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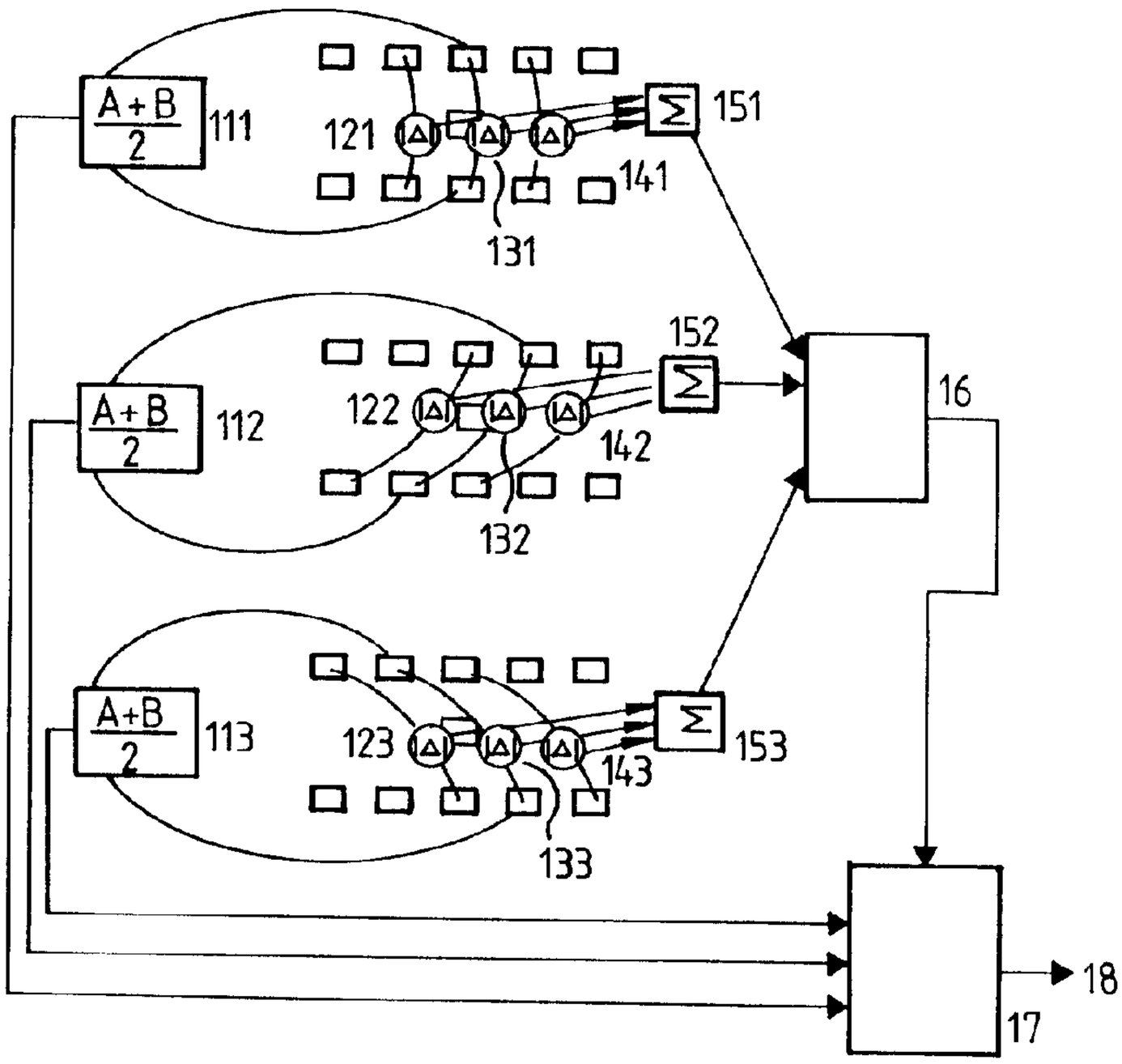
(54) Titre : METHODE ET DISPOSITIF D'INTERPOLATION DIRECTIONNELLE
(54) Title: METHOD AND APPARATUS FOR DIRECTION RELATED INTERPOLATION



(57) Abrégé/Abstract:
For Proscan conversion adjacent fields cannot be used to interpolate moving objects because motion blur will be introduced then. The most simple solution is to insert the average of the two adjacent lines for each missing line. A technique superior to vertical averaging represents the DIAG3 algorithm, where according to the found minimum gradient the orientation of the interpolation filter is chosen. But in case of high diagonal frequencies interpolation errors will occur. Therefore it is tested if the reconstructed pixel value exceeds or falls below the pixel values in the two adjacent lines of the input signal. If this happens, instead of one of the detected diagonal directions the vertical direction is taken, i.e. a vertical averaging is carried out.

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ABSTRACT

For Proscan conversion adjacent fields cannot be used to interpolate moving objects because motion blur will be introduced then. The most simple solution is to insert the average of the two adjacent lines for each missing line. A technique superior to vertical averaging represents the DIAG3 algorithm, where according to the found minimum gradient the orientation of the interpolation filter is chosen. But in case of high diagonal frequencies interpolation errors will occur.
Therefore it is tested if the reconstructed pixel value exceeds or falls below the pixel values in the two adjacent lines of the input signal. If this happens, instead of one of the detected diagonal directions the vertical direction is taken, i.e. a vertical averaging is carried out.

Fig. 5

Method and Apparatus for direction related interpolation

The present invention relates to a method and to an apparatus for direction related interpolation.

Background

For Proscan conversion adjacent fields cannot be used to interpolate moving objects because motion blur will be introduced then. The most simple solution is to insert the average of the two adjacent lines for each missing line.
A technique superior to vertical averaging represents the DIAG3 algorithm depicted in Fig. 1. According to the found minimum gradient (absolute value is averaged over three pixels) the orientation of the interpolation filter is chosen. For simplicity of the hardware complexity only the two diagonal and the vertical direction are possible for an interpolation.
In Fig. 1a the current pixel 103 is to be interpolated from pixels of the same field of an interlaced input signal, containing the upper adjacent line 101 and the lower adjacent line 102. The interpolation of the current pixel is related to the direction of a structure in the picture content.
In Fig. 1b three average values for the current pixel are calculated in vertical direction with a first averager 111, in diagonal ascending direction with a second averager 112 and in diagonal descending direction with a third averager 113. Three absolute difference values between adjacent pixel pairs of the two adjacent lines are calculated direction related in the respective branches with first absolute difference value means 121, 131 and 141, with second absolute difference value means 121, 132 and 142 and with third absolute difference value means 123, 133 and 143. The three absolute difference values of each branch are summed in a first adder 151, in a second adder 152 and in a third adder 153, respectively. The minimum of the three sums is detected in a minimum detector 16 and used in a selector 17 to select the average value of the respective branch for forming the current ouput pixel value 18. For reasons based on the

kind of orientation detection which is used, the DIAG3 interpolation method can produce some completely wrong structures. From the zone plate test signal interpolated with this method and shown in Fig. 2 it can be concluded that for only 5/8 (dark areas) of the f^X, f^Y plane the upconverted signal shows a correctly reproduced structure. The maximum correctly interpolated vertical frequency in a 625 line system is 138c/p (cycles per picture height).

Invention

In Fig. 3a it is assumed that the input signal represents a luminance signal with a sinusodial modulation having a certain spatial frequency of $f^X = f^X_0$ and $f^Y = f^Y_0$. For the given example all three differences for the depicted direction in Fig. 3b will become zero. This is obviously not the case in the other two directions. Therefore the wrong direction is chosen for the interpolation. Fig. 3c illustrates the reproduced wrong structure.

A closer look at the reproduced structure in Fig. 4a indicates that the algorithm tries to interpolate a higher vertical frequency component than it is possible in intrafield upconverted pictures, namely $f^Y = ½*d = 276c/h$, as depicted in Fig. 4b. If one assumes an interlace camera as pick-up device a structure with such a high vertical frequency is subjected to a high attenuation during the scanning process, since the vertical diameter of the camera spot is normally greater than the line distance of a frame. Then the scanned structure will either exhibit a small modulation depth or even disappear, as a consequence.

It is one object of the invention to disclose a method for improved direction related interpolation.

A broad aspect of the invention provides a method for improving the quality of pictures displayed with a line structure on a picture tube, wherein for line segments at vertical brightness transitions the beam is additionally deflected in vertical direction, characterized in that in order to compensate for reduced resolution caused by large, brightness-dependent spot diameter on a large format picture tube, the amount of said additional deflection is made dependent upon the variation in brightness across the said transitions, and in that the beam is deflected away to the bright side of the transition region, wherein said additional vertical deflection is not active if the brightness picture content including said brightness transition represents a high vertical frequency detail.

It is a further object of the invention to disclose an apparatus which utilizes the inventive method.

Another broad aspect of the invention provides an apparatus for improving the quality of pictures displayed with a line structure on a picture tube, wherein for line segments at vertical brightness transitions the beam is additionally deflected in vertical direction, for carrying out a method as described above, characterized in that said apparatus includes the following means to compensate for reduced resolution caused by large, brightness-dependent spot diameter on a large format picture tube, the amount of said additional deflection being made dependent upon the variation in brightness across the said transitions: two serially connected line delays, each of which is followed by subtraction means for forming for each field a difference signal between the input and output of said line delays, each of which is fed to a comparator which forms binary output signals logic circuit means for combining said binary

output signals; and for forming a control signal consisting of at least three levels, wherein said control signal is used for generating said additional vertical deflection and for reducing in a multiplier connected to the output of the first line delay the brightness amplitude at the bright side of said transition, wherein said additional vertical deflection is not active if the brightness picture content including said brightness transition represents a high vertical frequency detail.

Drawings

Preferred embodiments of the invention are described with reference to the accompanying drawings, in which:

Fig. 1 shows a direction related interpolation;

Fig. 2 shows a respectively interpolated test pattern;

Fig. 3 explains interpolation errors;

Fig. 4 shows how a high vertical frequency is generated by the interpolation;

Fig. 5 depicts the inventive direction related interpolation.

Preferred Embodiments

In Fig. 5 the current pixel 503 is to be interpolated from pixels of the same field of an interlaced input signal, containing the upper adjacent line 501 and the lower adjacent line 502. The interpolation of the current pixel is related to the direction of the structure in the picture content. Three average values for the current pixel 503 are calculated

in vertical direction with a first averager 511, in diagonal ascending direction with a second averager 512 and in diagonal descending

direction with a third averager 513. Three absolute difference values between adjacent pixel pairs of the two adjacent lines are calculated direction related in the respective branches with first absolute difference value means 521, 531 and 541, with second absolute difference value means 521, 532 and 542 and with third absolute difference value means 523, 533 and 543. The three absolute difference values of each branch are summed in a first adder 551, in a second adder 552 and in a third adder 553, respectively. The minimum of the three sums is detected in a minimum detector 56 and used in a selector 57 to select the average value X of the respective branch.

A first comparator circuit 591 determines the maximum and the minimum value of the two pixels vertically adjacent to the current pixel 503. The average value X is compared in a second comparator circuit 592 with the minimum and maximum value found in the first comparator. If X is greater than the maximum value or if X is less than the minimum value switch 593 connects the output of first averager 511 to output 58. Otherwise the output of selector 57 is connected to output 58 which delivers the current pixel value.

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

1. Method for improving the quality of pictures displayed with a line structure on a picture tube, wherein for line segments at vertical brightness transitions the beam is additionally deflected in vertical direction, characterized in that in order to compensate for reduced resolution caused by large, brightness-dependent spot diameter on a large format picture tube, the amount of said additional deflection is made dependent upon the variation in brightness across the said transitions, and in that the beam is deflected away to the bright side of the transition region, wherein said additional vertical deflection is not active if the brightness picture content including said brightness transition represents a high vertical frequency detail.

2. Method according to claim 1, wherein said additional deflection is not active if said bright area has a height of one line.

3. Method according to claim 1 or 2, wherein said variation in brightness is detected using the information from three subsequent lines each having a distance of one line period from the next.

4. Method according to any of claims 1 to 3, wherein in case of brightness transitions between grey and white levels the amplitude of said additional deflection is reduced.

5. Method according to any of claims 1 to 4, wherein said additional deflection is performed using an additional deflection coil.

6. Method according to any of claims 1 to 5, wherein the amount of said additional vertical deflection is dependent upon the slope of said transition.

7. Method according to any of claims 1 to 6, wherein the amount of said additional vertical deflection is dependent upon the difference in brightness between the two sides of said transition.

8. Method according to claim 7, wherein the amount of said additional vertical deflection is a staircase function of the difference in brightness between the two sides of said transition.

9. Apparatus for improving the quality of pictures displayed with a line structure on a picture tube, wherein for line segments at vertical brightness transitions the beam is additionally deflected in vertical direction, for carrying out a method according to any of claims 1 to 8, characterized in that said apparatus includes the following means to compensate

for reduced resolution caused by large, brightness-dependent spot diameter on a large format picture tube, the amount of said additional deflection being made dependent upon the variation in brightness across the said transitions:

two serially connected line delays, each of which is followed by subtraction means for forming for each field a difference signal between the input and output of said line delays, each of which is fed to a comparator which forms binary output signals logic circuit means for combining said binary output signals; and for forming a control signal consisting of at least three levels, wherein said control signal is used for generating said additional vertical deflection and for reducing in a multiplier connected to the output of the first line delay the brightness amplitude at the bright side of said transition,

wherein said additional vertical deflection is not active if the brightness picture content including said brightness transition represents a high vertical frequency detail.

10. Apparatus according to claim 9, wherein the second of said line delays is located between the second of said comparators and said logic circuit means instead of being in series with the first of said line delays, and wherein there is only one subtraction means, fed with the input and output of said first delay means, the output of said subtraction means being fed to the first comparator via an inverter and directly to said second comparator.

11. Apparatus according to claim 9 or 10, wherein said comparators generate said output signals with more than two levels and said logic circuit means accordingly generate said control signal with more than three levels.

12. Apparatus according to any one of claims 9 to 11, wherein said control signal is fed to a staircase circuit and said control signal is changed corresponding to the difference in brightness between the two sides of said transition.

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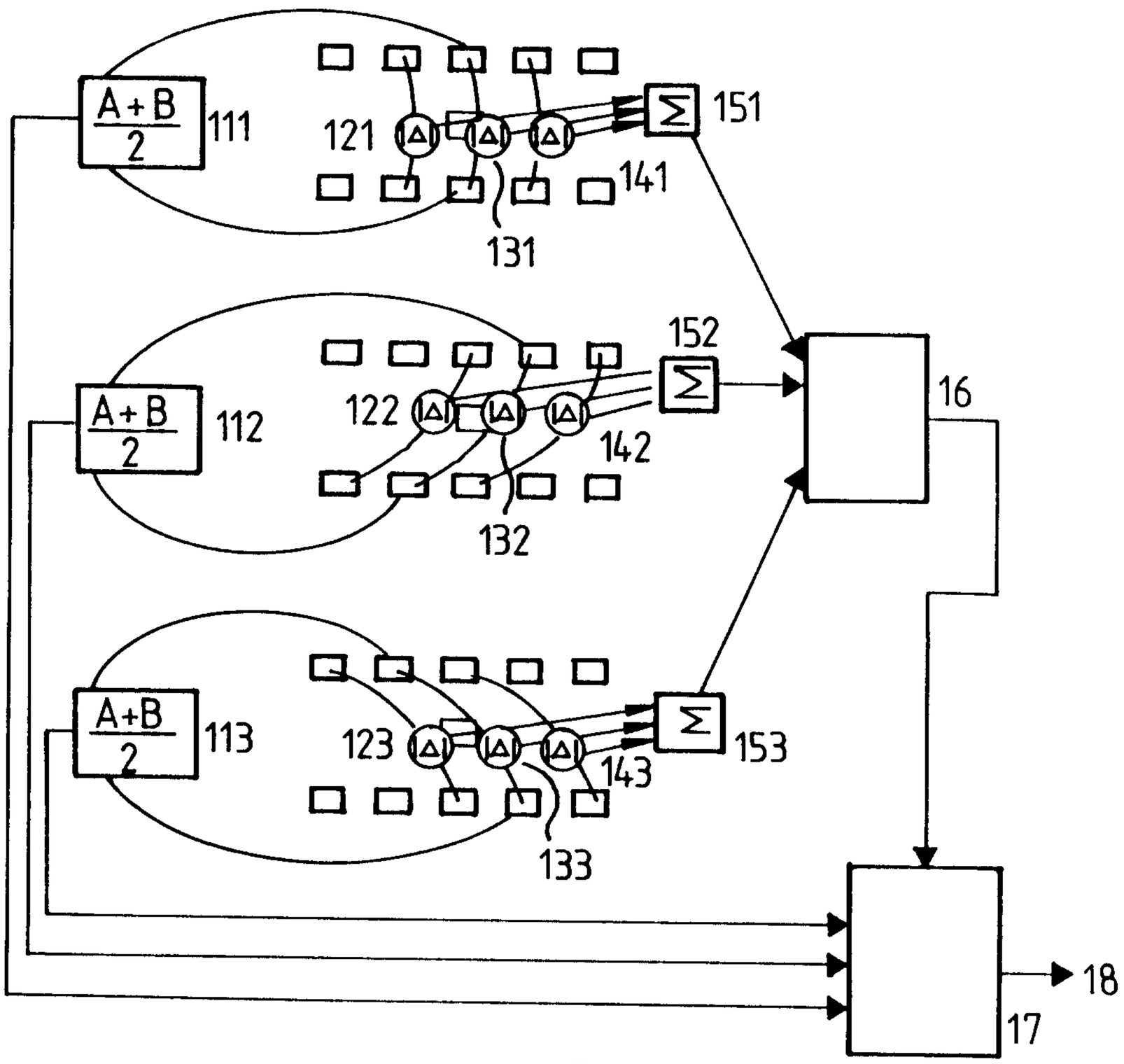

Fig.1b

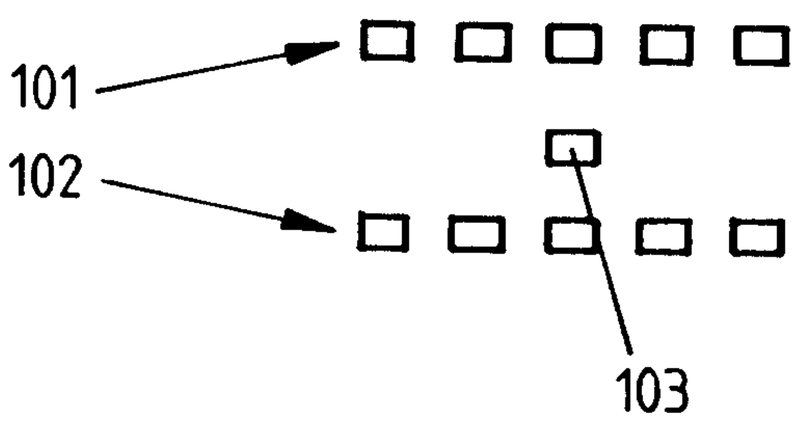

Fig.1a

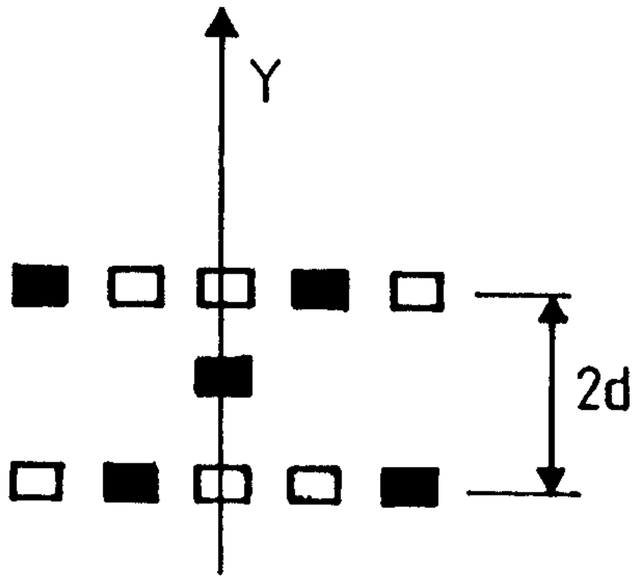

Fig.4a

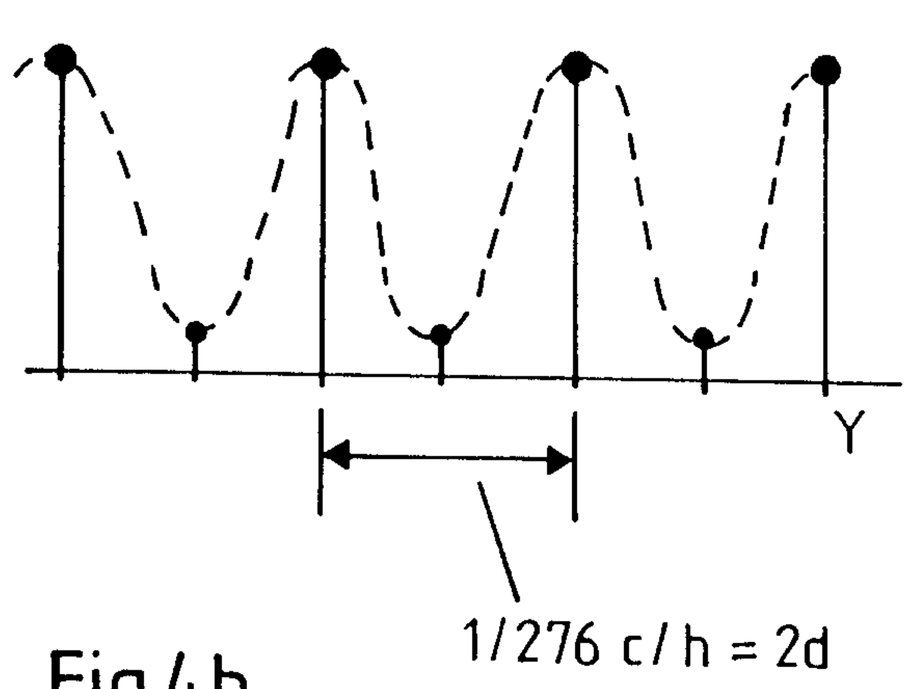

Fig.4b

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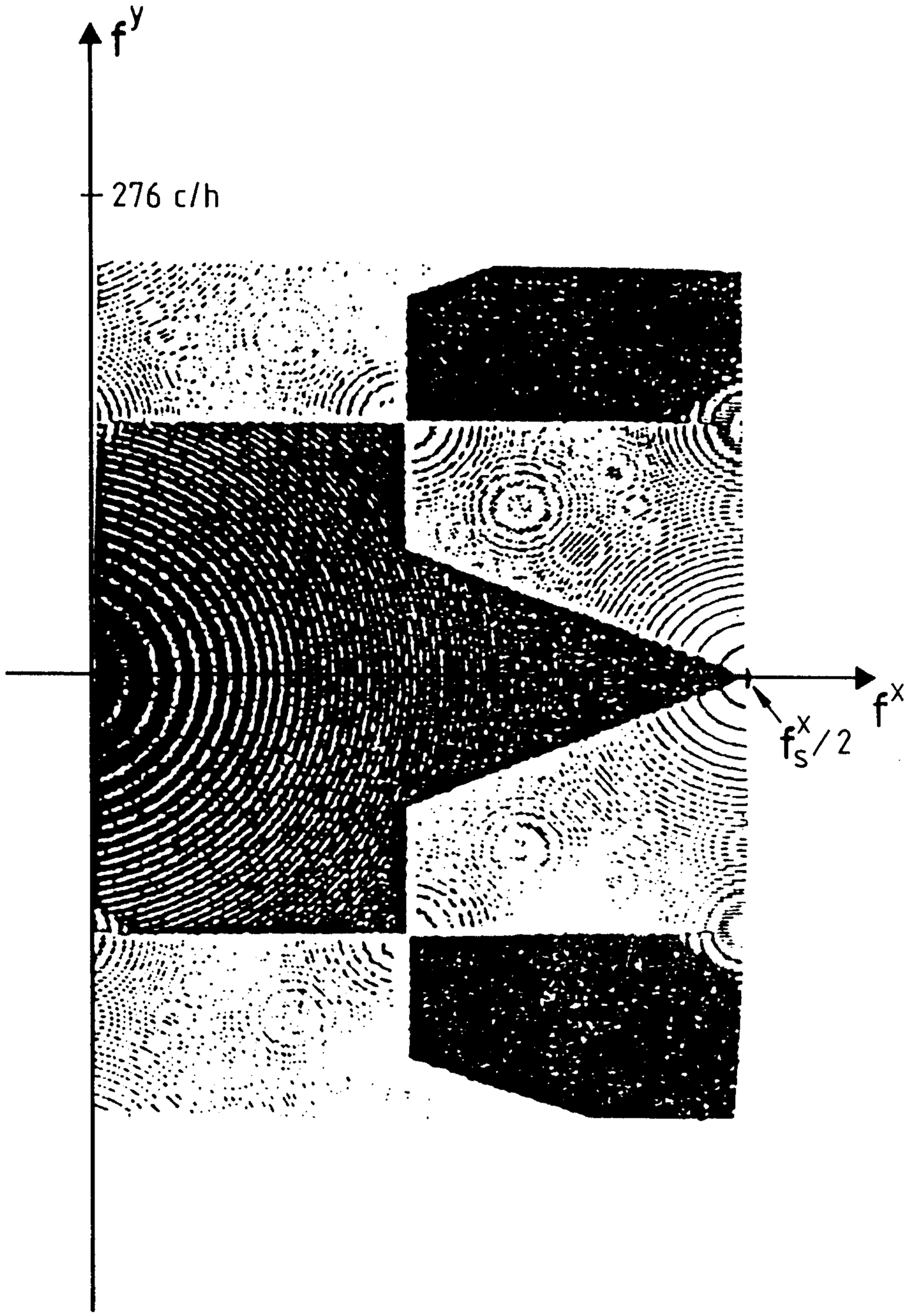

Fig.2

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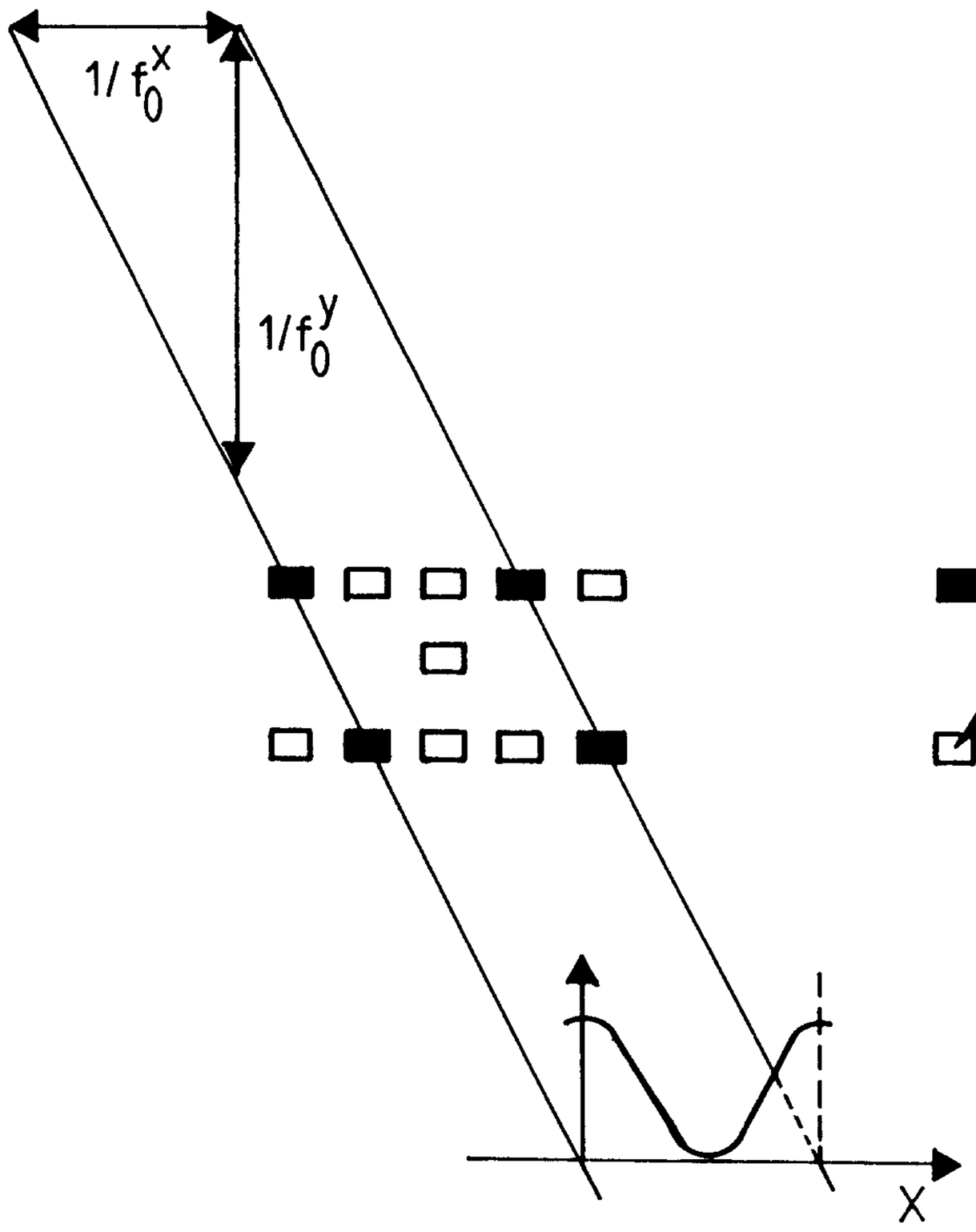

Fig.3a

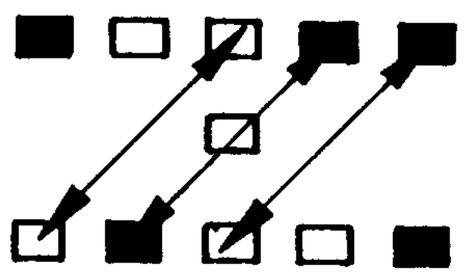

Fig.3b

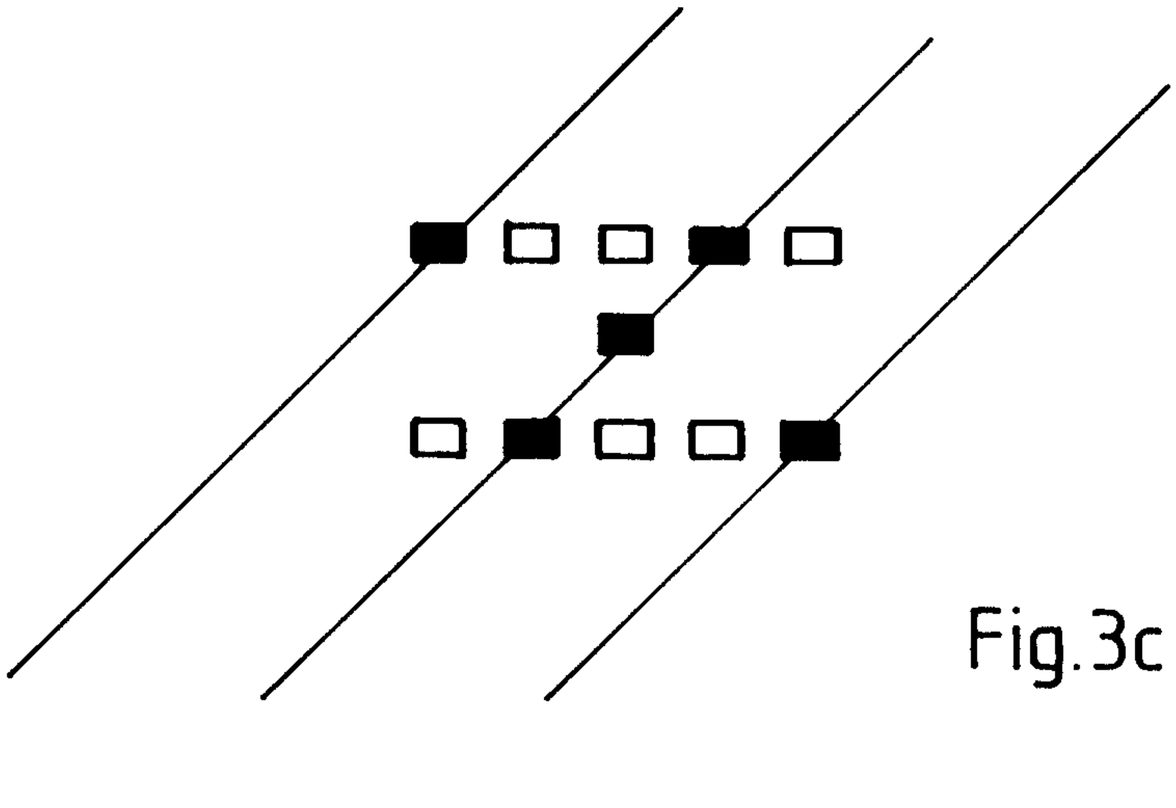

Fig.3c

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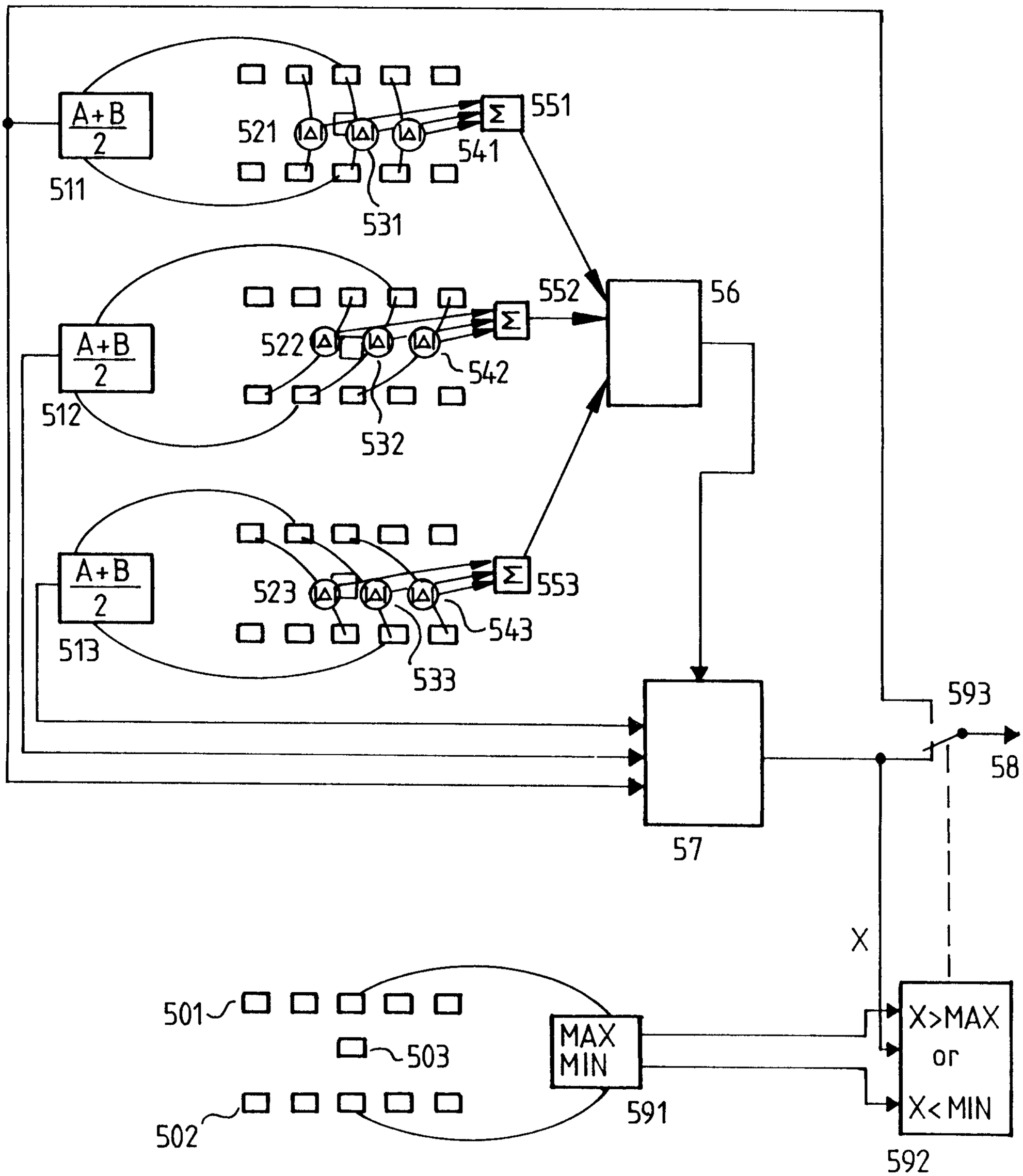
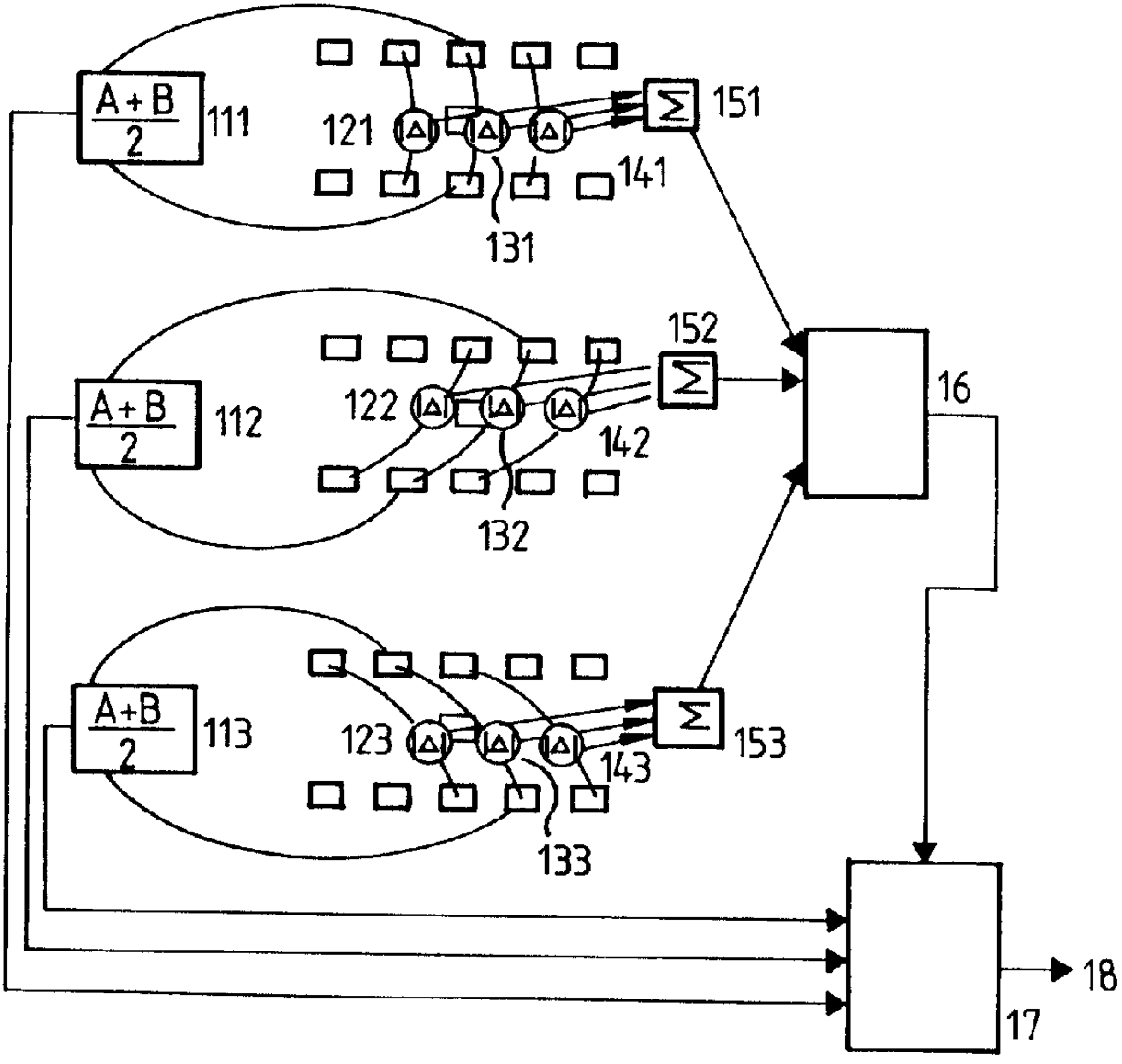


Fig. 5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