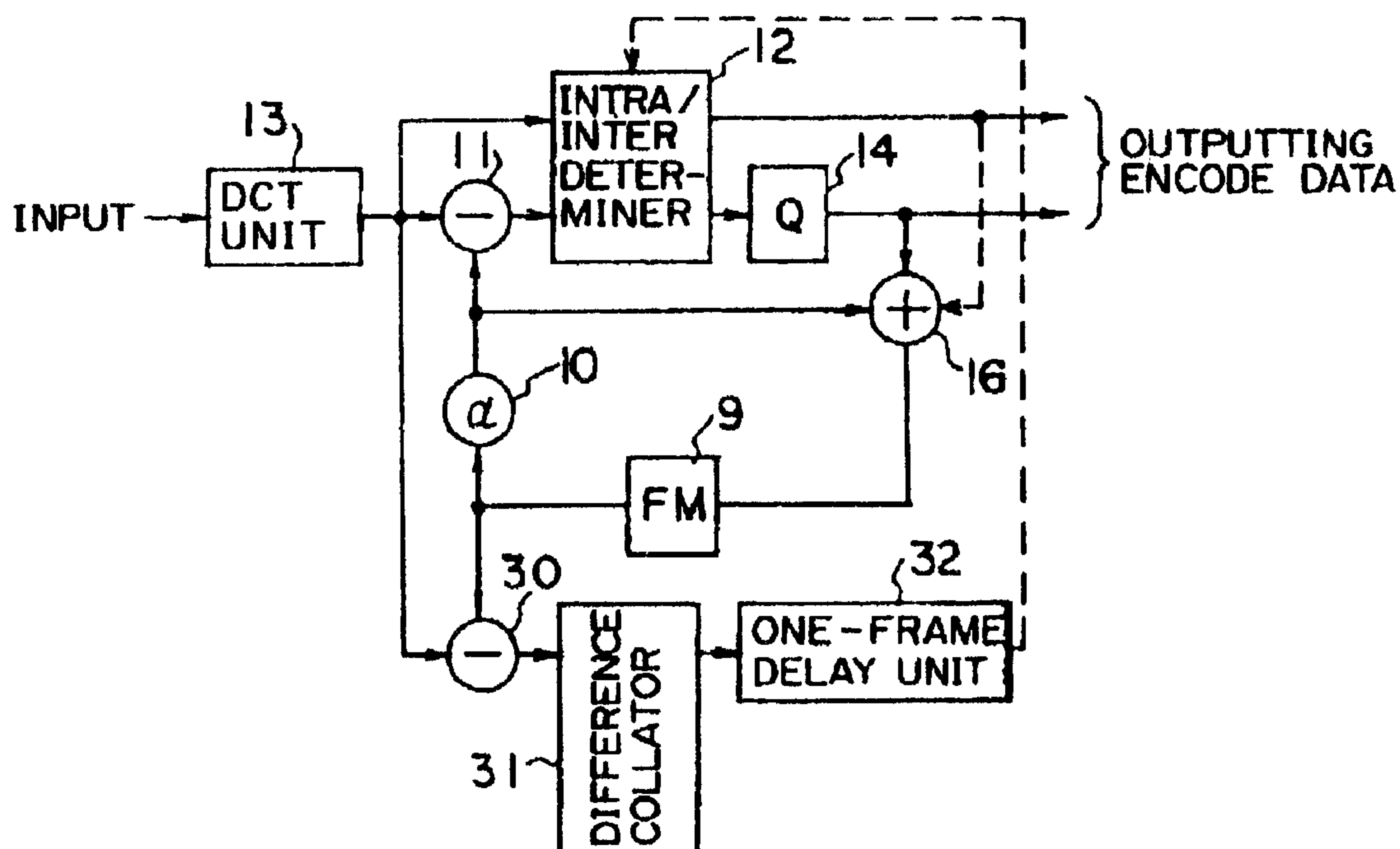
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(54) Title: AN IMAGE ENCODING AND TRANSMITTING SYSTEM



(57) Abrégé/Abstract:

An image encoding and transmitting system is an image transmission system for transmitting digital data such as TV telephones. The system for dividing input frame data into a plurality of blocks before transmitting them comprises on its sending side an intra-frame/inter-frame determiner for receiving intra-frame data and inter-frame data and selecting either of them for output, and a difference collator for having the intra-frame/inter-frame determiner compulsorily output intra-frame data at the time of data input for the next frame when one or more data in each block forming inter-frame data are larger than a predetermined threshold. The system also comprises on its receiving side an picture element domain frame data storage for storing received data in the picture element domain, and a motion vector detector for detecting according to the contents in the storage a motion vector using the data in the block surrounding the discarded block in order to guess the data in the discarded block.



Abstract

An image encoding and transmitting system is an image transmission system for transmitting digital data such as TV telephones. The system for dividing input frame data into a plurality of blocks before transmitting them comprises on its sending side an intra-frame/inter-frame determiner for receiving intra-frame data and inter-frame data and selecting either of them for output, and a difference collator for having the intra-frame/inter-frame determiner compulsorily output intra-frame data at the time of data input for the next frame when one or more data in each block forming inter-frame data are larger than a predetermined threshold. The system also comprises on its receiving side an picture element domain frame data storage for storing received data in the picture element domain, and a motion vector detector for detecting according to the contents in the storage a motion vector using the data in the block surrounding the discarded block in order to guess the data in the discarded block.

An Image Encoding and Transmitting System

Background of the Invention

The present invention relates to an efficient
5 image data encoding system used in a digital
transmission of TV telephone and TV conference data by
an NTSC method, or in a digital transmission of high-
definition TV (HDTV) data, and more specifically to an
image encoding and transmitting system used in an
10 image transmission system for dividing input frame
image data into a plurality of blocks comprising a
plurality of picture elements, encoding them in block
units, and transmitting the encoded data in cell
units.

15 An asynchronous transfer mode (ATM) has been
widely accepted and is being standardized to realize a
broadband ISDN, a new generation network. In the ATM,
data are put into a single format "cell" (a fixed
length packet) and transmitted by a label multiplexing
20 technology. In an image communication field, it is
regarded as an efficient improvement in the
utilization of lines and regenerated image quality
through a variable bit rate transmission. However, in
an efficient encoding system based on an inter-frame
25 encoding process, the quality of images are badly

deteriorated if a cell-discarding operation makes an error in image data during transmission. Therefore, an efficient encoding system having a cell-discard compensation function is earnestly required.

5 Recently, various image data processors have been digital oriented, and new systems for transmitting digital image data signals have been extensively developed in many application fields such as TV
10 telephones, etc. Generally, image data involve a large volume of information when transmitted. For example, when TV data are digitalized, they require 100Mb/s transmission capacity and involve 1,500 times
15 as much as voice data. In the TV broadcast, a screen is switched 30 times in a second, and a frame is switched every 1/30 second. Normally, picture elements are arranged in a two-dimensional array in one screen corresponding to one frame. Therefore,
20 there have to be a large volume of information for image data of one frame even though the density of one picture element can be represented by 8 bits.

 However, the contents of an image in each frame may not vary greatly even when a frame is switched every 1/30 second. That is, a large part of an image is static including the sky and a scene in the
25 background. Only a small part of it varies in each

frame. Therefore, an inter-frame encoding system has been developed to compress and encode image data.

In the inter-frame encoding system, for example, the difference in density data is obtained between corresponding image pictures in two time-series frames. The difference is encoded by a Huffman code, for example, and transmitted to the transmission line. If the density does not vary for most picture elements, the difference between picture elements results in "0" and can be represented by about 2 bits. A large difference between picture elements requires 8 or more bits. However, since only large differences must be encoded, total transmission data can be greatly compressed. By contrast, a system of encoding data in 1 frame "as is" is referred to as an "intra-frame encoding system."

In the inter- and intra-frame encoding systems, two basic operations "sampling" and "quantization" are required for representing image signals digitally. There are two methods of sampling an image. First, an image is sampled by representing by density values for a discrete point array corresponding to picture elements. Second, a density value function (image function) defined on the XY plane corresponding to a frame plane is expanded orthogonally, and the

expansion coefficient is determined to be a sampling value.

Figure 1 is a block diagram for explaining the general configuration of the image transmission system using an orthogonal transform. In Figure 1, noises are removed through a filter from inputted image data by a preprocessor 1, and picture element data are divided in block units. The block-division does not mean an orthogonal transform collectively performed on data comprising $K \times N$ picture elements in a two-dimensional array in one frame, but is performed to shorten the transformation time by obtaining a transformation coefficient for each block comprising 4×4 to 16×16 picture elements.

In a source encoder 2, data are quantized for the reduction of bits after the inter-frame encoding, the transformation-encoding, etc. as encoding processes for removing redundancy in space and time directions. The orthogonal transforms performed in this technology are, for example, Adamar transform, cosine transform, Karounen Roebé transform, etc. Among them, the discrete representation in cosine transforms is commonly used, and the discrete cosine transform (DCT) is applied most.

In such orthogonal transformation-encoding

systems, the inter-relation in a small area is regarded and an orthogonal transform is performed using picture elements of a small area as a numerical string. The resultant transformation coefficient corresponds to a frequency component indicating each level ranging from a low frequency to a high frequency. Since an image signal normally has a low frequency component rather than a high frequency component, a larger number of bits are assigned to a low frequency component and a smaller number of bits to a high frequency component prior to the quantization. Thus, the volume of transmission data can be reduced greatly.

Figure 1 shows a variable length encoder 3 for encoding data by a Huffman code, run-length code, etc. to eliminate statistical redundancy, and a cell assembler 4 for assigning side information for detecting cell-discard and a header to a cell. Thus, an assembled cell is outputted through a network.

On the receiving side, a cell disassembler 5 detects cell-discard in a cell inputted through the network, and the cell is disassembled to data. Then, the received bit string is decoded by a variable length decoder 6, and image data are decoded by a source decoder 7 by performing the source encoding

process in reverse. Then, a post-processor 8 performs an unblock process, a noise removal process using a filter, etc., and the data are outputted.

Figure 2 is a block diagram for explaining the configuration for the inter-frame DCT encoding system as the first example of a typical conventional encoding system. In Figure 2, a subtracter 11 on the sending side calculates the difference between inputted image data divided into block data and the data obtained by multiplying the block data stored in a frame memory 9 at the same block position but in the preceding frame by the leak coefficient α provided by a leak coefficient unit 10. The difference and the inputted data are applied to an intra-frame/inter-frame determiner 12 for determining which is effective, to encode the data in the present frame, that is, to encode the intra-frame data as is, or to encode the difference between the data in the present frame and those at the corresponding position in one frame before the present data. The data determined to be more effective are applied to a discrete cosine transform (DCT) unit 13, and quantized by a quantizer 14.

The output of the quantizer 14 and the intra-frame/inter-frame determination result indicated by

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the broken line shown in Figure 2 are outputted to the variable length encoder 3 shown in Figure 1. Simultaneously, the output of the quantizer 14 is inversely transformed again to the picture element domain by an inverse discrete cosine transform (IDCT) unit 15, added by an adder 16 to the product obtained by multiplying the data stored in the frame memory 9 by α from the leak coefficient unit 10, and then stored again in the frame memory 9. However, when an intra-frame data encoding is selected, the adder 16 does not add the data in the prior frame according to the input of a determination signal as shown by the broken line, but stores the output of the IDCT unit 15 as is in the frame memory 9.

15 In Figure 2, on the receiving side, the input data are inversely transformed to the picture element domain by an IDCT unit 17. The result is added by an adder 20 to the data obtained by multiplying the data in the preceding frame stored in a frame memory 18 by α from a leak coefficient unit 19, and then outputted to the post-processor 8 shown in Figure 1 and stored again in the frame memory 18. When an intra-frame data encoding is selected, the data in the prior frame are not added. For a block which does not receive data due to cell- discard, the prior frame data is

added to the input 0, and the result is stored in the frame memory 18. That is, at the cell-discard, the prior frame data are stored as is to the frame memory 18.

5 In Figure 2, both on the sending and the receiving sides, the leak coefficient unit exists between the output of the frame memory and the adder. The product obtained by multiplying the output of the frame memory by the leak coefficient δ is used as a
10 value of the data in the preceding frame. If the leak coefficient δ is set to a value between 0 and 1 and an error E arises between the contents stored in the frame memories on both the sending and the receiving sides, the error results in $E \times \delta^n$ after n frames.
15 The error gradually gets smaller with time, and finally converges to zero. Therefore, the quality of a regenerated image can be restored when the error value has decreased down to near zero even though an error E has arisen on the sending and the receiving
20 sides due to cell-discard and has incurred the deterioration in the quality of a regenerated image.

Figure 3 is a block diagram for explaining the configuration for realizing the DCT inter-frame encoding system as the second embodiment of the
25 conventional encoding system. The configuration of

this system is similar to the system shown in Figure 2 except the following points: the discrete cosine transform (DCT) unit 13 is located in the source encoder 2, the input image data are transformed by the DCT unit 13 to a frequency domain coefficient, and the inter-frame or intra-frame data encoding system is selected for the transformed coefficient data.

On the receiving side, data in the frequency domain are decoded using the frame memory 18 depending on the selection of the inter-frame or intra-frame encoding system. The result is transformed by the IDCT unit 17 to the picture element domain, and outputted to the post-processor 8.

Figure 5 is a configurational block diagram for explaining the motion compensation inter-frame DCT encoding system of the prior art technology. It is similar in its configuration to Figure 2 showing the first example of the prior art technology. However, since the intra-frame encoding system is not used in the operation shown in Figure 5, the intra-frame/inter-frame determiner 12 is not provided on the sending side. Instead, a motion vector detector 100 for detecting a motion vector of each block according to inputted data and the data in the preceding frame stored in the frame memory 9 and a

variable delay unit 101 for delaying the contents stored in the frame memory 9 and outputting them to the leak coefficient unit 10 are added to the sending side.

5 Also on the receiving side, a variable delay unit 102 for delaying by the necessary time period the data in the preceding frame stored in the frame memory 18 according to a motion vector received from the sending side and outputting them to the leak coefficient unit
10 19 is added.

 In the conventional encoding system shown in Figures 2 and 3, the image quality can be automatically restored with time using a leak coefficient α even though the quality of an image has
15 deteriorated due to cell-discard. For a block in which the time difference is comparatively small between the previous frame and the present frame, an error in the image data between the sender and the receiver is small, and can rapidly converge to zero
20 using the leak coefficient. Therefore, the deterioration of the image quality can be limited to a visually admitted level. However, for a block in which the time difference is comparatively large, the error between these image data becomes large and the
25 deterioration in the image quality is badly

outstanding when the cell-discard rate is high because the error takes much time in converging using a leak coefficient.

5 Summary of the Invention

 An object of the present invention is to shorten the time taken for restoring the deteriorated quality of an image, that is, for converging to zero the error in the image data between a sender and a receiver
10 caused by cell-discard. Another object of the present invention is, when cell-discard has arisen, to minimize an error in an image data between a sender and a receiver by guessing using a motion vector a data block in which the cell-discard has arisen.

15 A feature of the present invention relates in an image encoding and transmitting system for dividing inputted frame image data into a plurality of blocks comprising picture elements, encoding them in block units, and transmitting said encoded data in packet
20 units, said system comprising on its sending side, intra-frame/inter-frame determining means for receiving the first difference data as the difference between inputted frame data and data in the preceding frame or the difference between inputted frame data
25 and data obtained by multiplying said data in the

preceding frame by a constant γ , and selecting and outputting either of the intra-frame data as the inputted frame data or the inter-frame data as the first difference data, and difference collating means for receiving inputted frame data and the second difference data between said inputted frame data and the data in one frame before the present frame, and having said inter-frame/intra-frame determiner compulsorily output the intra-frame data at the data input of the next frame for the same block position when more than one piece of data in each block forming the second difference data are larger than a predetermined threshold, wherein the deterioration of image quality of frame data having a large difference can be prevented.

In accordance with an aspect of the present invention, there is provided an image encoding and transmitting system for dividing inputted frame image data into a plurality of blocks comprising picture elements, encoding them in block units, and transmitting said encoded data in packet units, said system comprising on its sending side: intra-frame/inter-frame determining means for receiving inputted frame data, and first difference data as the difference between inputted frame data and data obtained by multiplying the inputted frame data in the preceding frame by a constant α , and selecting and outputting either of the intra-frame data as the inputted frame data or the inter-frame data as the first difference data, and difference collating means for receiving second difference data as the difference

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between said inputted frame data and the data in one frame before the present frame, and having said inter-frame/intra-frame determining means compulsorily output the intra-frame data at the data input of the next frame for the same block position when more than one piece of data in each block forming the second difference data are larger than a predetermined threshold.

10 In accordance with another aspect of the invention, there is provided image processing apparatus for encoding and transmitting data representing a succession of image frames, the frame image data being divided into a plurality of block units of picture elements, selectively encoded using inter-frame encoding or intra-frame encoding, and transmitted in packet units, said apparatus comprising: an intra-frame/inter-frame determiner including: a receiver to receive the frame image data for a current frame after the frame image data has been divided into block units and before encoding, a first calculator to calculate first difference data as the difference between inputted frame data in each block of said current frame and data in the corresponding blocks of a preceding frame multiplied by a constant, and a selector to selectively output either the encoded frame data as intra-frame data, or the first difference data as inter-frame data, and a difference collator including: a second calculator to calculate second difference data as the difference between the input data for the current frame and the data for the previous frame, and a controller to cause said intra-frame/inter-frame

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determiner to compulsorily output the inter-frame data as the data for the current frame for the same block position when more than one piece of data in each block forming the second difference data are larger than a predetermined threshold.

10 In accordance with another aspect of the invention, there is provided an image processing method for encoding and transmitting data representing a succession of image frames, the frame image data being divided into a plurality of block units of picture elements, selectively encoded using an inter-frame encoding technique or an intra-frame encoding technique, and transmitted in packet units, said apparatus comprising:
receiving the frame image data for a current frame after the frame image data has been divided into block units and before encoding, calculating first difference data as the difference between inputted frame data in each block of said current frame and data in the corresponding blocks of a preceding frame multiplied by a constant, selecting and outputting either the encoded frame data as intra-frame data, or the first difference data as inter-frame data, calculating second
20 difference data as the difference between the input data for the current frame and the data for the previous frame, and compulsorily outputting the inter-frame data as the data for the current frame for the same block position when more than one piece of data in each block forming the second difference data are larger than a predetermined threshold.

Brief Description of the Drawings

One of skill in the art can easily understand

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additional features and objects of this invention from the description of the preferred embodiments and some of the attached drawings. In the drawings:

Figure 1 is a block diagram for explaining the general configuration of the image transmission system;

Figure 2 is a block diagram for explaining the configuration of the first embodiment of the inter-

frame DCT encoding system;

Figure 3 is a block diagram for explaining the configuration of the second embodiment of the DCT inter-frame encoding system;

5 Figure 4 is a block diagram for explaining the configuration of the motion compensation inter-frame DCT encoding system according to the third example of the prior art technology.

10 Figure 5 is a block diagram for explaining the principle of the present invention;

Figure 6 shows the concept of the compulsory intra-frame encoding system;

Figure 7 shows an error in the compulsory inter-frame encoding system;

15 Figure 8 shows how to convert picture element data to a frequency domain coefficient.

✓ Figure 9 is a block diagram for explaining the configuration of the first principle of the present invention;

20 Figure 10 shows the detailed configuration of the intra-frame/inter-frame determiner, the difference collator, and the one-frame delay unit shown in Figure 9;

25 Figure 11 shows the concept of the motion vector detecting system in the second principle (at a normal

reception);

Figure 12 shows the concept of the motion vector detecting system in the second principle (of the prior art technology);

5 Figure 13 shows the concept of the motion vector detecting system in the second principle (of the present invention);

10 Figure 14 is the block diagram for explaining the configuration of an embodiment of the second principle;

Figure 15 is a block diagram for explaining the configuration of other embodiments of the second principle;

Figure 16 shows an embodiment of a cell format.

15 Figure 17 is a block diagram for explaining the configuration of the cell disassembler.

Figure 18 is a block diagram for explaining the configuration of the adder.

20 Figure 19 is a block diagram for explaining the configuration of the leak coefficient unit.

Figure 20 is a flowchart of an embodiment of a data replacing process using a motion vector;

Figure 21 is a flowchart of an embodiment of the first motion vector detecting process;

25 Figure 22 is a detailed flowchart of a motion

vector detecting process shown in Figure 21;

Figure 23 is a flowchart of an embodiment of the second motion vector detecting process; and

Figure 24 is a detailed flowchart of a motion
5 vector detecting process shown in Figure 23.

Figure 25 is a block diagram for explaining the configuration of the MC replacement unit shown in Figures 14 and 15.

Figure 26 is a block diagram for explaining the
10 configuration of the embodiment to which a part of the second principle is applied.

Figure 27 is a block diagram for explaining the configuration of the MC replacement unit shown in Figure 26.

15 Figure 28 is a flowchart for explaining the calculation for obtaining an average value of motion vectors shown in Figure 26.

Description of the Preferred Embodiment

20 Figure 5 is a block diagram for explaining the principle of the present invention. It shows the principle of the image encoding and transmitting system used in an image transmission system in which image data in an inputted frame are divided into
25 blocks each comprising a plurality of picture

elements, the data are encoded in block units, and the encoded data are transmitted in cell units.

For the detailed explanation of the present invention, a transmission method in which encoded data are transmitted in an ATM cell, for example. However, an encoded data transmission method is not limited to the method using the ATM cell, but can be realized using any kind of packet such as variable length packets, fixed length packets, etc.

Figure 5 is a block diagram for explaining the first principle. It shows the principle of the image encoding and transmitting system for minimizing the influence of cell-discard by performing a compulsory intra-frame encoding on the frame data after the data having a comparatively large difference are transmitted through an inter-frame encoding so as to prevent the image quality from being greatly deteriorated when data having a large difference are cell-discarded.

In Figure 5A, an intra-frame/inter-frame determiner 22 receives inputted frame data and the first difference data which indicate the difference between the inputted frame data and the data in the preceding frame or between the inputted frame data and the data obtained by multiplying the data in the

preceding frame by a constant, for example, a leak coefficient α , and selects and outputs either of the intra-frame data as the inputted frame data or the inter-frame data as the first difference data. The selection is determined by calculating a sum of squares of data in each block, collating the sums of squares for an intra-frame data and an inter-frame data, and selecting and outputting whichever has a smaller sum of squares. Thus, the length of the data code transmitted to the receiving side can be shortened.

A difference collator 23 receives the second difference data between the inputted frame data and the data in one frame before the present frame, and causes the inter-frame/intra-frame determiner 22 to compulsorily output the intra-frame data when the data at the same block position in the next frame are inputted when more than one piece of data in each block forming the difference data is larger than a predetermined threshold. Although comparatively large difference data are inter-frame -encoded, transmitted, and then cell-discarded, the quality of the image can be prevented from being deteriorated by intra-frame-encoding the next frame data. The inter-frame/intra-frame determiner 22 and the difference collator 23 are

provided on the sending side in an image transmission system.

Figure 5B is a block diagram for explaining the principle of the second embodiment. It shows the principle of the image encoding and transmitting system for guessing data in a block whose data were not received due to cell-discard by detecting a motion vector using the data in the blocks surrounding the missing block.

In Figure 5B, a picture element domain frame data storage 24 is, for example, a frame memory, and stores received image data in a picture element domain. If image data are transmitted as a coefficient of a frequency domain orthogonally transformed in the transmission line, they are stored in the picture element domain frame data storage 24.

A motion vector detector 25 detects a motion vector using the data in the blocks surrounding the block whose encoded data were not received due to cell-discard among the frame data stored in the picture element domain frame data storage 24 when a cell-discard detection signal is inputted. The motion vector detector 25 replaces data using this motion vector. The picture element domain frame data storage 24 and the motion vector detector 25 are provided on

the receiving side in an image transmission system.

As shown in Figure 5A for explaining the first principle, an object of the present invention is to shorten the time taken for converging to zero an error caused by cell-discard in image data between a sender and a receiver, that is, to shorten the time taken for reconstructing discarded data in a block having a large inter-frame difference. If the inter-frame encoding system is performed in spite of a comparatively large inter-frame difference, the data at the same block position in the next frame are compulsorily intra-frame-encoded. Therefore, the next frame can be encoded without the influence of the preceding frame even though a large difference block data may be discarded, thereby greatly shortening the time taken for restoring acceptable image quality.

As shown in Figure 5B for explaining the second principle of the present invention, a motion vector is detected when a cell-discard detecting signal is inputted to the receiving side so that determination can be made as to which position of a block in the preceding frame replaces the discarded block. Thus, data are replaced using the motion vector. However, a motion vector cannot be obtained directly from the discarded block, but can be obtained indirectly using

a surrounding block not affected by the cell-discard.

In the first system of obtaining a motion vector for replacing block data, motion vectors each for one or more blocks not affected by cell-discard are obtained. Then, an average value of the motion vectors is calculated as a replacing motion vector. In the second system, a general motion vector is detected in one block group comprising one or more blocks not affected by cell-discard. It is used as a replacing motion vector.

In Figure 5B for explaining the second principle, the picture element domain frame data storage 24 stores received image data in the picture element domain. Among the frame data stored here, block data not received due to cell-discard are replaced by the motion vector detector 25. If encoded data in the coefficient domain orthogonally transformed in the transmission line are transmitted, a second frame memory for storing the frame data in the coefficient domain as well as a frame memory corresponding to the picture element domain frame data storage 24 are provided on the receiving side. When cell-discard has arisen, block data in the preceding frame stored in the second frame memory are inversely transformed to the picture element domain. Then, the inversely-

transformed data are stored in a frame memory corresponding to the picture element domain frame data storage 24.

As described above, when data having a comparatively large inter-frame difference are transmitted, an intra-frame encoding is compulsorily selected for the same block position in the next frame, and, on the receiving side, the data in the discarded block can be replaced using a motion vector for the blocks surrounding the discarded block.

Figure 6 shows the concept of the first principle, that is, the compulsory intra-frame encoding system. Figure 7 indicates the prior art technology in which the difference between the present frame and the preceding frame are transmitted even though the difference is comparatively large unless an intra-frame encoding is selected from between the intra-frame encoding and the inter-frame encoding. Therefore, the time taken for reconstructing the deteriorated image quality caused by cell-discard is kept until, at the maximum, an error converges to zero using a leak coefficient.

In the concept of the present invention shown in Figure 6, an inter-frame coding is selected, for example. If the difference is comparatively large, a

compulsory intra-frame-encoding is selected for the next frame. Therefore, the error in the next frame is immediately converged to zero even though data having a large difference are discarded.

5 Figure 7 is a view for explaining an error in the compulsory intra-frame encoding system. Figure 7A indicates the prior art technology in which an error converges based on an almost equal time constant regardless of an error level. Inter-frame data having
10 a large difference are discarded. When an error is very large, it takes a long time for it to converge to zero. By contrast, in the present invention shown in Figure 7B, an error can converge in almost the same time as the conventional system if the difference is
15 smaller than a predetermined threshold and a compulsory intra-frame encoding is not selected for the next frame. However, an error immediately converges to zero when the difference is larger than a predetermined threshold and a compulsory intra-frame
20 encoding is selected for the next frame.

 Figure 8 shows a block diagram for explaining how to convert picture element data to a coefficient for a frequency domain by the discrete cosine transform. For example, a discrete cosine transform is performed
25 on 8x8 picture element data to obtain 64

transformation coefficients for the frequency domain. The coefficients refer to the frequency component, and the coefficient C_{00} at the upper left corner generally indicates a direct current component. The
5 coefficients toward right and downward therefrom show the higher frequency components.

Figure 9 is a block diagram for explaining the configuration of the embodiment of the first principle. It shows the configuration on the sending
10 side where a discrete cosine transform is performed on inputted data, and an intra-frame/inter-frame determination is made on the transformed data in the coefficient domain like in the second example of the encoding system of the prior art technology shown in
15 Figure 3. The same parts as those in Figure 3 are assigned the same numbers.

The configuration shown in Figure 9 comprises, in addition to the configuration on the sending side shown in Figure 3, a subtracter 30 for calculating the
20 difference between the output of the DCT unit 13 and the output of the frame memory 9, that is, for calculating an inter-frame difference for all data in a block, a difference collator 31 for determining whether or not the difference is larger than a
25 predetermined threshold, a one-frame delay unit 32 for

delaying by one frame the output of the difference collator 31 and having the intra-frame/inter-frame determiner 12 select a compulsory intra-frame encoding for the next frame when the difference collator 31
5 determines that the difference is larger than the threshold.

Figure 10 is a detailed block diagram of the intra-frame/inter-frame determiner 12, the difference collator 31, and the one-frame delay unit 32 shown in
10 Figure 9. In Figure 10, the difference collator 31 corresponds to comparators 33a - 33n and an AND circuit 34, and the one-frame delay unit 32 corresponds to a first-in-first-out memory (FIFO) 35.

The number of comparators 33a - 33n is equal to
15 the number of the transformation coefficient data in a block. In each comparator, an inter-frame difference of block data is compared with a threshold. If the absolute value of the difference is larger than the threshold, "0" is outputted. If it is smaller than
20 the threshold, "1" is outputted. If the inter-frame differences for all transformation coefficient data in a block are smaller than the threshold, the AND circuit 34 outputs "1". If any one absolute value of
the difference in any data is larger than the
25 threshold, it outputs "0", and the value is stored in

the FIFO 35.

The intra-frame/inter-frame determiner 12 shown in Figure 5 can be formed of a sum-of-squares calculator 36a for obtaining a sum of squares of data in transformation coefficient data in a block for the inter-frame difference data outputted by the subtracter shown in Figure 9, a sum-of-squares calculator 36b for obtaining a sum of squares of data in transformation coefficient data in a block for the intra-frame data outputted by the DCT unit 13, a comparator 37, for comparing the outputs of two sum-of-squares calculators, an AND circuit 38, a delay unit 39a for delaying the output of the subtracter 11 by the time taken for intra-frame/inter-frame determination, a delay unit 39b for delaying the output of the DCT unit 13 by the above described time, and a selector 40 for outputting the output from either of two delay units, each being shown in Figure 10.

In Figure 10, the comparator 37 outputs "0" when a sum of squares of an inter-frame difference data is larger than a sum of squares of an intra-frame data, and outputs "1" when a sum of squares of an inter-frame difference data is smaller than a sum of squares of an intra-frame data. When the comparator 37

outputs "0", the AND circuit 38 outputs "0". At this time, the selector 40 outputs the output of the delay unit 39b, that is, intra-frame data, to the variable length encoder 3 shown in Figure 22.

5 By contrast, an inter-frame encoding may be selected when the comparator 37 outputs "1". In this case, the FIFO 35 must also output "1". That is, the difference in all data in a block between the present and the previous frames must be smaller than a
10 predetermined threshold. Then, the AND circuit 38 outputs "1", the selector 40 outputs the output from the delay unit 39a, that is, the inter-frame difference data outputted by the subtracter 11, to the variable length encoder 3. If the FIFO 35 outputs "0"
15 while the comparator 37 outputs "1", that is, if the inter-frame difference at the same block position between the present and previous frames is larger than a predetermined threshold, the AND circuit 38 outputs "0", thereby selecting a compulsory intra-frame
20 encoding.

Figures 11 - 13 show the concept of the motion vector detecting system of the second principle of the present invention. Figure 11 shows an example of a present frame, one frame before the present frame, and
25 the next frame when no cell-discard has arisen, that

is, transmission data are normally received. In this example, an image is positioned at the right, and a camera is moved to the left.

Figure 12 shows an example of the conventional system in which data are replaced with block data in a preceding frame when cell-discard has arisen. In Figure 12, if block 10 is discarded in the present frame, the missing data must be normally replaced with those in block 9 in the preceding frame. However, since the data in block 9 in the preceding frame is also discarded, the data is replaced with those in block 10 in the preceding frame "as is". In the next frame, the data in block 9 in the present frame, that is, the data with only its upper left corner lacking, are received unless additional cell-discard does not arise. However, the cell-discard affects block 10 in the present frame, thereby generating a block data with its upper right corner lacking.

Figure 13 shows an example of replacement through a motion vector. Like in Figure 12, the data in block 10 are assumed to be discarded in the present frame. As shown in Figure 13B, if, for example, a motion vector is detected in block 4 above block 10 and in block 16 below block 10, and block 3 and 15 in the preceding frame are determined to move to block 4 and

16 respectively, then block 9 is assumed to move to
block 10. Thus, as shown in Figure 15, the influence
of the cell-discard in block 10 can be eliminated by
replacing the data in block 10 in the preceding frame
5 with those in block 9.

Figure 14 is a block diagram for explaining the
configuration of an embodiment of the second
principle. It shows the configuration on the
receiving side for performing by the IDCT unit 17 an
10 inverse orthogonal transform on received input data
and then decoding them like in the first example of
the prior art technology shown in Figure 2. In Figure
14, like the frame memory 18 shown in Figure 2, a
frame memory 41 is used in a common decoding process,
15 and also used for replacing discarded block data using
a motion vector. A motion compensation replacement
unit 42 for replacing discarded block data using a
motion vector detects a motion vector using block data
surrounding the discarded block data when a cell-
20 discard detection signal is inputted by the cell
disassembler 5 and replaces the discarded block data.
Detection of a motion vector and replacement of block
data are described later.

Figure 15 is a block diagram for explaining the
25 configuration of another embodiment of the second

principle of the present invention. It corresponds to the second prior art technology shown in Figure 3. The frame memory 18 stores the data in the coefficient domains. A motion vector cannot be detected in these data. Therefore, the IDCT unit 17 stores the data converted to the picture element domain in a second frame memory 43. When cell-discard is detected, an MC replacement unit 44 replaces discarded block data with the block data stored in the second frame memory 43. When cell-discard is detected, a detection signal is applied to the leak coefficient unit 19. The data stored in the frame memory 18 are not processed with a leak coefficient, but stored again in the frame memory 18. Simultaneously, they are transformed to the data in the picture element domain by the IDCT unit 17, and then outputted to the second frame memory 43.

In the embodiment of the second principle of the present invention, the operation when an intra-frame encoding is selected on the sending side is the same as the conventional operation shown in Figures 2 and 3.

Next, a cell-discard detecting system in the second principle of the present invention is described below. Figure 22 shows an embodiment of a cell format. In Figure 22, a 5-byte header is stored

before the 53-byte cell, followed by a 1-byte sequence number as side information. Cell-discard can be detected by monitoring a sequence number. The encoded data in a cell occupy 47 bytes.

5 Figure 17 is a configurational block diagram of the cell disassembler 5. In Figure 23, the header is removed from the received cell by a header removing unit 103. The cell whose header is removed is applied to a disassembler 104, and is divided to a 1-byte
10 sequence number and 47-byte encoded data. The value in a cell counter 105 is stepped up when a cell is received. The counter value and the sequence number outputted from the disassembler 104 are compared by a comparator 106, and a cell-discard detection signal is
15 outputted when a sequence number is omitted. The 47-byte encoded data from the disassembler 104 is provided for the variable length decoder 6 shown in Figure 1 as encoded data by a read controller 108 through a memory 107. When cell-discard is detected,
20 "0", for example, are outputted for 47 bytes as dummy data.

 Figure 18 is a configurational block diagram of the adder 20 shown in Figures 14 and 15. When an intra-frame encoding is selected, inputted data and
25 the encoded data from a read controller 108 shown in

Figure 17 and "0" are added together and outputted. When an inter-frame encoding is selected, an output from the leak coefficient unit 19 and the encoded data are added together and outputted.

5 Figure 19 is a configurational block diagram of the leak coefficient unit 19. For example, when cell-discard is detected as shown in Figure 21, dummy data "0" are applied from the cell disassembler. At this time, the data in the preceding frame stored in the
10 frame memory 18 are outputted as is to the adder 20 without performing a multiplication by the leak coefficient. When cell-discard is not detected, the content in the frame memory 18 is multiplied by the leak coefficient, and the result is outputted.

15 Figure 20 is a flowchart of an embodiment of a data replacement process using a motion vector. In Figure 20, when the process starts, determination is made in step S 51 as to whether or not block B(i,j) has been discarded. In block B(i,j), the coordinates
20 of the point at the upper left corner are (i,j) as shown in Figure 20B. One block comprises 8x8 picture elements.

 In step S 52, the difference y of the coordinates in the vertical direction (e.g. downward) from the
25 upper left corner point (i,j) of a block is set to

"0". In step S 53, the difference x of the coordinates in the horizontal direction (e.g. to the right) is set to "0". In step S 54, the data for the coordinates (i+x,j+y) in the present frame can be
5 calculated by the following expression using the motion vectors x and y.

$$\text{presf}(i+x,j+y) = \text{prevf}(i+x+\text{vector } x, j+y+\text{vector } y)$$

where "presf" indicates the present frame, and "prevf" indicates the preceding frame.

10 Then, in step S 55, the value of x is stepped up. In step S 56, determination is made as to whether or not x equals 8. If not, the processes are repeated from step S 54.

15 If x equals 8 as the result of the determination in step S 56, the difference of the coordinates in the horizontal direction, that is, the horizontal replacement range by a motion vector, has reached the width of one block. Accordingly, in step S 57, the value of y is stepped up. In step S 58, determination
20 is made as to whether or not the value of y has reached 8. If not, the processes are repeated from step S 53. In step S 58, if y has reached 8, the process is terminated. If block B(i,j) is not determined to have been discarded in step S 51, the
25 process is terminated immediately.

Figure 21 is a flowchart for explaining the first embodiment of an average value calculation process of a motion vector for one or more blocks in the motion vector general detection process. In the flowchart shown in Figure 21A, when the process starts, determination is made in step S 60 as to whether or not block B(i,j) has been discarded. If not, the process is terminated immediately.

When block B(i,j) is determined to have been discarded, the number of significant blocks, that is, the number of significant blocks blkct used for detecting a motion vector is set to "0" in step S 61. In step S 62, determination is made as to whether or not block B(i,j-8) has been discarded. As shown in Figure 21B, block B(i,j-8) is positioned above block B(i,j) which is detected as being discarded.

If the block above (shown in Figure 21B) is not discarded in step S 62, a motion vector is detected using the block above in step S 63. In step S 64, the number of significant blocks blkct is stepped up and the vectors x and y are obtained. Then, control is transferred to step S 65. If the block above is detected as being discarded in step S 62, it is impossible to detect a motion vector. Therefore, control is transferred to the process in step S 65

without performing the processes in steps S 63 and S 64.

5 In step S 65, determination is made as to whether or not the block below the discarded block B(i,j) shown in Figure 21B has been discarded. If not, a motion vector is detected using the block below in step S 66 like it is detected using the block above in step S 63. In step S 67, the value of blkck is stepped up, and the motion vectors x and y are
10 obtained using the vector obtained in step S 66 and the motion vectors x and y obtained in step S 64. If the block above is discarded and the process in step S 64 is not performed, the motion vectors x and y obtained in step S 67 equal to the motion vectors
15 detected in step S 66. If cell-discard is detected in step S 65, control is transferred to the process in step S 68 without performing the processes in steps S 66 and S 67.

20 In step S 68, determination is made as to whether or not the number of significant blocks equals "0". If yes, both the blocks above and below are discarded. In this case, since a motion vector cannot be obtained, the process is terminated with the motion vectors x and y set to "0" in step S 69. If the
25 number of significant blocks does not equal "0", the

values of the motion vectors x and y already obtained in step S 70 divided by the number of significant blocks respectively are assigned as the final values of the vectors x and y , and the process is terminated.

5 Figure 22 is a detailed flowchart of a motion vector detecting process shown in Figure 21. It is used in detecting a motion vector for a block above described in step S 63 in Figure 21 and used in detecting a motion vector for a block below described
10 in step S 66.

 In Figure 22, when the process is started, in step S 71, the value of sum 1 is set to 10,000 as the minimum initial value of the sum of absolute values described later. In step S 72, the value of the
15 vertically-variable vector "vecy" is set to -4. In step S 73, the value of the horizontally-variable vector "vecx" is set to -4. In step S 74, using the variable vectors set in steps S 72 and S 73, a difference is calculated between the data of a point
20 obtained by adding a variable vector to the coordinates of any point in the preceding frame, and the data of the point at the same position as the above described "any point" in the present frame. The sum of the absolute values sum 2 of the differences
25 described above are calculated for all the points in

the block. In step S 75, determination is made as to whether or not the grand total of the calculation performed in step S 75 is smaller than the initial value set in step S 71.

5 If the sum is smaller than the initial value in
step S 75, variable vectors are assigned as motion
vectors in step S 76. In step S 74, the obtained sum
of absolute values sum 2 is determined to be the
minimum value sum 1 of the sum of absolute values, and
10 control is transferred to step S 77. If the sum is
not smaller than the initial value in step S 75, the
variable vector is not determined to be close to the
motion vector. Therefore, control is transferred to
the process in step S 77 without performing the
15 process in step S 76.

 In step S 77, the value of the horizontally-
variable vector is stepped up. In step S 78,
determination is made as to whether or not the value
of the horizontally-variable vector has reached 5. If
20 not, data have not been checked up to the half of the
width of the block. The processes are repeated from
the process in step S 74. If the value of the
horizontally-variable vector has reached 5 in step S
78, the value of the vertically-variable vector is
25 stepped up. In step S 80, determination is made as to

whether or not the value has reached 5. If not, the processes are repeated from the process in step S 73. If yes, the process is terminated immediately.

5 Figure 23 is a flowchart for explaining the second embodiment of the motion vector general detecting process. In the second embodiment, unlike the first embodiment described by referring to Figure 21, the blocks above and below a discarded block are regarded as one group. Among them, one motion vector
10 is detected.

In the flowchart shown in Figure 23A, when the process is started, determination is made in step S 81 as to whether or not $B(i,j)$ has been discarded. If not, the process is terminated immediately. If it has
15 been discarded, determination is made in step S 82 whether or not block $B(i,j-8)$, that is, the block above (refer to Figure 23B), is discarded. If not, the vertical coordinate minj at the upper limit within the motion vector detection range is set to $j-8$ in
20 step S 83. If yes, the value is set to j in step S 84 and control is transferred to the process in step S 85.

In step S 85, determination is made as to whether or not block $B(i,j+8)$, that is, the block below has
25 been discarded. If yes, the vertical coordinate maxj

at the lower limit within the motion vector detection range is set to $j+7$ in step S 86. If not, the value is set to $j+15$ in step S 87, and control is transferred to the process in step S 88.

5 In step S 88, determination is made as to whether or not the minimum value $\min j$ of the vertical coordinate within the detection range is equal to j , and the vertical coordinate $\max j$ at the lower limit within the range is equal to $j+7$. If yes, both the
10 blocks above and below has been discarded. Therefore, a motion vector cannot be detected, and the process is terminated with these values set to "0" in step S 89. If even one of the above described $\min j$ and $\max j$ is
15 different from the indicated value, a motion vector is detected in step S 90 with blocks having no cell-discard between the maximum and minimum values of the vertical coordinate established as one group, and then the process is terminated.

 Figure 24 is a detailed flowchart for explaining
20 the motion vector detecting process shown in Figure 23. The flowchart is similar to that shown in Figure 22 except in the domain in which a sum of absolute values of differences is obtained in step S 94 and in the expression which is different from that in S 74
25 shown in Figure 22. The first paragraph of the object

in a block S 94 corresponds to the sum of absolute values of the differences for the blocks above. The second paragraph corresponds to the sum of absolute values of the differences for the blocks below. With
5 these paragraphs, if an upper limit is smaller than a lower limit in a vertical coordinate y, the total sum in the paragraph equals "0".

Figure 25 is a configurational block diagram of the MC replacement unit shown in Figures 14 and 15.
10 The embodiment shown in Figures 21 and 22 are different from that shown in Figures 23 and 24 in the motion vector detecting system. However, they have a similar configuration of the MC replacement unit.

As described in the above described flowchart,
15 data in the blocks above and below must be received in processing a target replacement block. Thus, as shown in Figure 25, a $B(i, j-8)$ discard detector 112 detects the discard of a block above the target block according to a 2-block line delay unit 110, a $B(i, j)$
20 discard detector 113 detects the discard of the target block according to a 1-block line delay unit 111, and a $B(i, j+8)$ discard detector 114 detects the discard of a block below the target block. A motion vector 115 detects a motion vector according to the outputs from
25 these 3 discard detectors 112 - 114 and the content of

the frame memory. Using the detected motion vector, a replacement controller 116 reads data in the prevf domain in the frame memory for storing data in the preceding frame, and replaces the discarded data with them by writing the replacement data into the presf domain.

Figure 26 is a configurational block diagram for explaining the embodiment to which a part of the second principle is applied. Figure 26 corresponds to the third example of the prior art technology shown in Figure 5, and additionally contains an MC replacement unit 118 for replacing block data using a motion vector received from the sending side when cell-discard is detected.

Figure 27 is a configurational block diagram of the MC replacement unit 118 shown in Figure 26. The configuration shown in Figure 27 is the same as that shown in Figure 25 except that a 2-block line delay unit 120 and a 1-block line delay unit 121 for delaying a motion vector are added such that the motion vector can use data received from the sending side, and a motion vector detector 122 outputs the motion vector to the replacement controller 116.

The flowchart of the data replacement process performed by the replacement controller 116 is the

same as that shown in Figure 20. When block data are replaced using an average value of motion vectors for the blocks above and below the target block of the replacement, the process of obtaining an average value of motion vectors is the same as that shown in Figure 21. However, the motion vector itself should be received from the sending side. Therefore, the processed in steps S 63 and S 66 are not required. Figure 28 is a flowchart for explaining a motion vector average value calculating process.

As described above, the present invention reduces the serious deterioration of image quality caused by cell-discard by, on a sending side, performing a compulsory intra-frame encoding on the next frame after sending data having a comparatively large difference and encoded by the inter-frame encoding system, and by, on a receiving side, replacing the data in a discarded block with a motion vector after detecting it. Thus, the present invention can limit the deterioration of the image quality to a visually acceptable level, and greatly improve the quality of images processed by an image transmission system.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An image encoding and transmitting system for dividing inputted frame image data into a plurality of blocks comprising picture elements, encoding them in block units, and transmitting said encoded data in packet units, said system comprising on its sending side:

intra-frame/inter-frame determining means for receiving inputted frame data, and first difference data as the difference between inputted frame data and data obtained by multiplying the inputted frame data in the preceding frame by a constant α , and selecting and outputting either of the intra-frame data as the inputted frame data or the inter-frame data as the first difference data, and

difference collating means for receiving second difference data as the difference between said inputted frame data and the data in one frame before the present frame, and having said inter-frame/intra-frame determining means compulsorily output the intra-frame data at the data input of the next frame for the same block position when more than one piece of data in each block forming the second difference data are larger than a predetermined threshold.

2. The image encoding and transmitting system according to claim 1, wherein

said intra-frame/inter-frame determining means comprises:

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an intra-frame/inter-frame determiner,

said difference collating means comprises:

a difference collator for determining whether or not the value of one or more data in blocks involved in said second difference data is larger than a predetermined threshold, and

a one-frame delay unit for delaying said determination result by 1 frame when said difference collator determines that one or more data in said block is larger than said threshold to compulsorily output said data in said frame to said intra-frame/inter-frame determiner,

said image transmitting system further comprises on its sending side;

a discrete cosine transform unit for performing a discrete cosine transform on inputted image data,

a first subtracter for obtaining the difference between said input frame data as an output of said discrete cosine transform and data obtained by multiplying the data in the preceding frame by a leak coefficient α as said constant to output the result as said first difference data to said intra-frame/inter-frame determiner,

a quantizer for quantizing an output from said intra-frame/inter-frame determiner,

an adder for outputting the sum of an output from said quantizer and data obtained by multiplying the data in the preceding frame by a leak coefficient α when said intra-frame/inter-frame determiner outputs inter-frame data, and outputting an output from said quantizer as is when it outputs

intra-frame data,

a frame memory for storing an output from said adder,

a leak coefficient unit for multiplying an output from said frame memory by a leak coefficient α to output the result to said first subtracter and said adder, and

a second subtracter for obtaining the difference between an output of said discrete cosine transform and an output from said frame memory to output it as said second difference data to said difference collator.

3. The image encoding and transmitting system according to claim 2, wherein

said difference collator comprises:

comparators as many as the number of blocks in one frame for comparing the absolute value of said first difference data for each piece of data with a predetermined threshold, and outputting "0" when said absolute value of said first difference data is greater than said threshold and "1" when it is smaller than said threshold, and

an AND circuit for receiving an output of each of said comparators, wherein

said one-frame delay unit comprises a first-in-first-out memory for delaying by one frame an output from said AND circuit.

4. The image encoding and transmitting system according to claim 3, wherein

said intra-frame/inter-frame determiner comprises:

a first sum-of-squares unit for receiving an output from said first subtracter and calculating a sum of squares of data in each block for said first difference data,

a second sum-of-squares unit for receiving inputted frame data as an output from said discrete cosine transform unit, and calculating a sum of squares of data in each block for said input frame data,

a comparator for comparing an output from said first sum-of-squares with an output from said second sum-of-squares, and outputting "0" when said output from said first sum-of-squares is larger than said output from said second sum-of-squares, and "1" when it is smaller than said output from said second sum-of-squares,

an AND circuit for receiving an output from said comparator and an output from said first-in-first-out memory,

a first delay unit for delaying an output from said first subtracter to the time point when a comparison result is outputted by said comparator,

a second delay unit for delaying an output from said discrete cosine transform unit by the delay time of said first delay unit, and

a selector for selecting and outputting an output from said first delay unit when said AND circuit outputs "1", and an output from said second delay unit when said AND circuit outputs "0".

5. Image processing apparatus for encoding and transmitting data representing a succession of image frames, the frame image data being divided into a plurality of block units of picture elements, selectively encoded using inter-frame encoding or intra-frame encoding, and transmitted in packet units, said apparatus comprising:

an intra-frame/inter-frame determiner including:

a receiver to receive the frame image data for a current frame after the frame image data has been divided into block units and before encoding,

a first calculator to calculate first difference data as the difference between inputted frame data in each block of said current frame and data in the corresponding blocks of a preceding frame multiplied by a constant, and

a selector to selectively output either the encoded frame data as intra-frame data, or the first difference data as inter-frame data, and

a difference collator including:

a second calculator to calculate second difference data as the difference between the input data for the current frame and the data for the previous frame, and

a controller to cause said intra-frame/inter-frame determiner to compulsorily output the inter-frame data as the data for the current frame for the same block position when more than one piece of data in each block forming the second difference data are larger than a predetermined threshold.

6. The image processing apparatus of claim 5 further comprising:

a one-frame delay unit to delay by one frame the output of said difference collator.

7. The image processing apparatus of claim 5 further comprising:

a discrete cosine transform unit to perform a discrete cosine transform on inputted image data before said inputted frame image data is used by said first calculator.

8. The image processing apparatus of claim 5 wherein said one-frame delay unit comprises a first-in-first-out memory.

9. The image processing apparatus of claim 5 wherein said intra-frame/inter-frame determiner comprises:

a first sum-of-squares unit to receive an output from said first calculator and calculating a sum of squares of data in each block for said first difference data,

a second sum-of-squares unit to receive inputted frame data as an output from said discrete cosine transform unit, and to calculate a sum-of-squares of data in each block for said input frame data,

a comparator to compare an output from said first sum-of-squares with an output from said second sum-of-squares, and outputting "0" when said output from said first sum-of-squares

is larger than said output from said second sum-of squares, and "1" when it is smaller than said output from said second sum-of-squares,

an AND circuit to receive an output from said comparator and an output from said first-in-first-out memory,

a first delay unit to delay an output from said first calculator to the time point when a comparison result is outputted by said comparator,

a second delay unit to delay an output from said discrete cosine transform unit by the delay time of said first delay unit, and

a selector to select an output select and output an output from said first delay unit when said AND circuit outputs "1" and an output from said second delay unit when said AND circuit outputs "0".

10. An image processing method for encoding and transmitting data representing a succession of image frames, the frame image data being divided into a plurality of block units of picture elements, selectively encoded using an inter-frame encoding technique or an intra-frame encoding technique, and transmitted in packet units, said apparatus comprising:

receiving the frame image data for a current frame after the frame image data has been divided into block units and before encoding,

calculating first difference data as the difference between inputted frame data in each block of said current

frame and data in the corresponding blocks of a preceding frame multiplied by a constant,

selecting and outputting either the encoded frame data as intra-frame data, or the first difference data as inter-frame data,

calculating second difference data as the difference between the input data for the current frame and the data for the previous frame, and

compulsorily outputting the inter-frame data as the data for the current frame for the same block position when more than one piece of data in each block forming the second difference data are larger than a predetermined threshold.

11. The image processing method of claim 10 further comprising:

delaying the output of said difference collator by one frame.

12. The image processing method of claim 10 further comprising:

performing a discrete cosine transform on inputted image data before said inputted frame image data is used in said first difference calculating step.

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OTTAWA, CANADA

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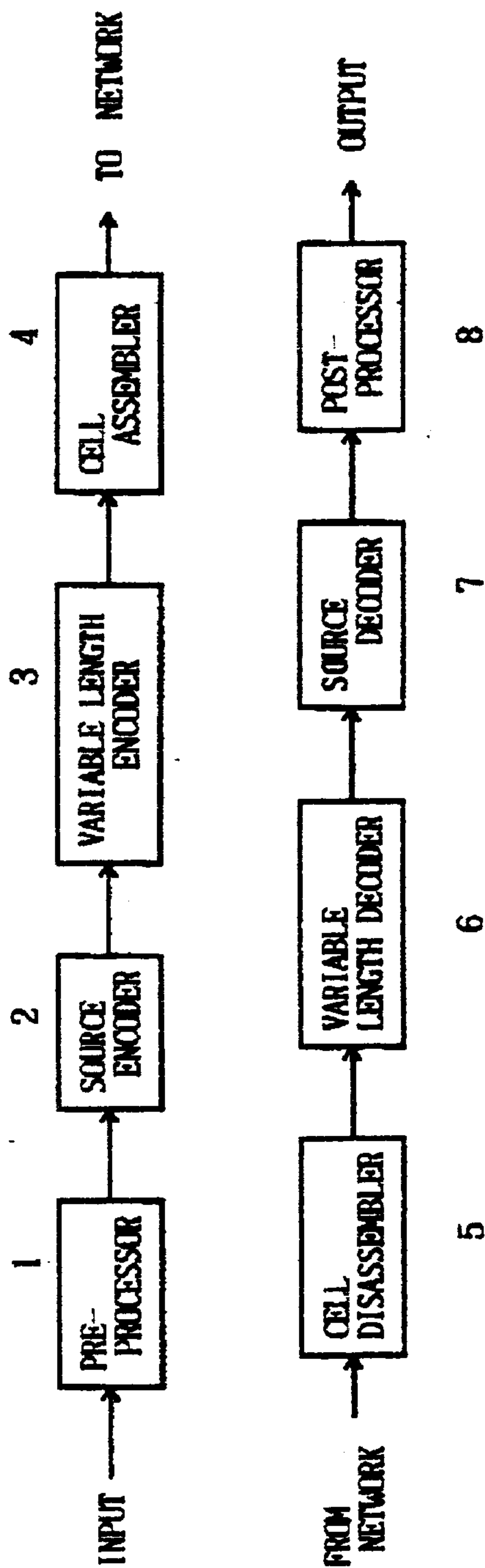


Fig. 1

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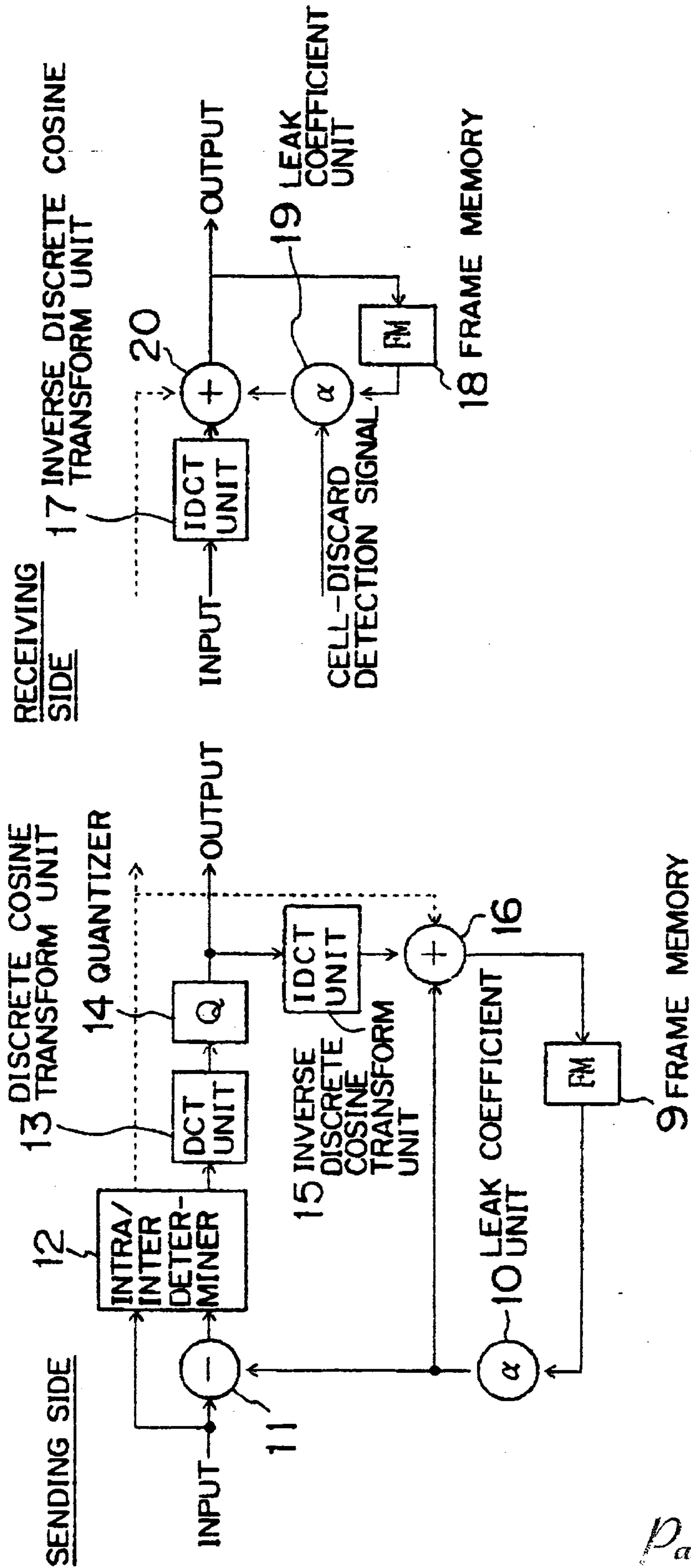


Fig. 2

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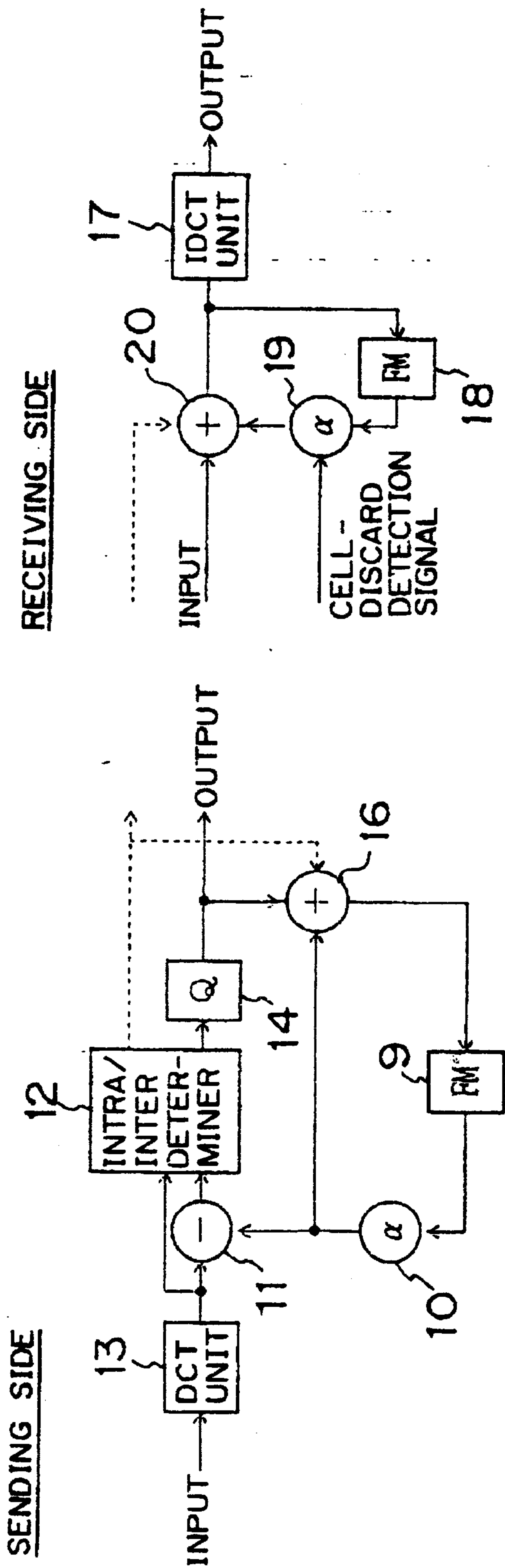


Fig. 3

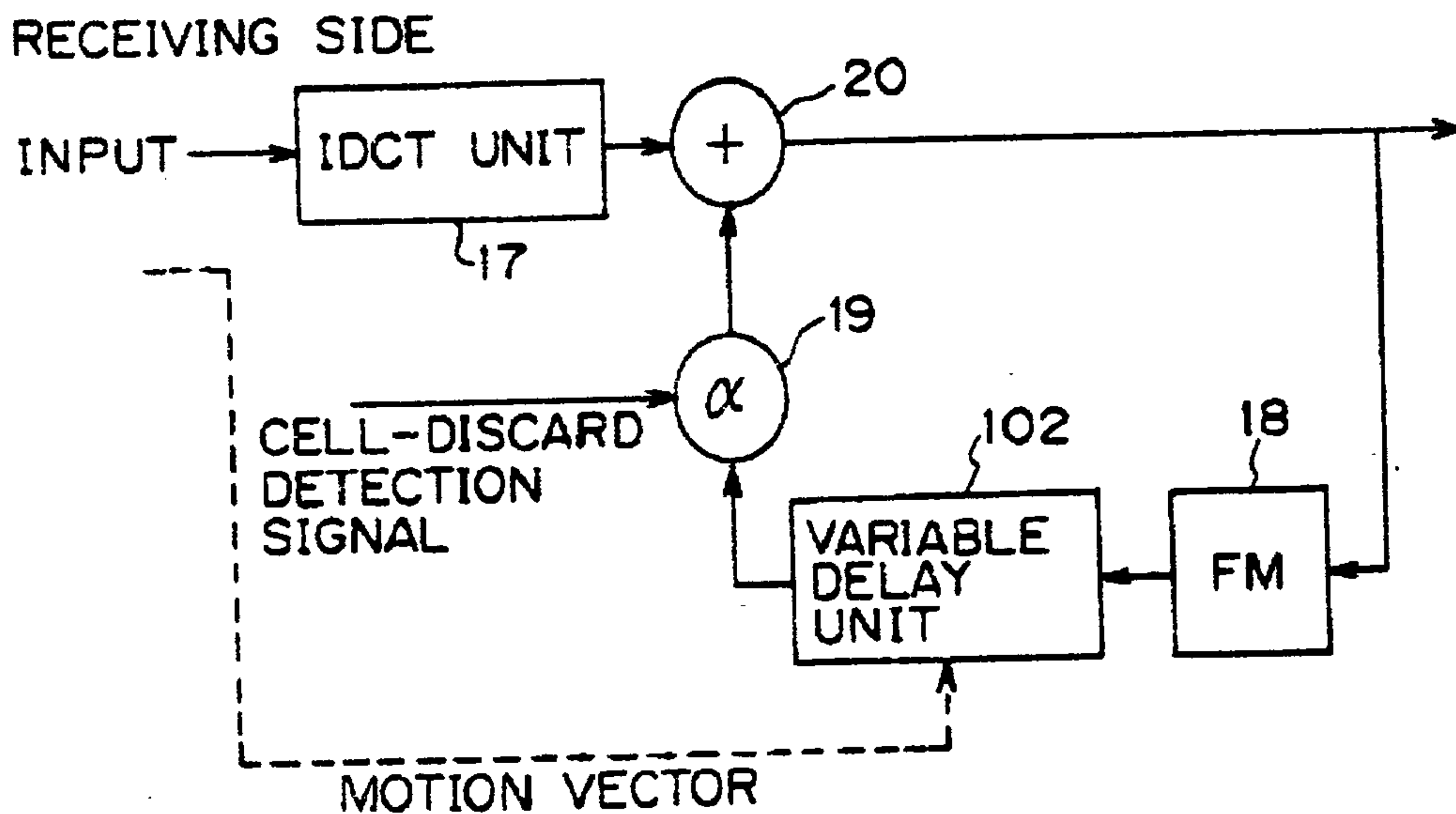
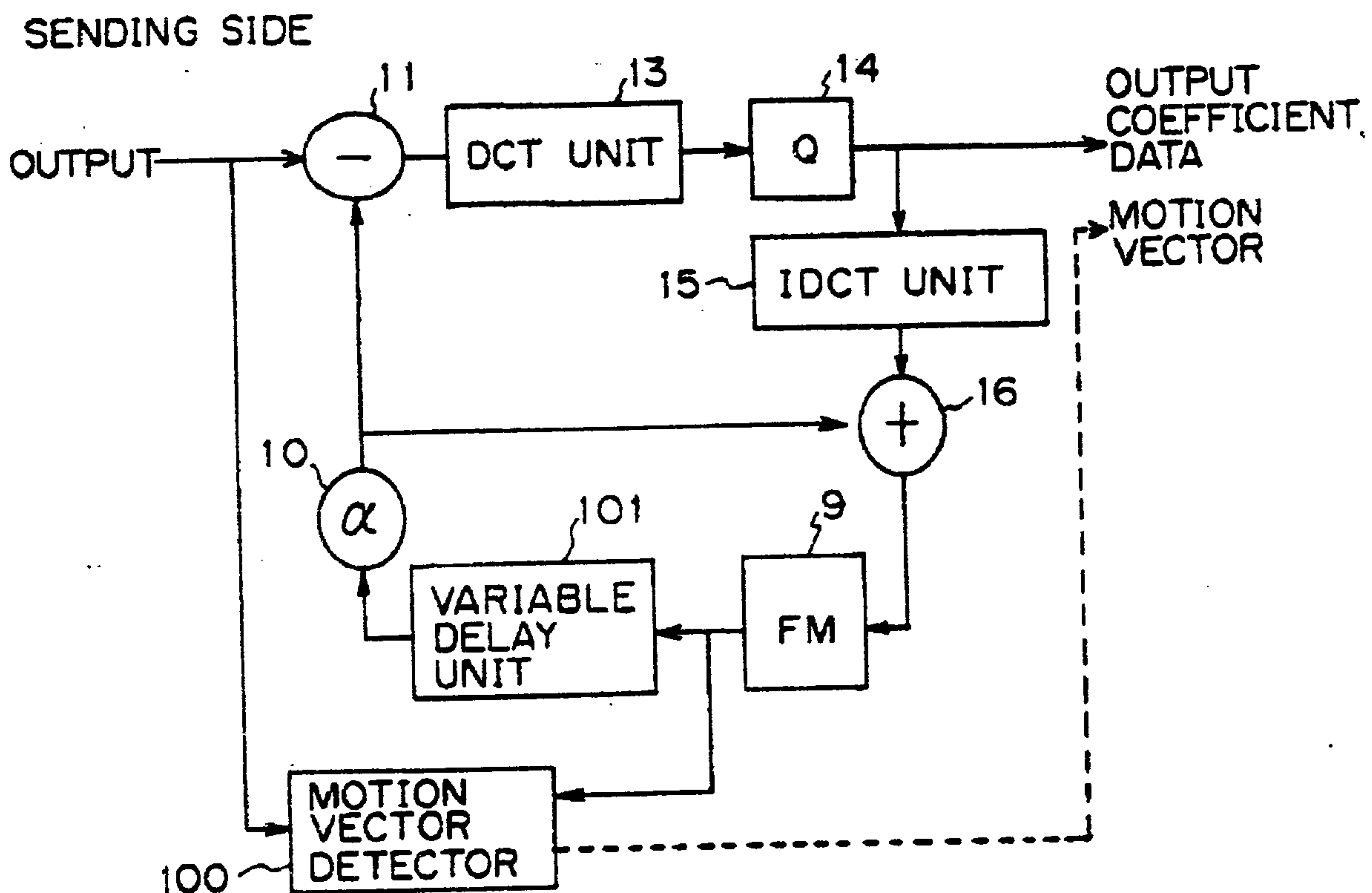
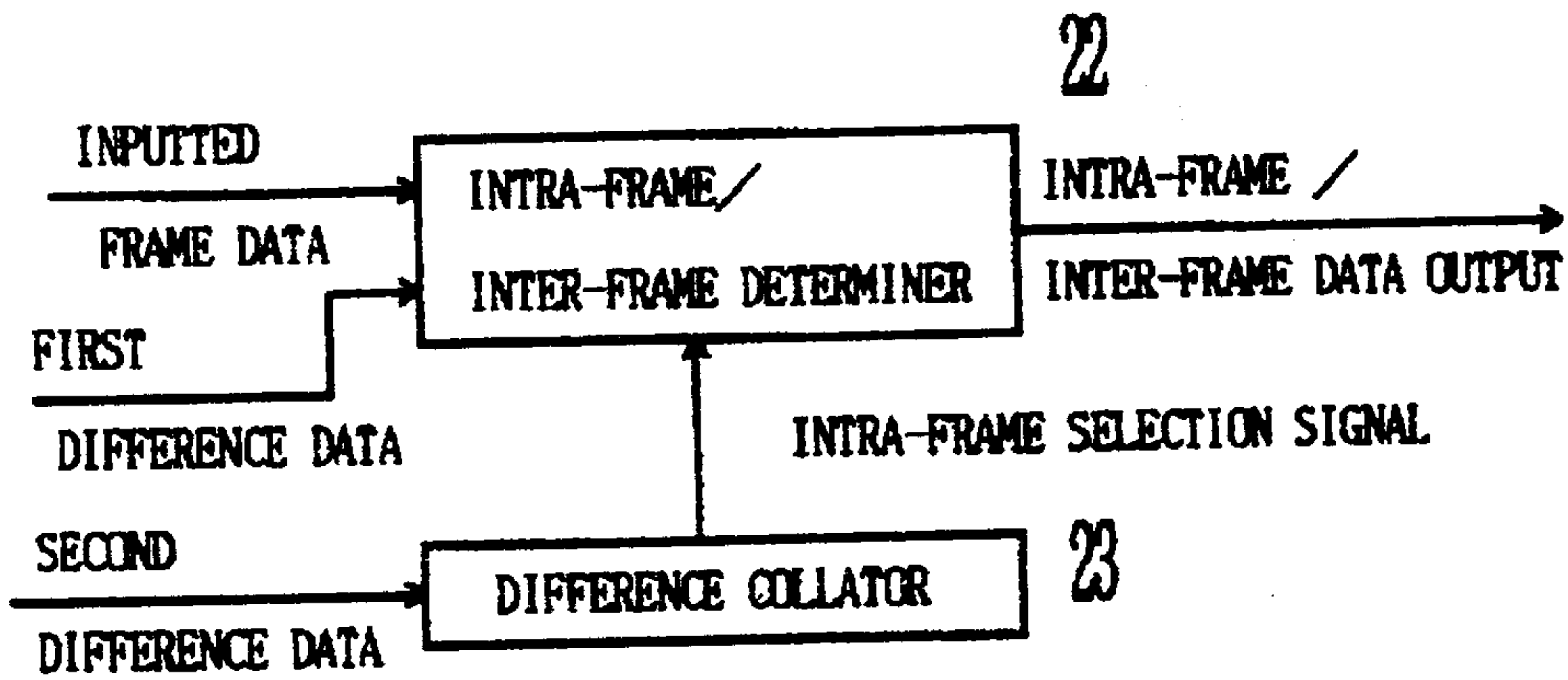
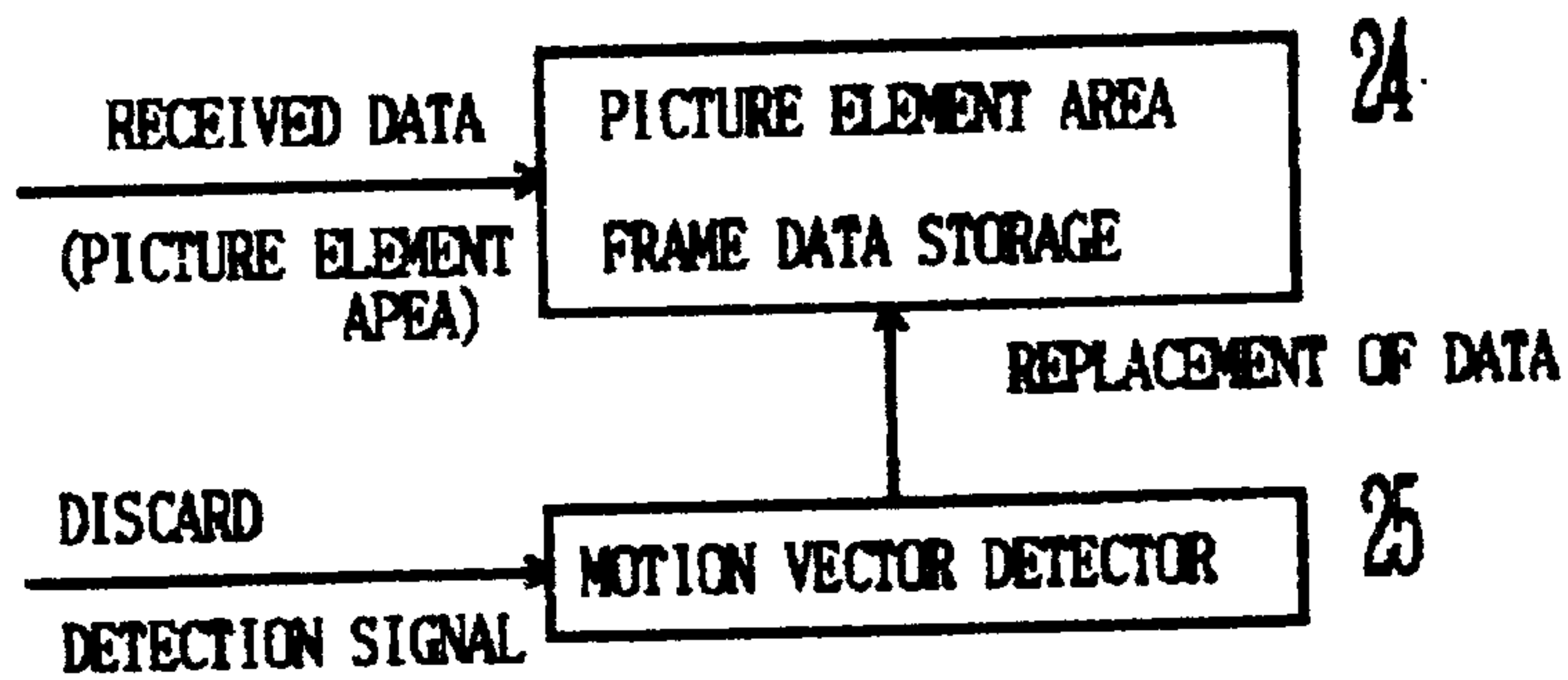


Fig. 4

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F i g . 5 A



F i g . 5 B

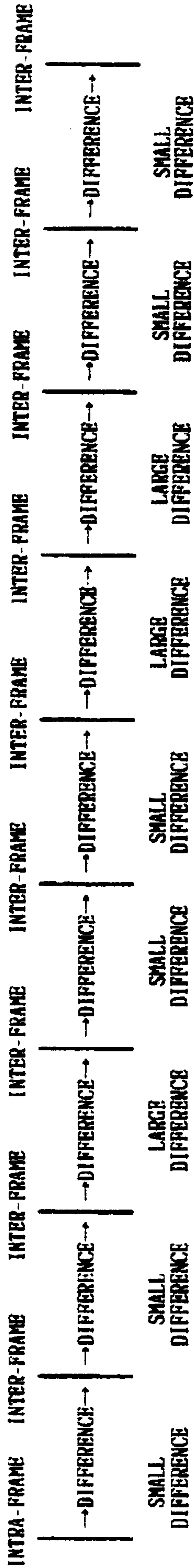


Fig. 6 A

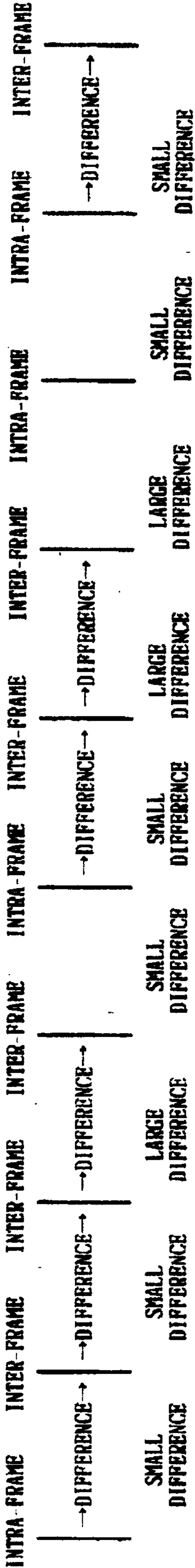


Fig. 6 B

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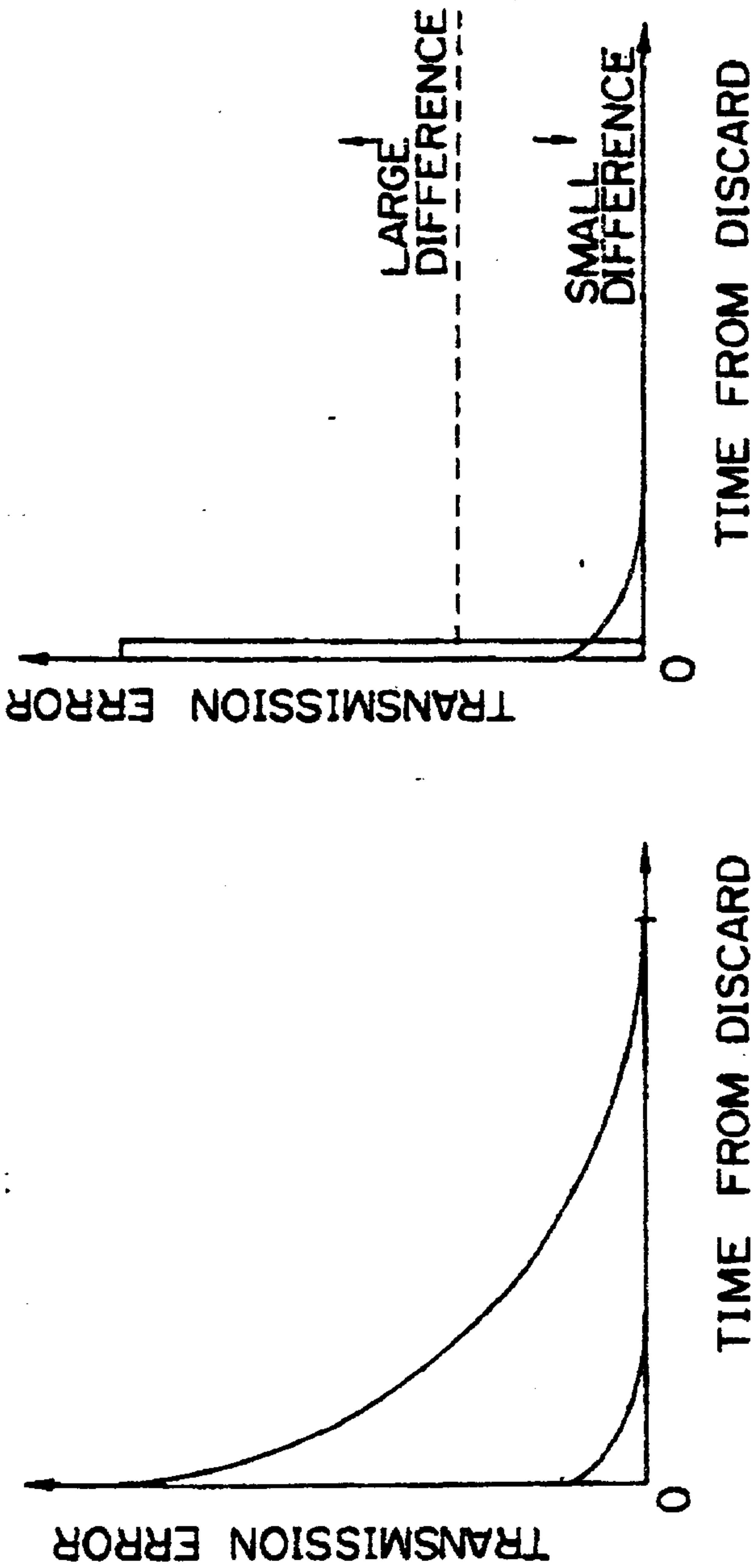


Fig. 7 B

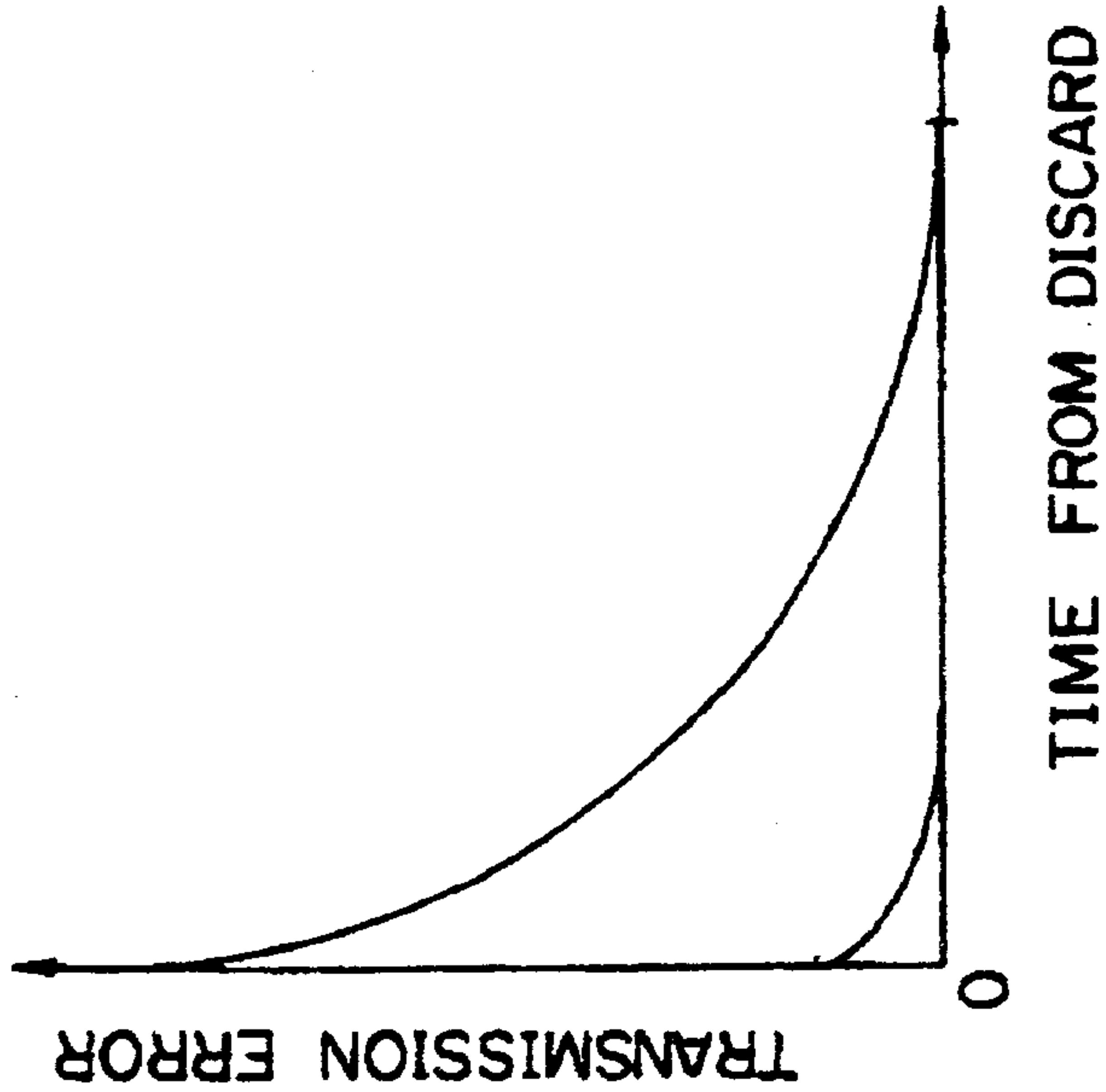


Fig. 7 A

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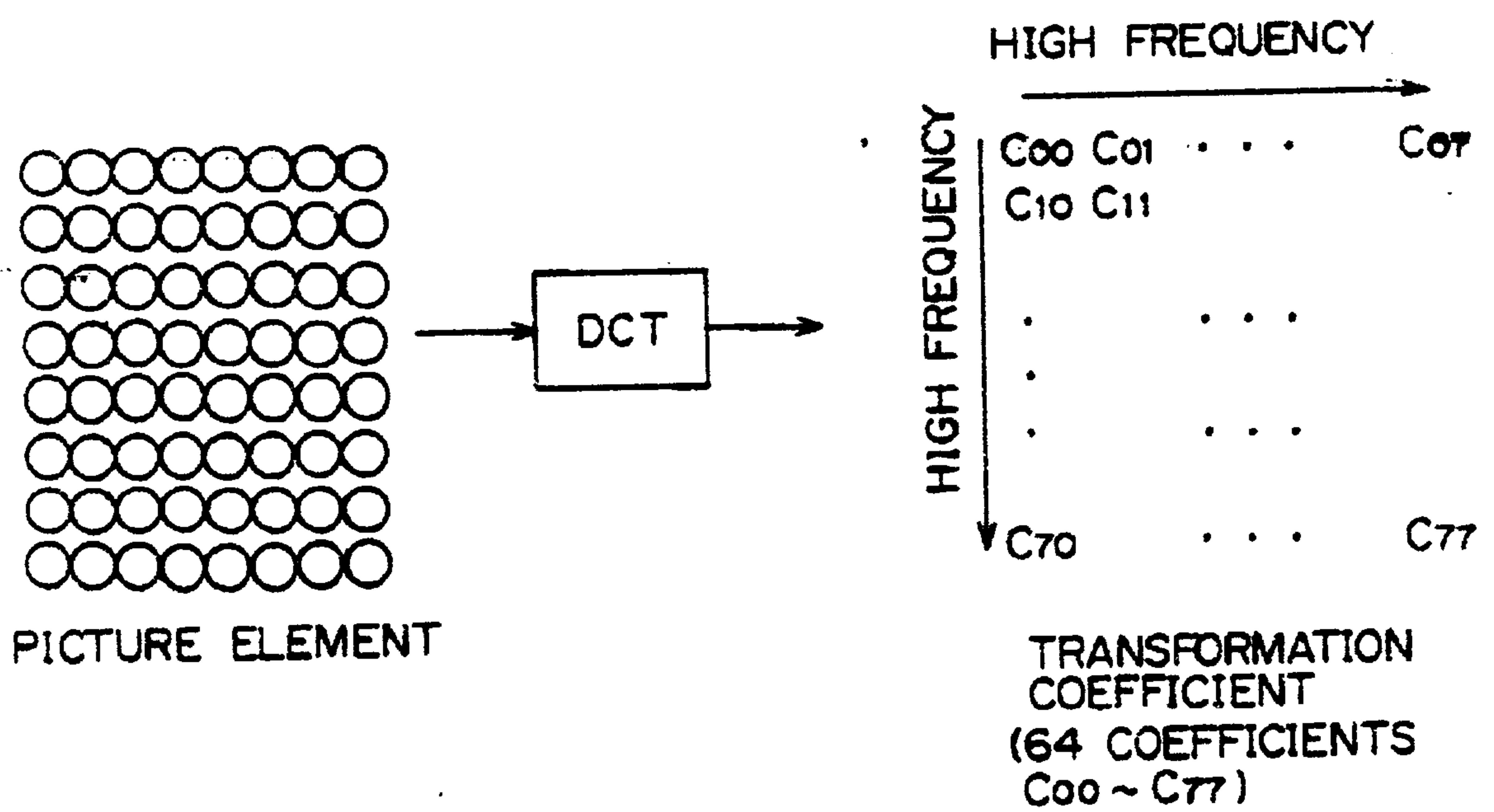
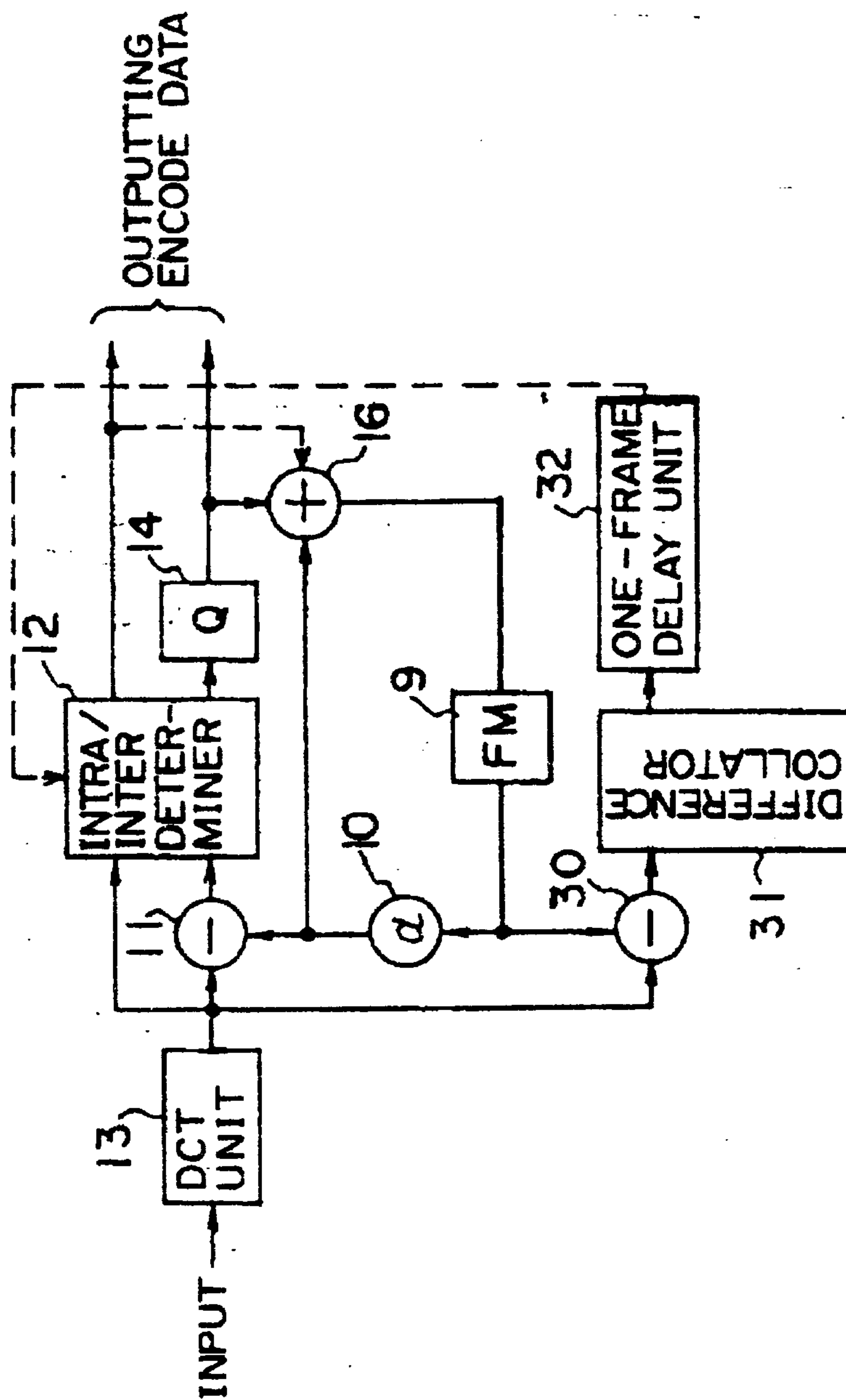


Fig. 8



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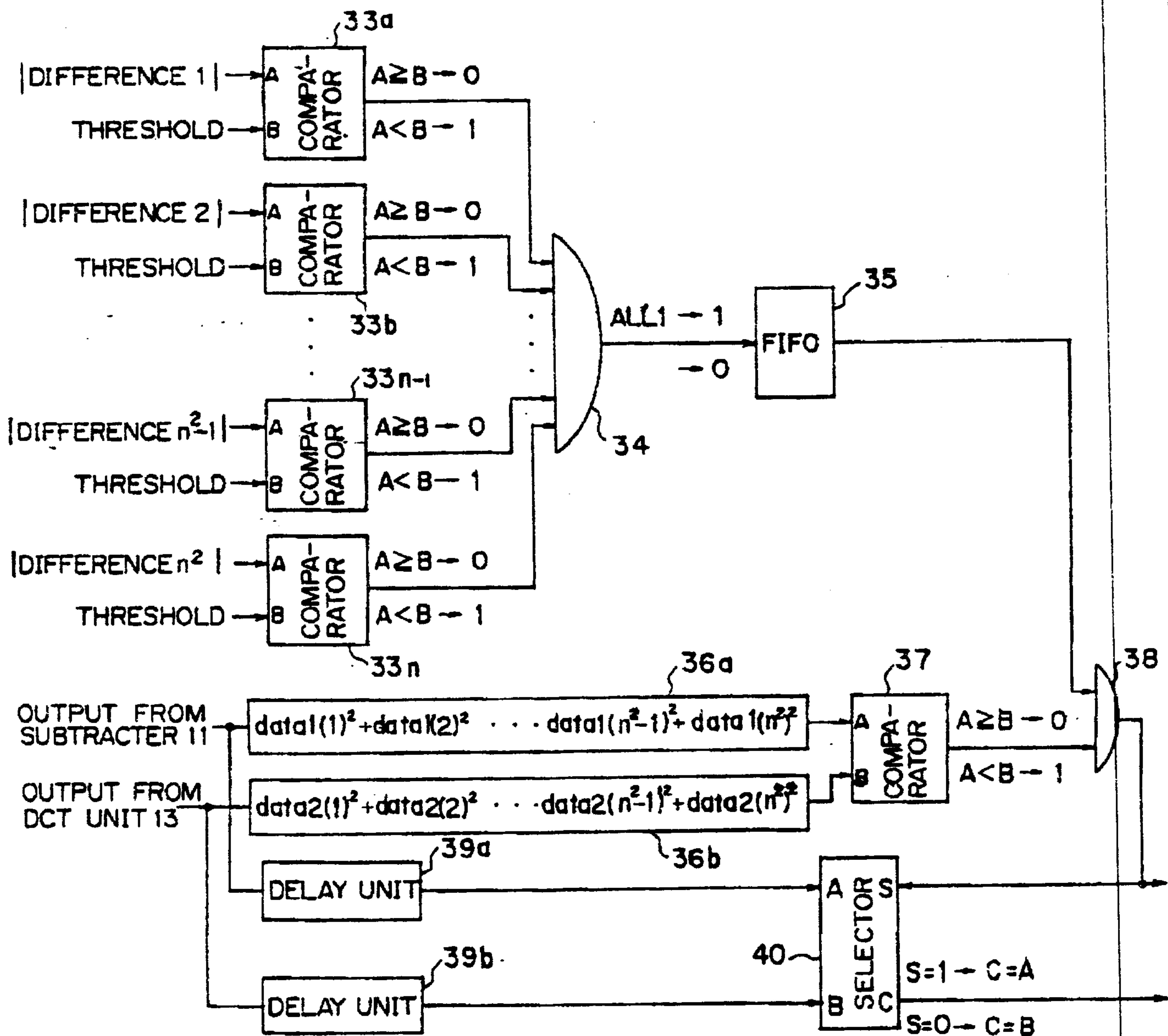


Fig. 10

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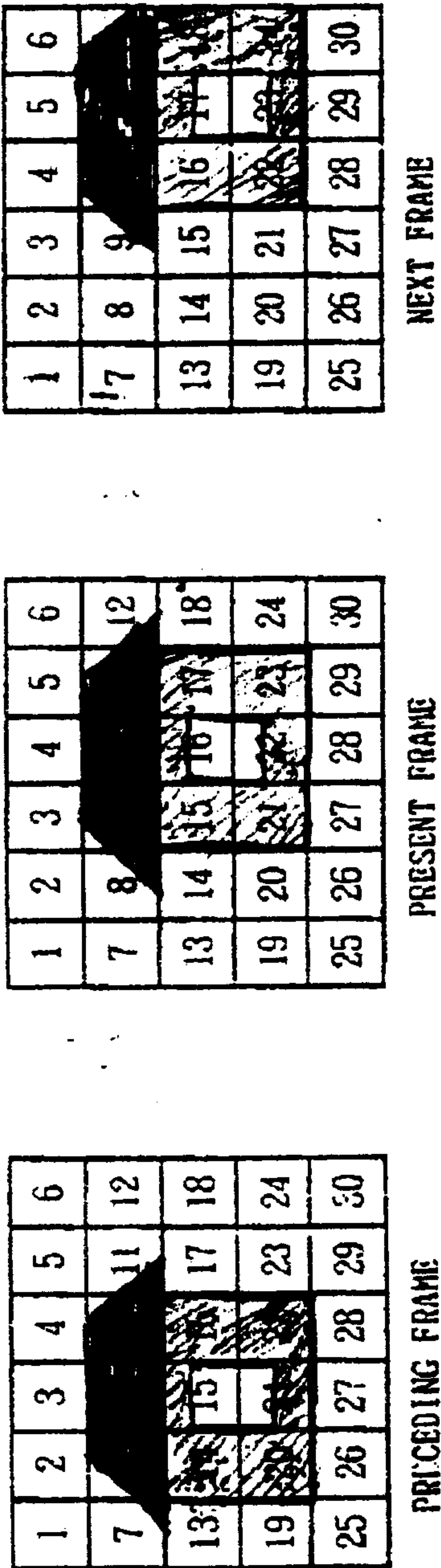


Fig. 11

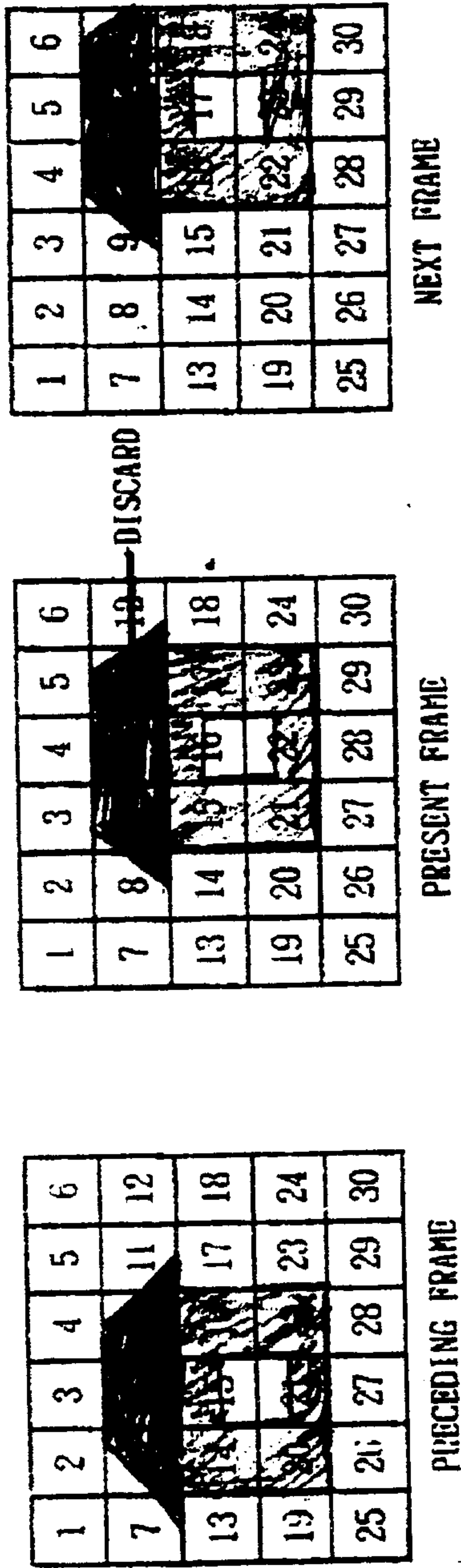


Fig. 12

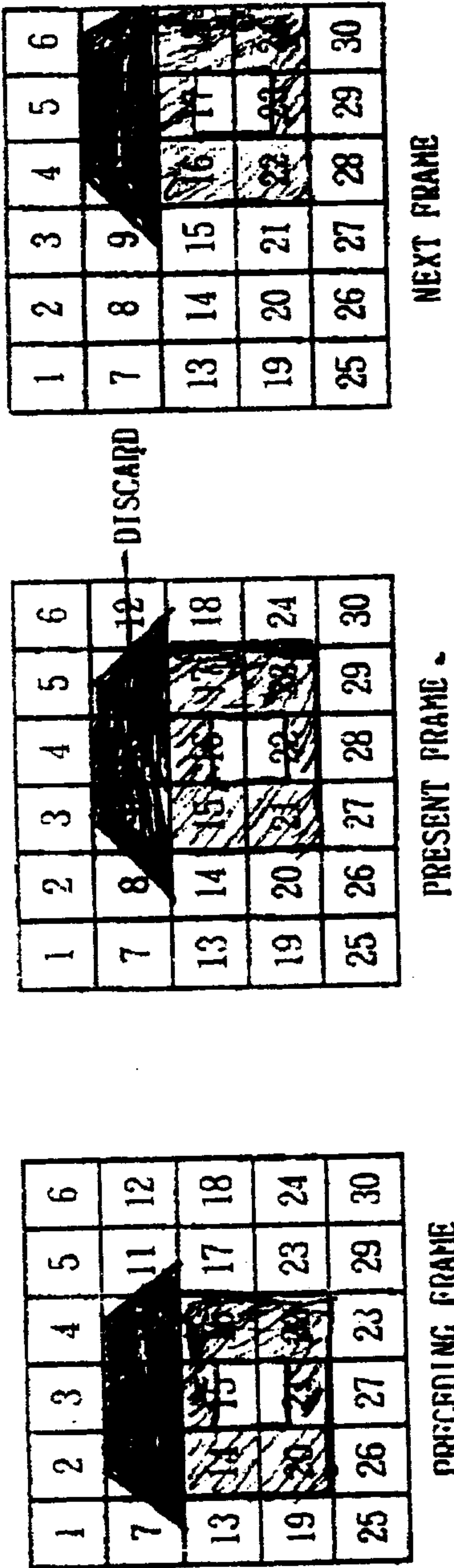


Fig. 13A



Fig. 13B

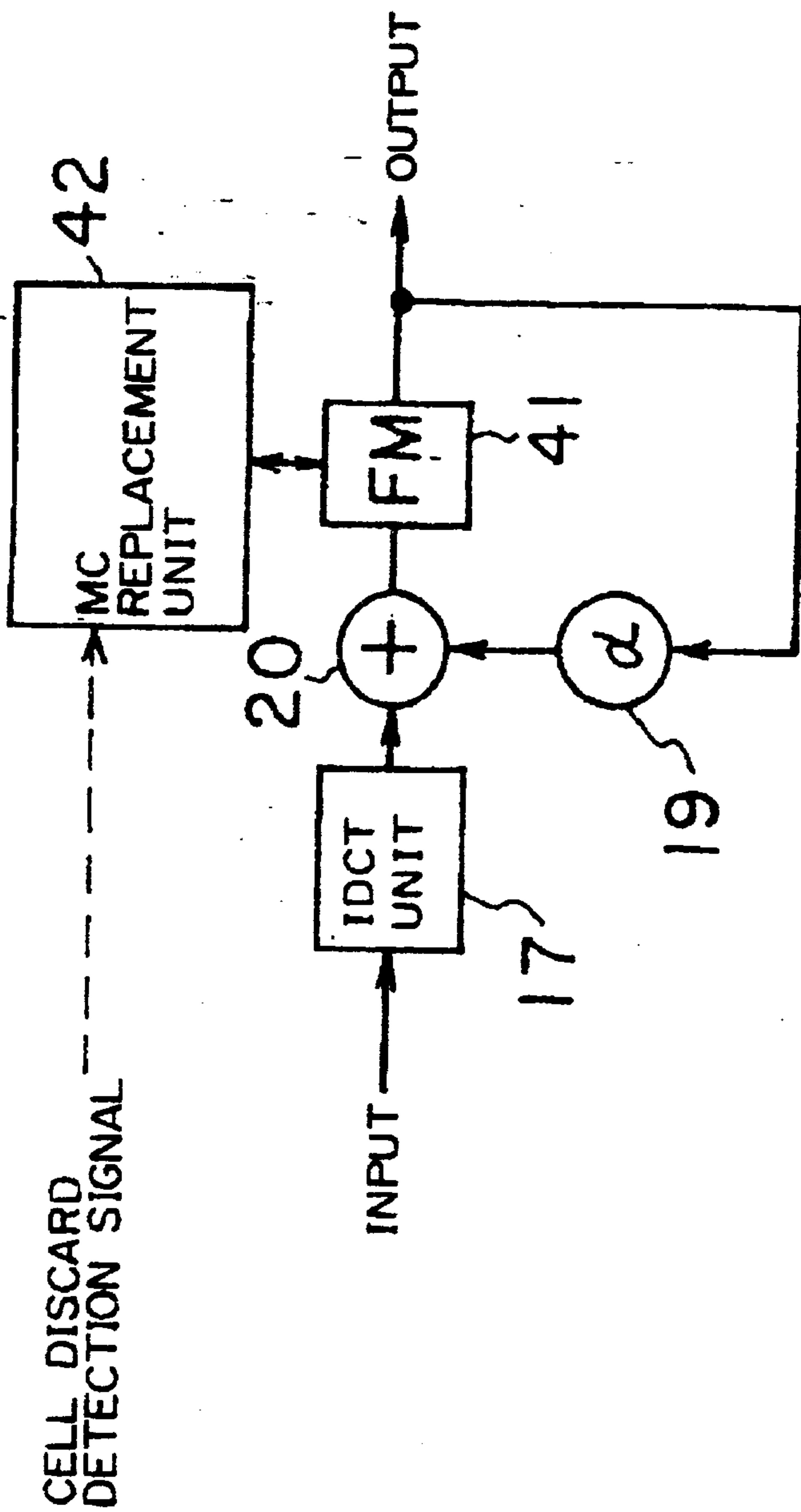


Fig. 14

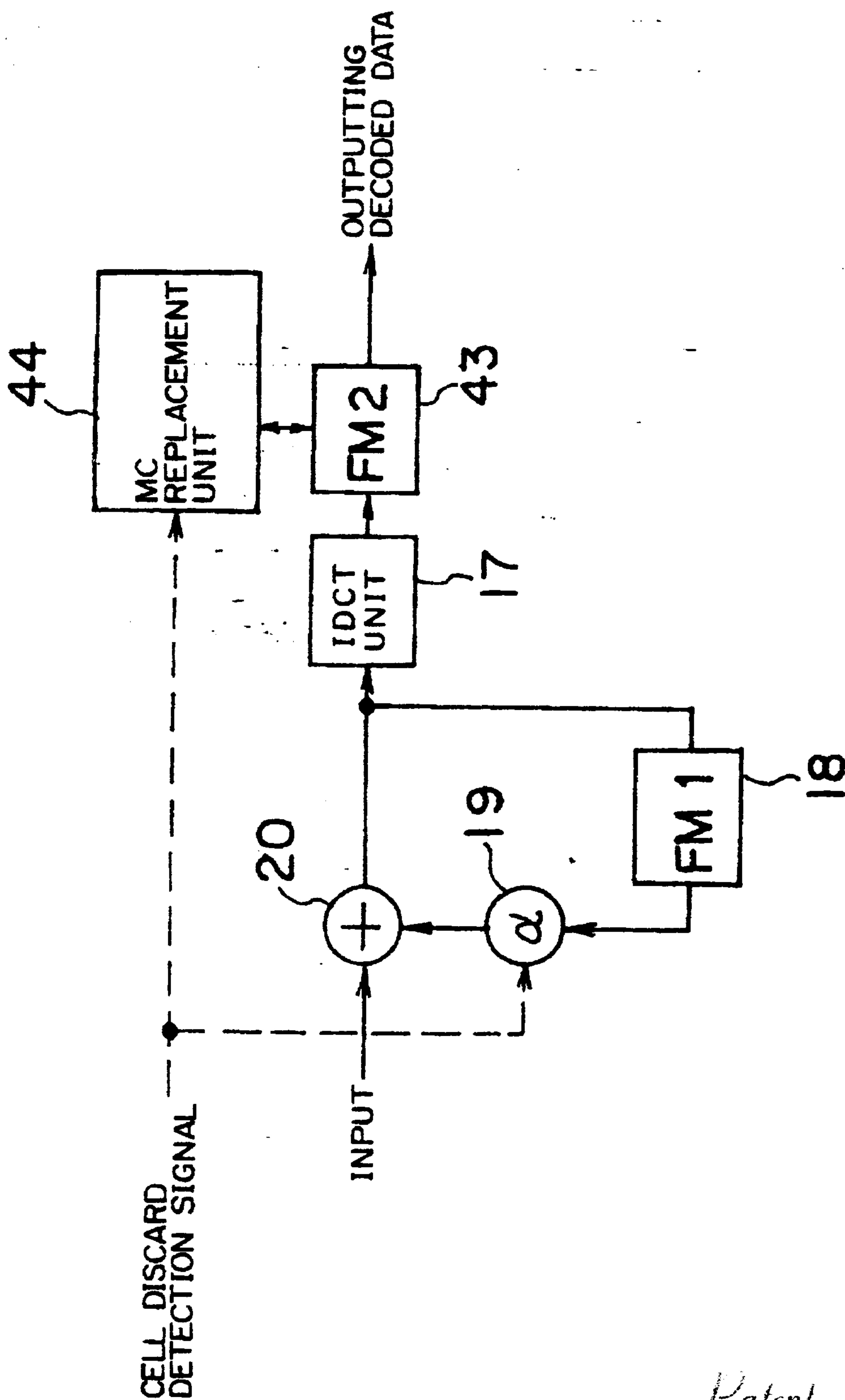


Fig. 15

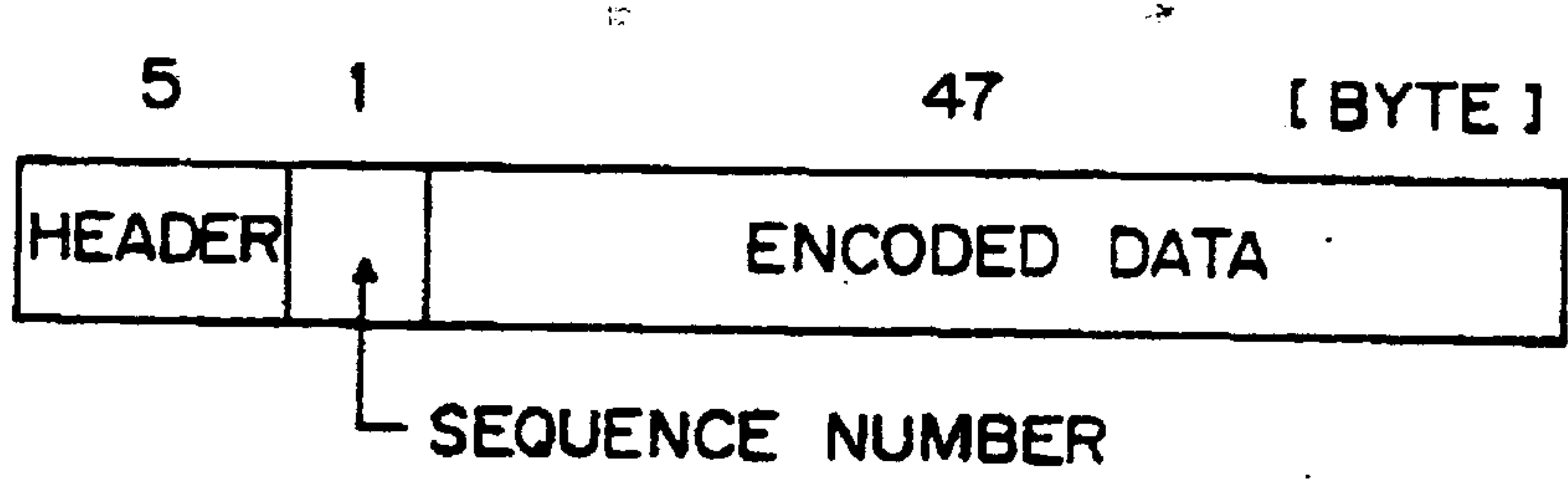


Fig. 16

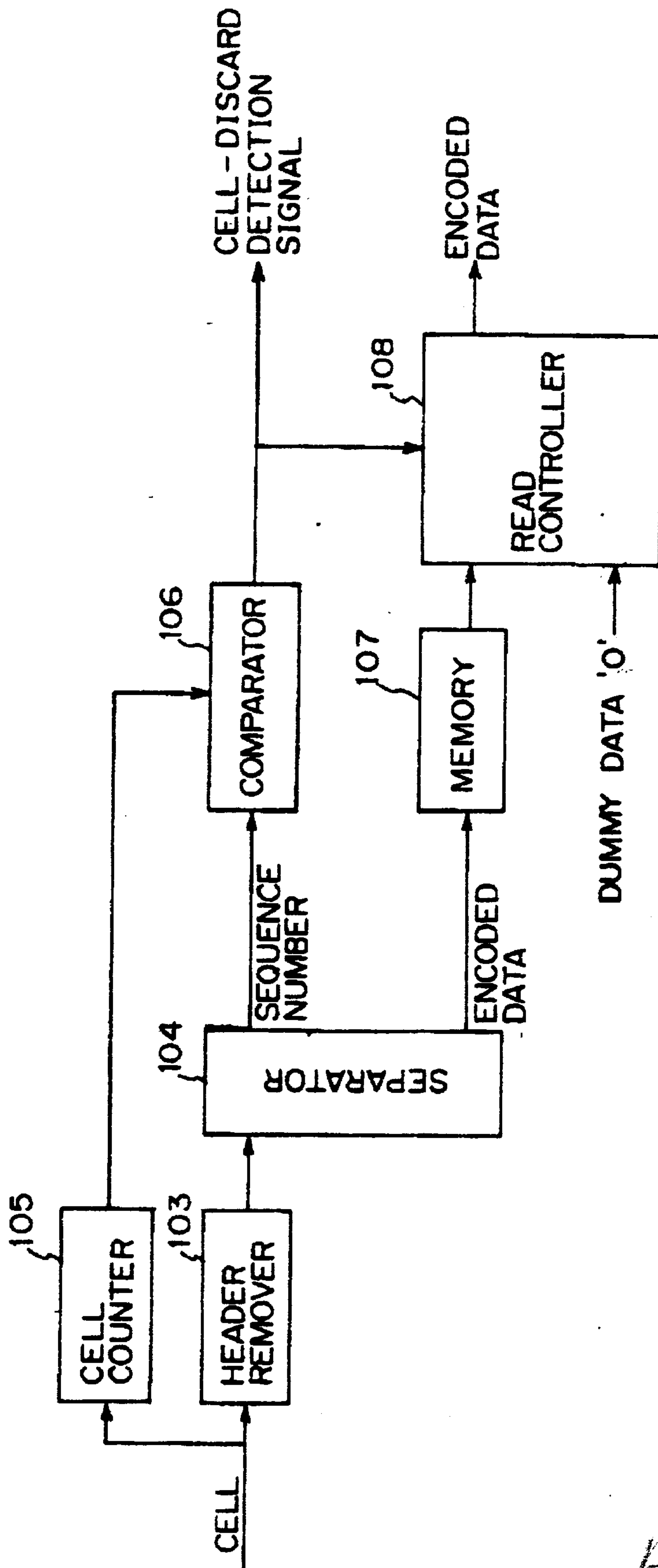


Fig. 17

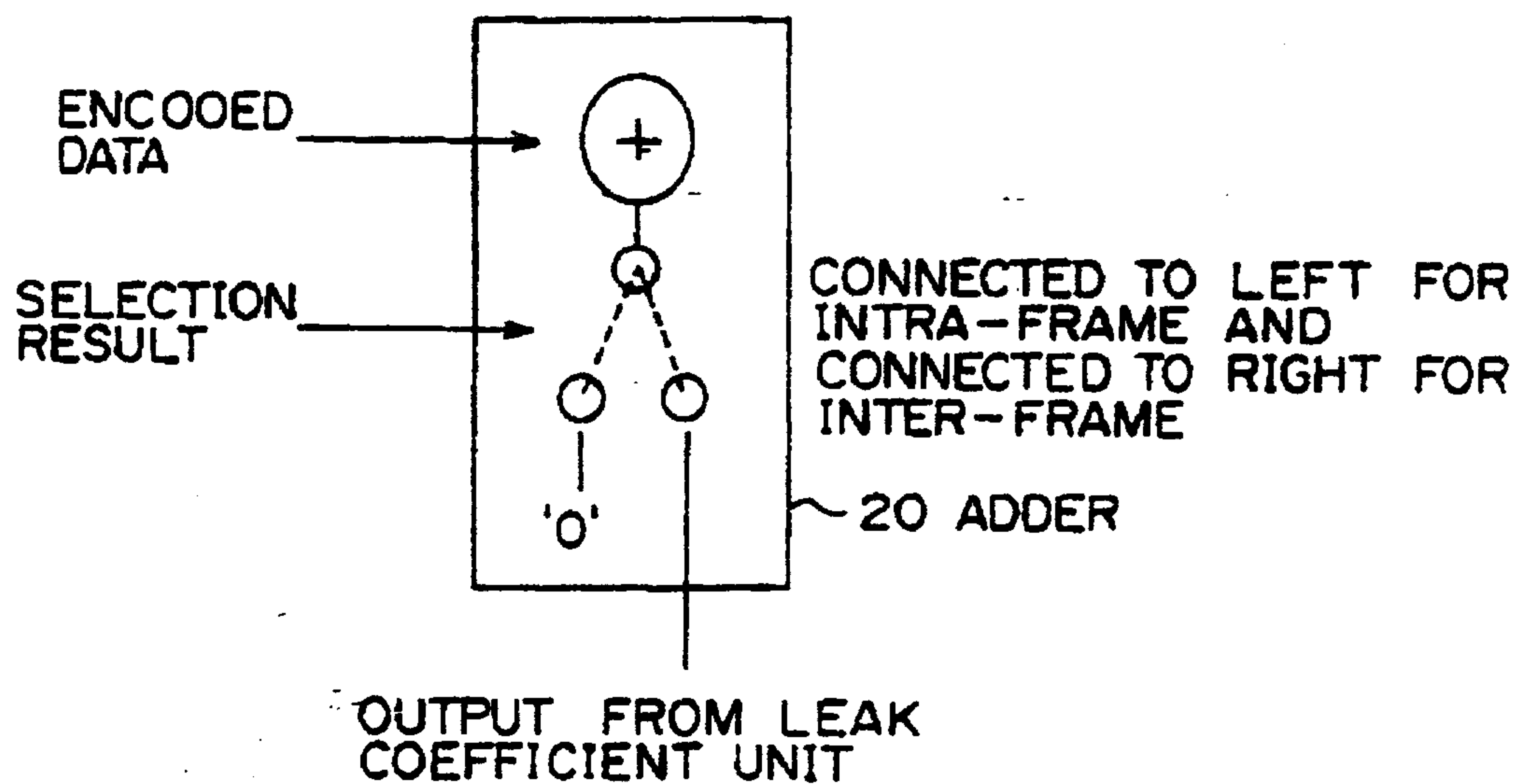


Fig. 18

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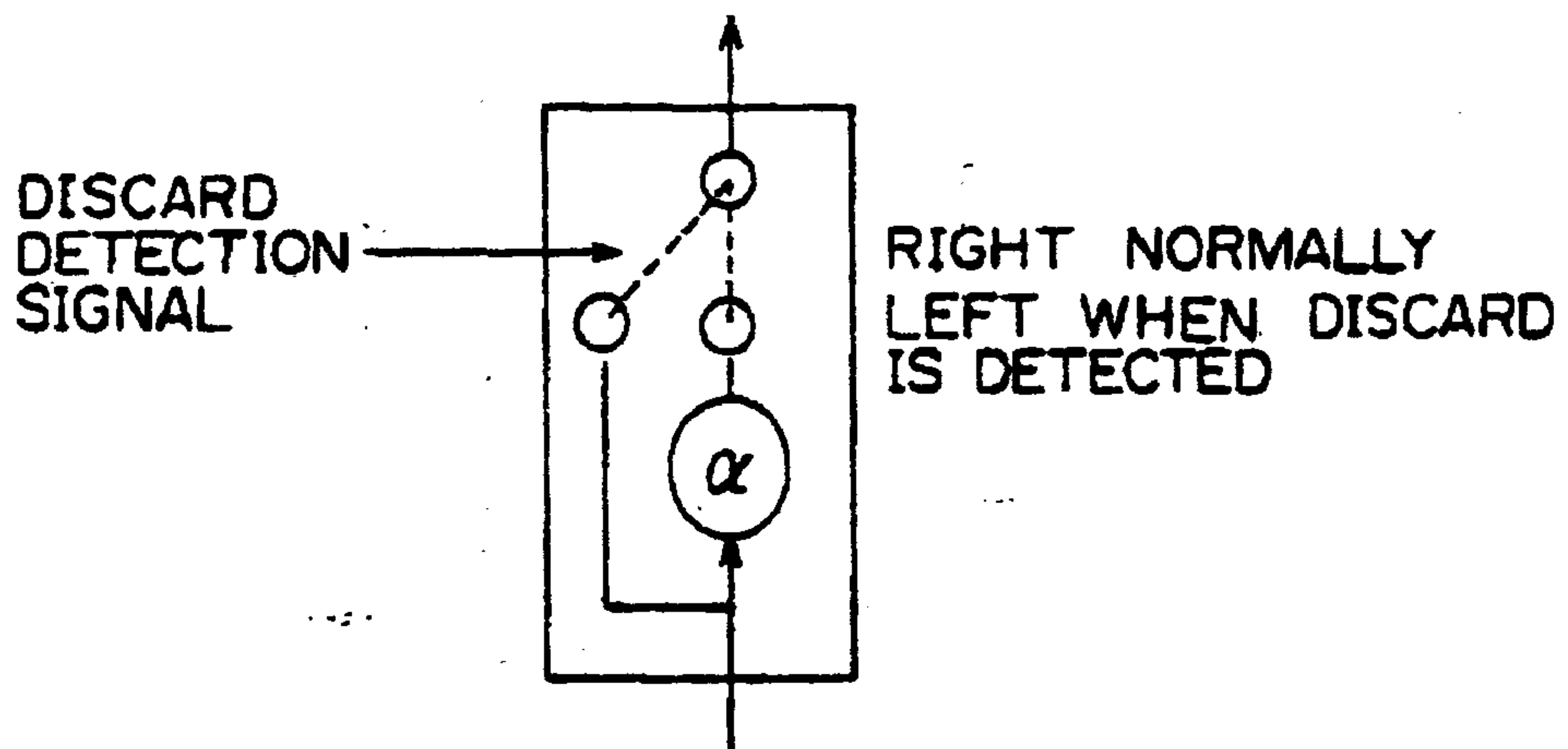
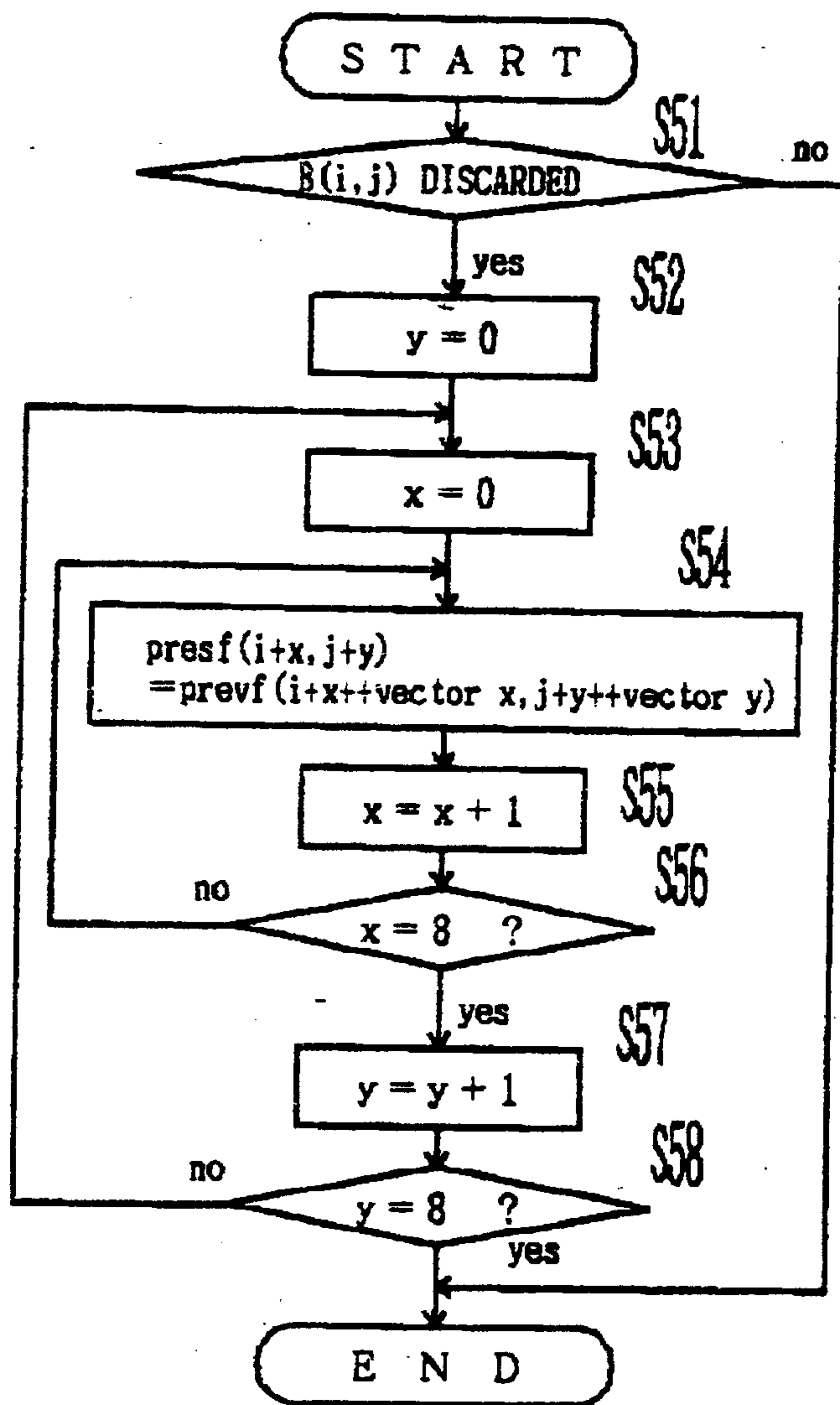
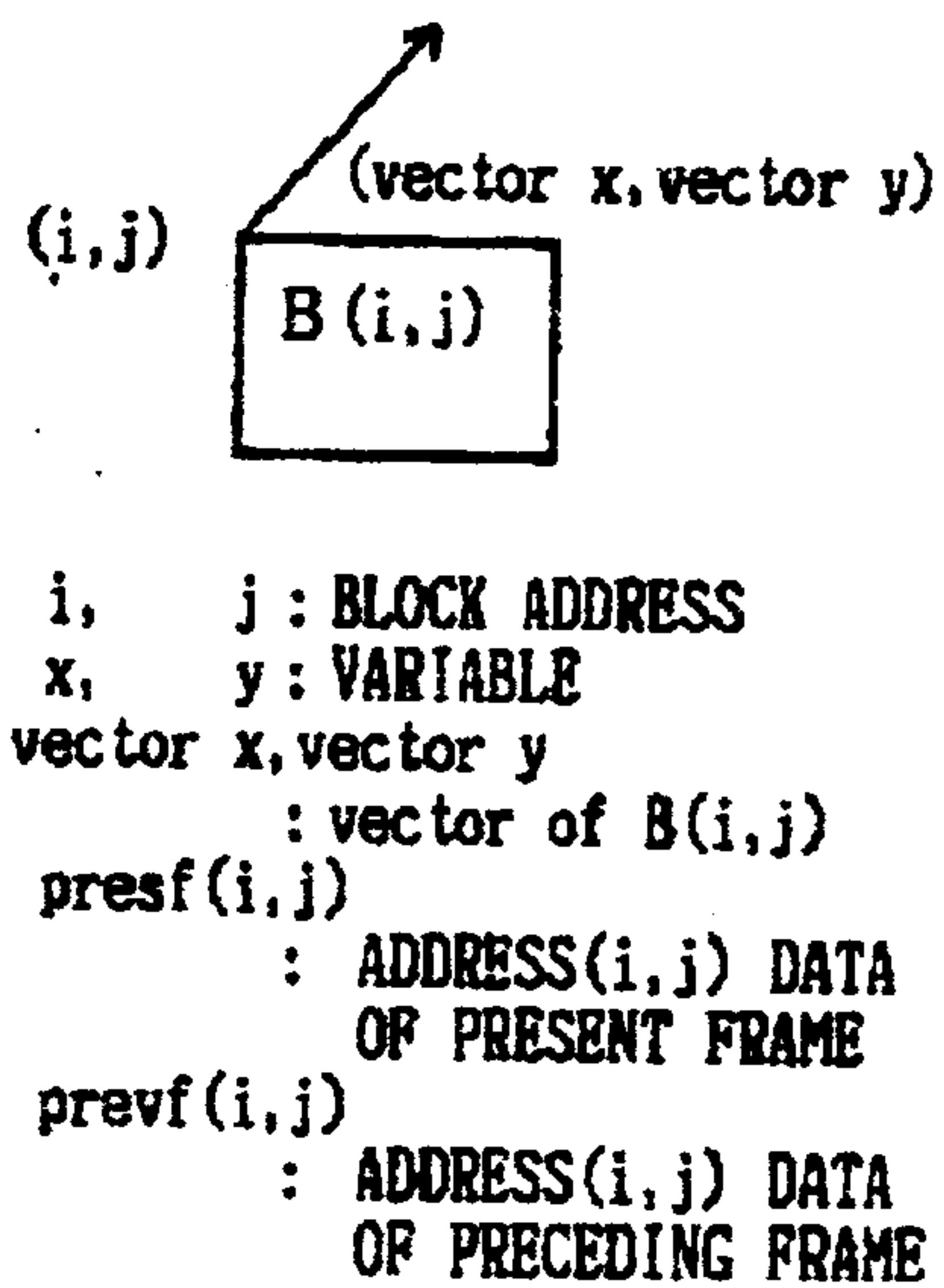


Fig. 19

Patent Att.



F i g . 2 0 A



F i g . 2 0 B

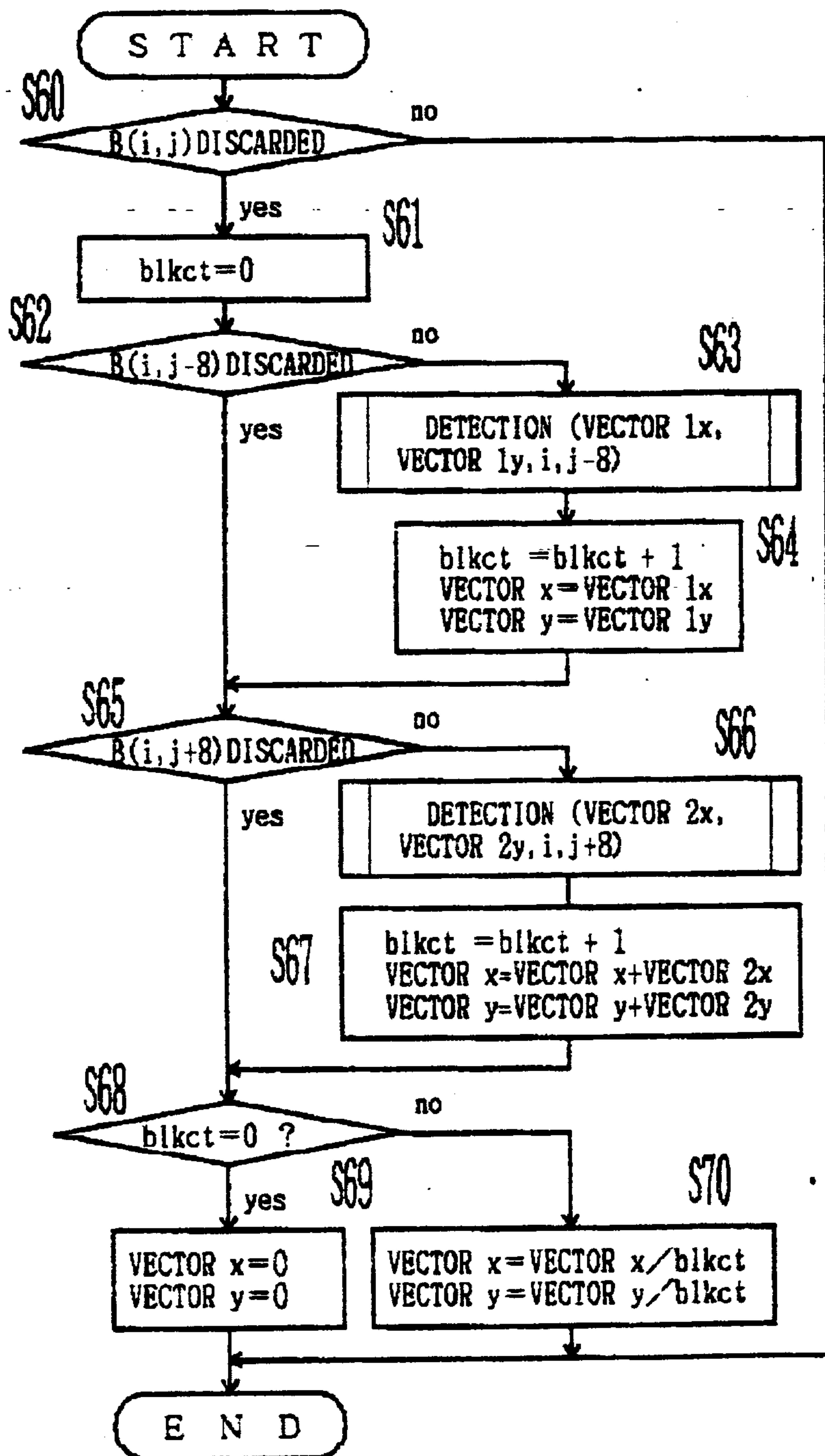


Fig. 21A

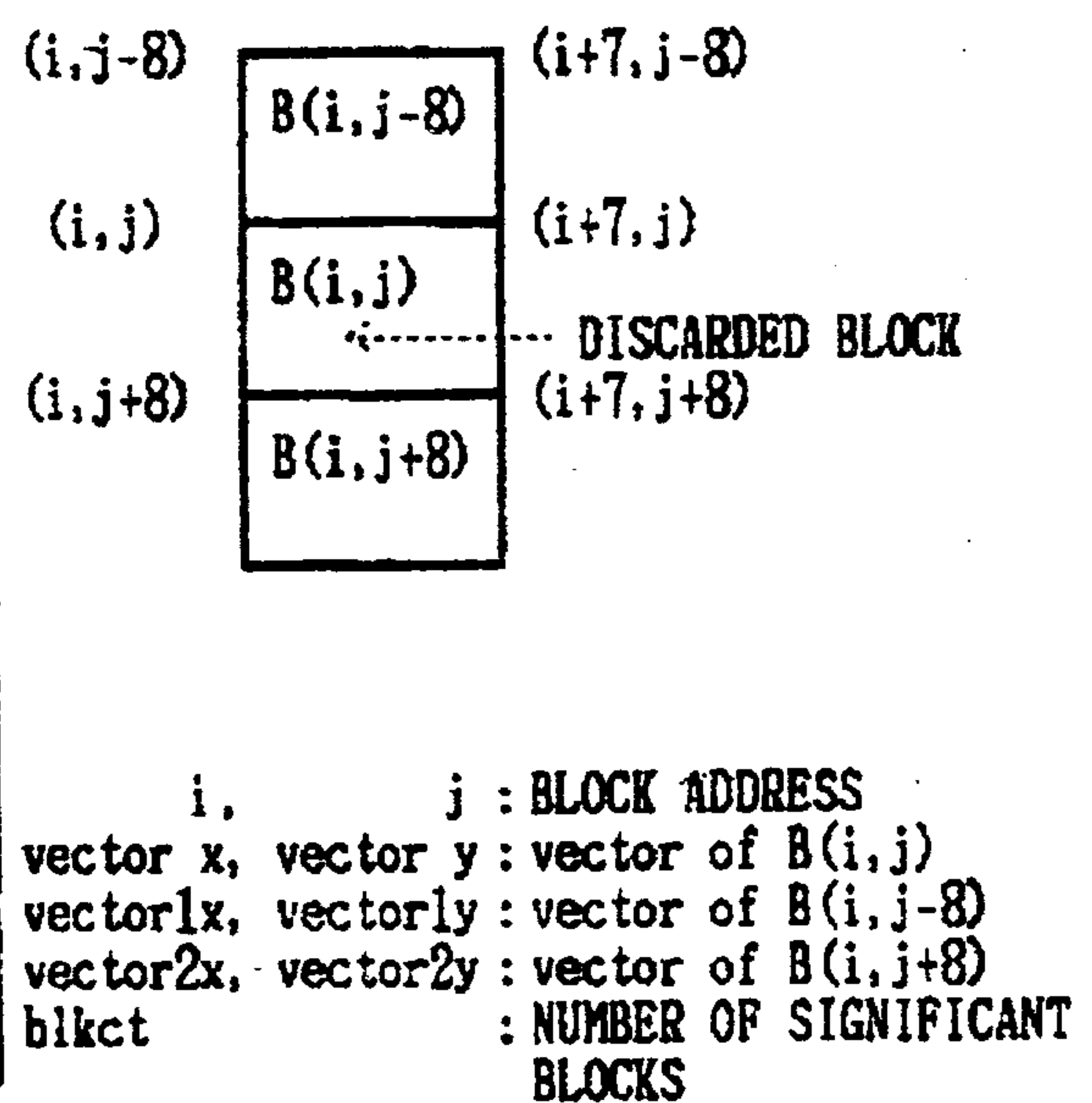
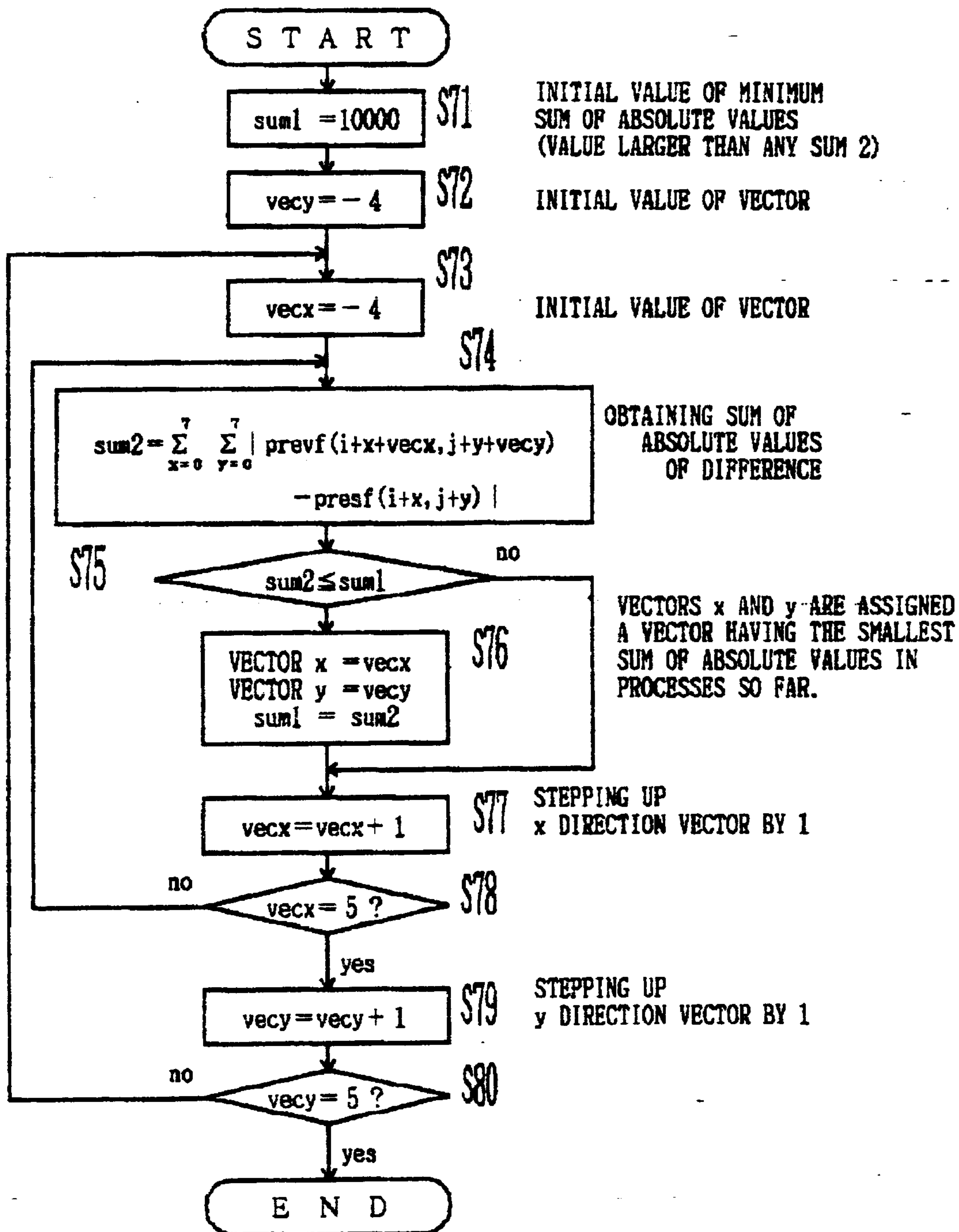


Fig. 21B



i , j : ABSOLUTE COORDINATES OF UPPER LEFT CORNER POINT OF DETECTED BLOCK
 vector x, vector y : VECTOR WITH MINIMUM SUM OF ABSOLUTE VALUES
 vecx , vecy : VECTOR
 x , y : RELATIVE COORDINATE TO UPPER LEFT CORNER POINT OF DETECTED BLOCK
 sum 1 : MINIMUM SUM OF ABSOLUTES
 sum 2 : SUM OF ABSOLUTE VALUES
 presf (i,j) : ADDRESS(i,j) DATA OF PRESENT FRAME
 prevf (i,j) : ADDRESS(i,j) DATA OF PRECEDING FRAME

F i g . 2 2

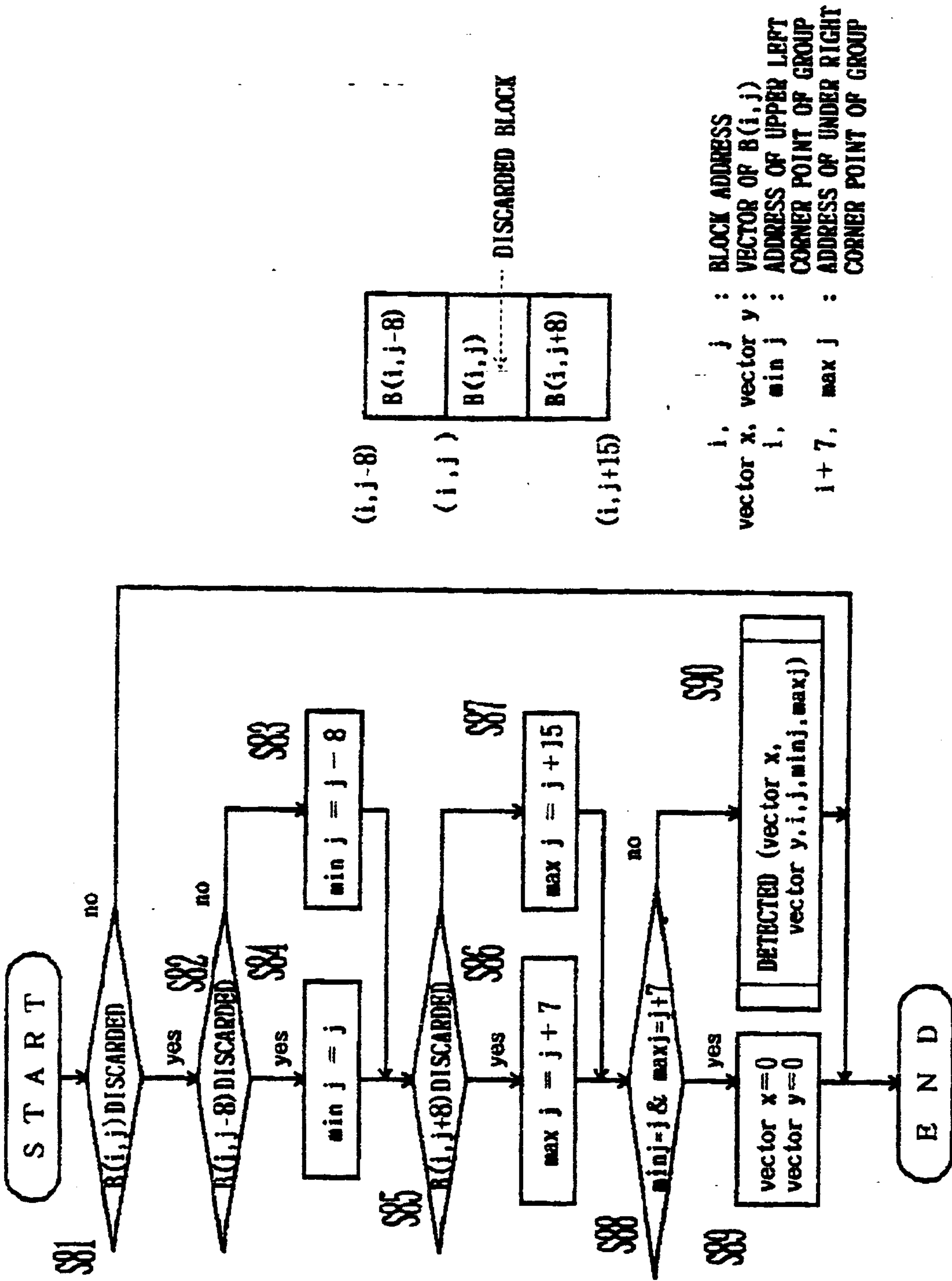
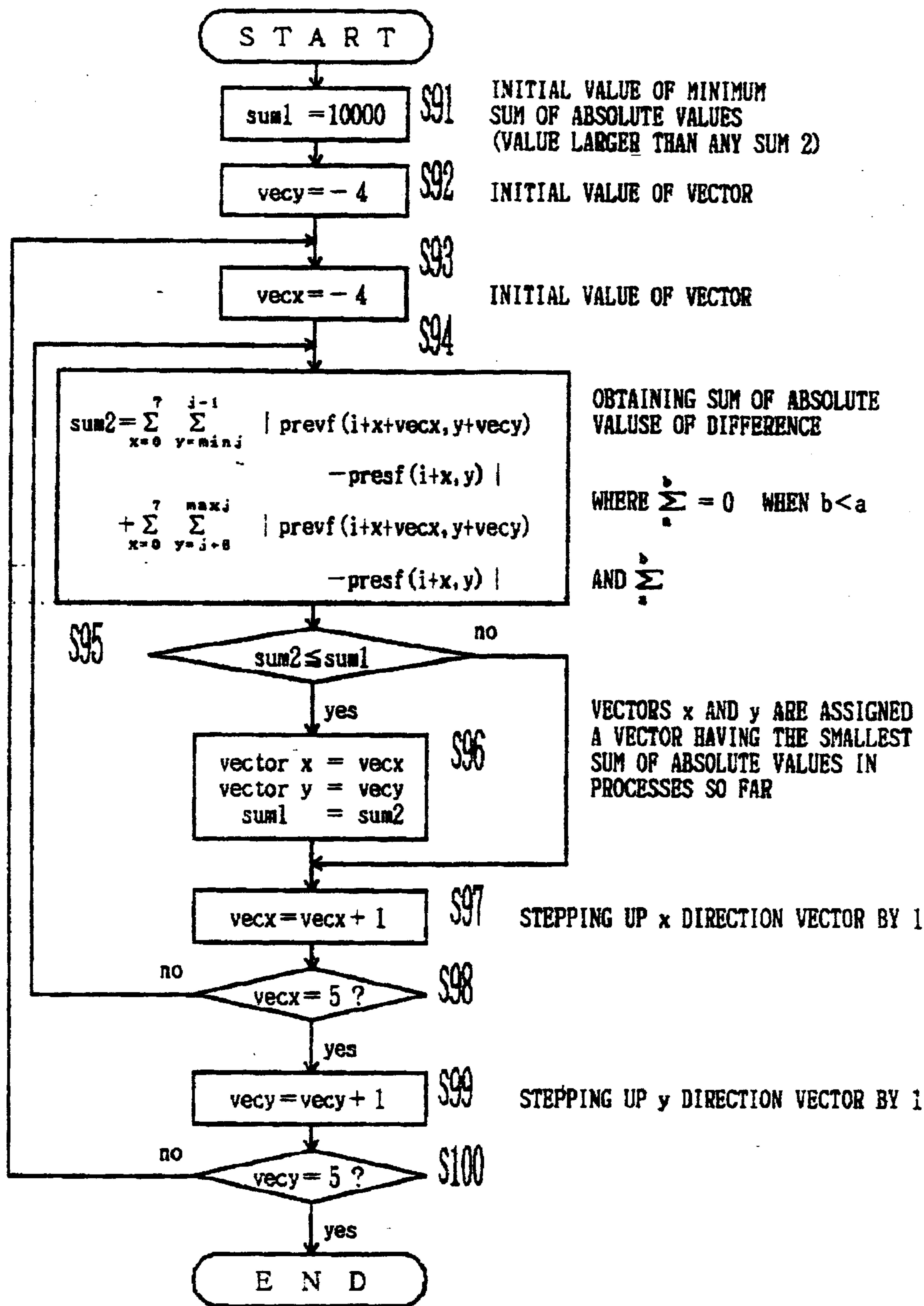


Fig. 23B

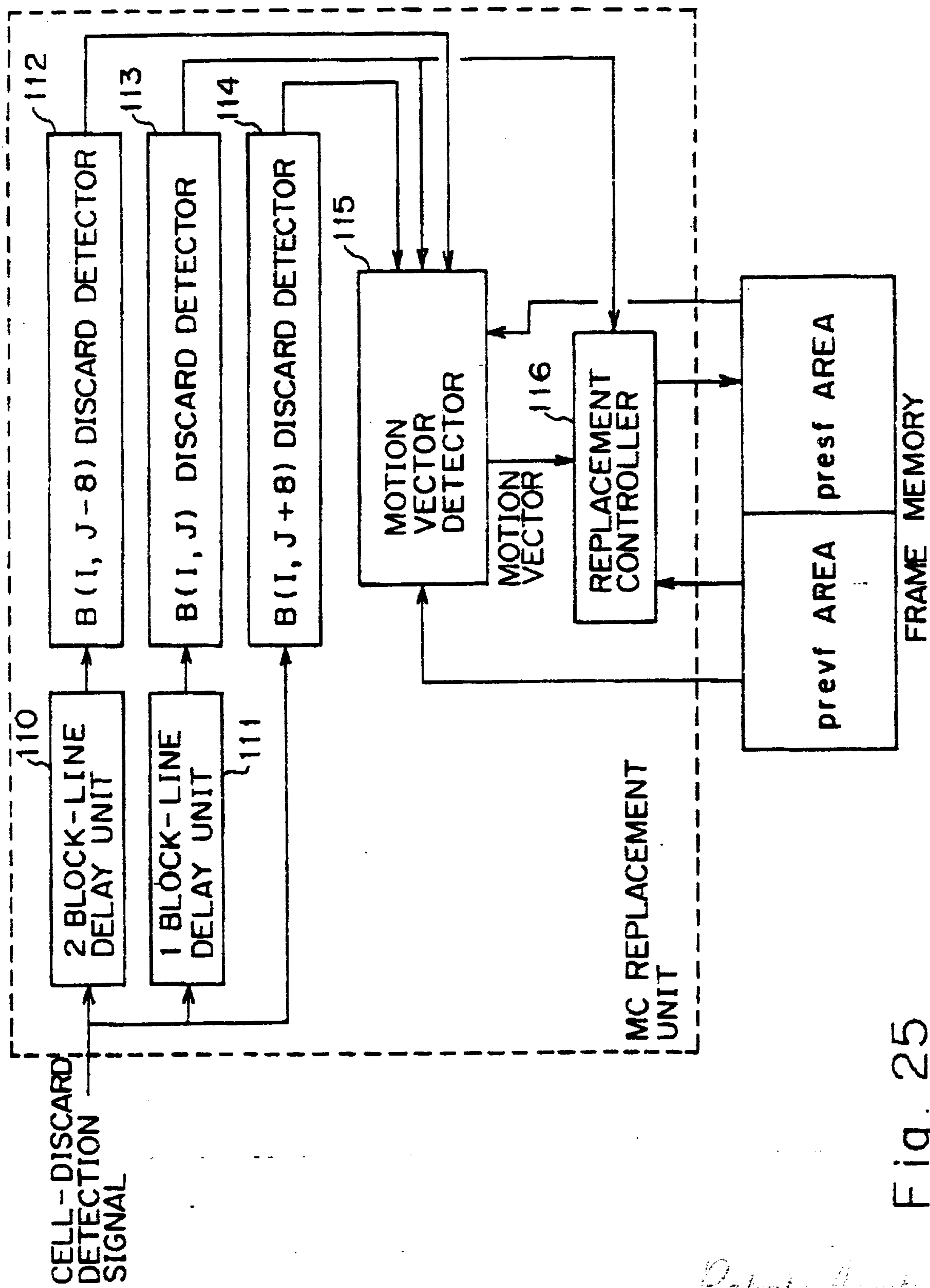
Fig. 23A



i , j : ABSOLUTE COORDINATES OF UPPER LEFT CORNER POINT OF DETECTED BLOCK
 vector x, vector y : VECTOR WITH MINIMUM SUM OF ABSOLUTE VALUES
 vecx , vecy : VECTOR
 x , y : RELATIVE COORDINATE TO UPPER LEFT CORNER POINT OF DETECTED BLOCK
 sum 1 : MINIMUM SUM OF ABSOLUTES
 sum 2 : SUM OF ABSOLUTE VALUES
 presf (i, j) : ADDRESS(i, j) DATA OF PRESENT FRAME
 prevf (i, j) : ADDRESS(i, j) DATA OF PRECEDING FRAME

Fig. 24

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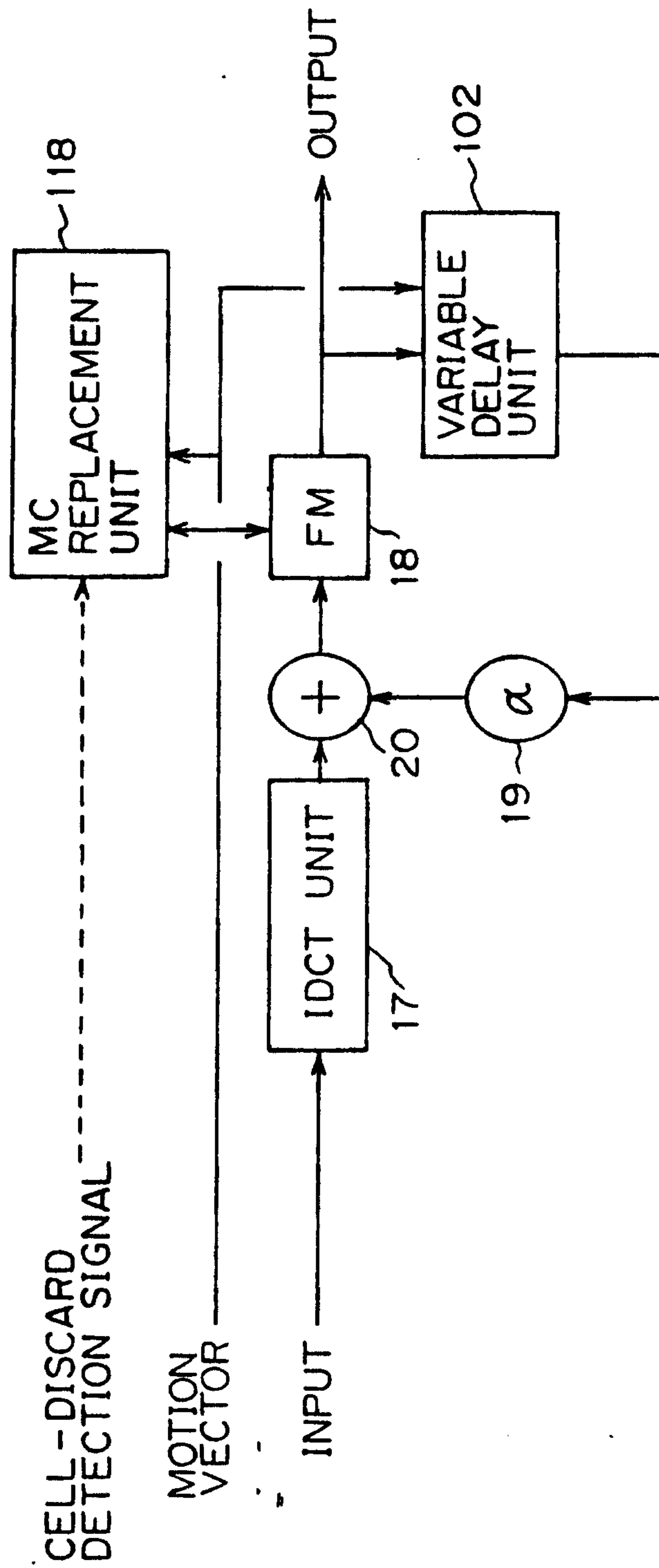


Fig. 26

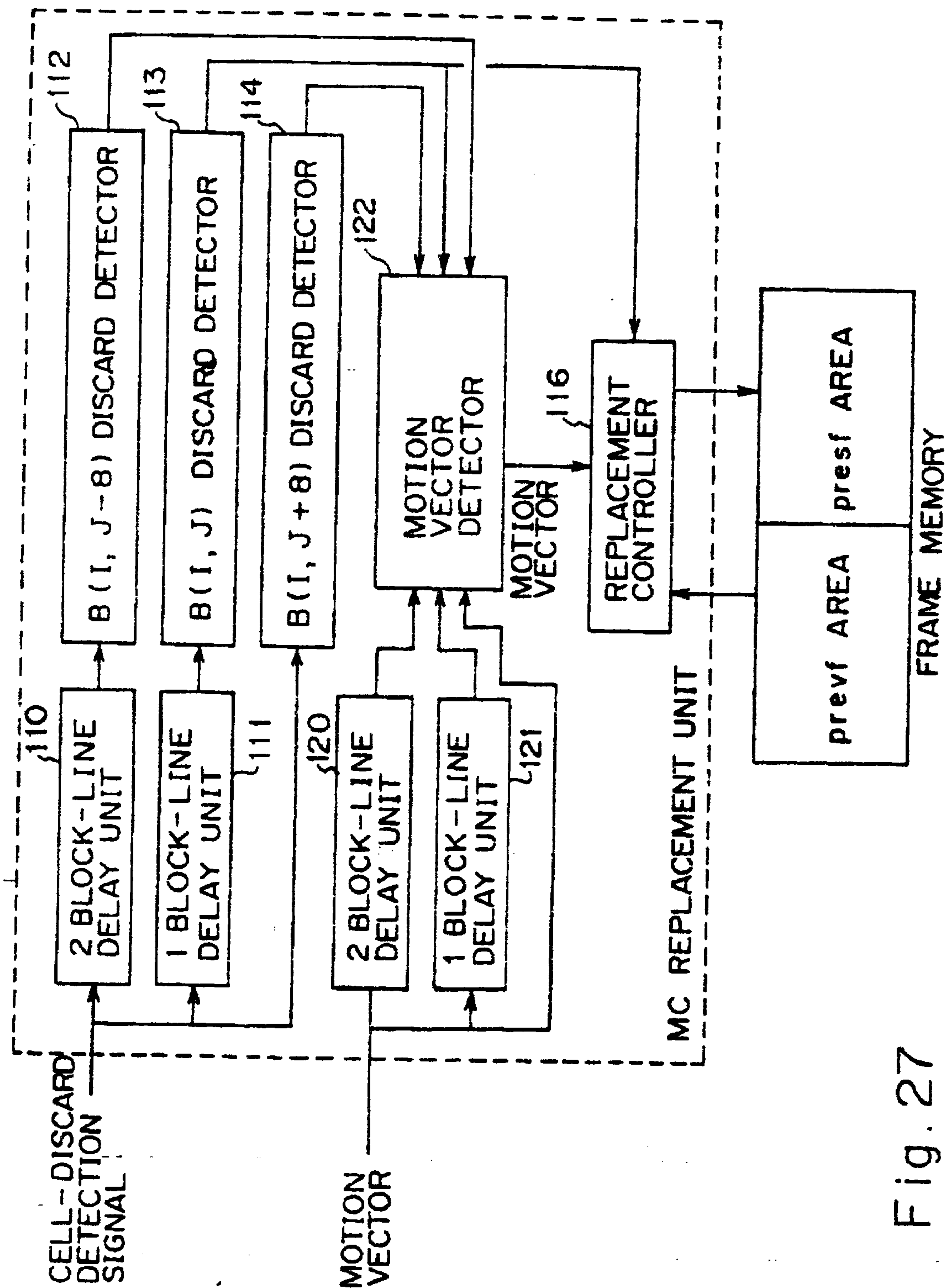


Fig. 27

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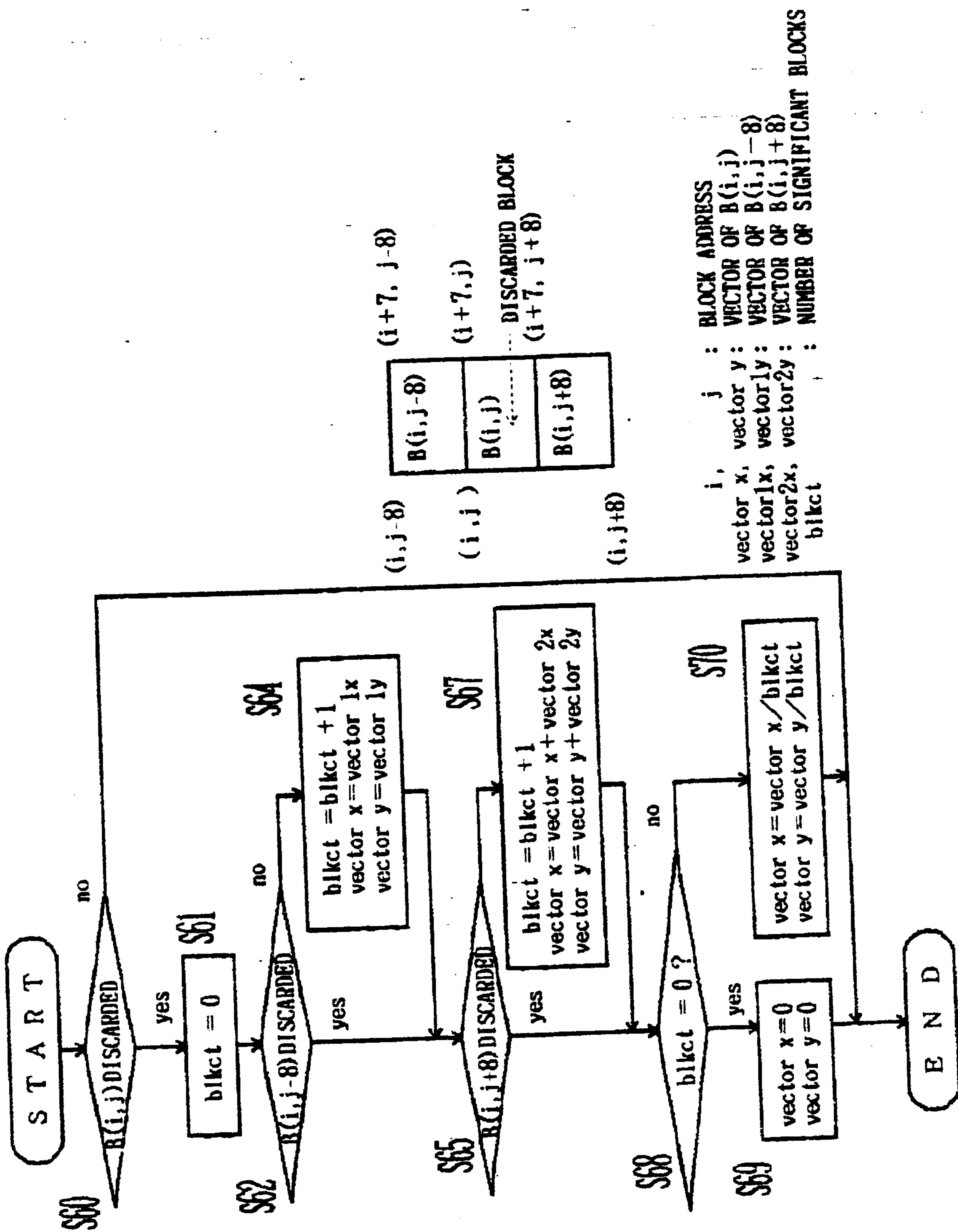


Fig. 28B

Fig. 28A

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J. L. Hough & Co.

