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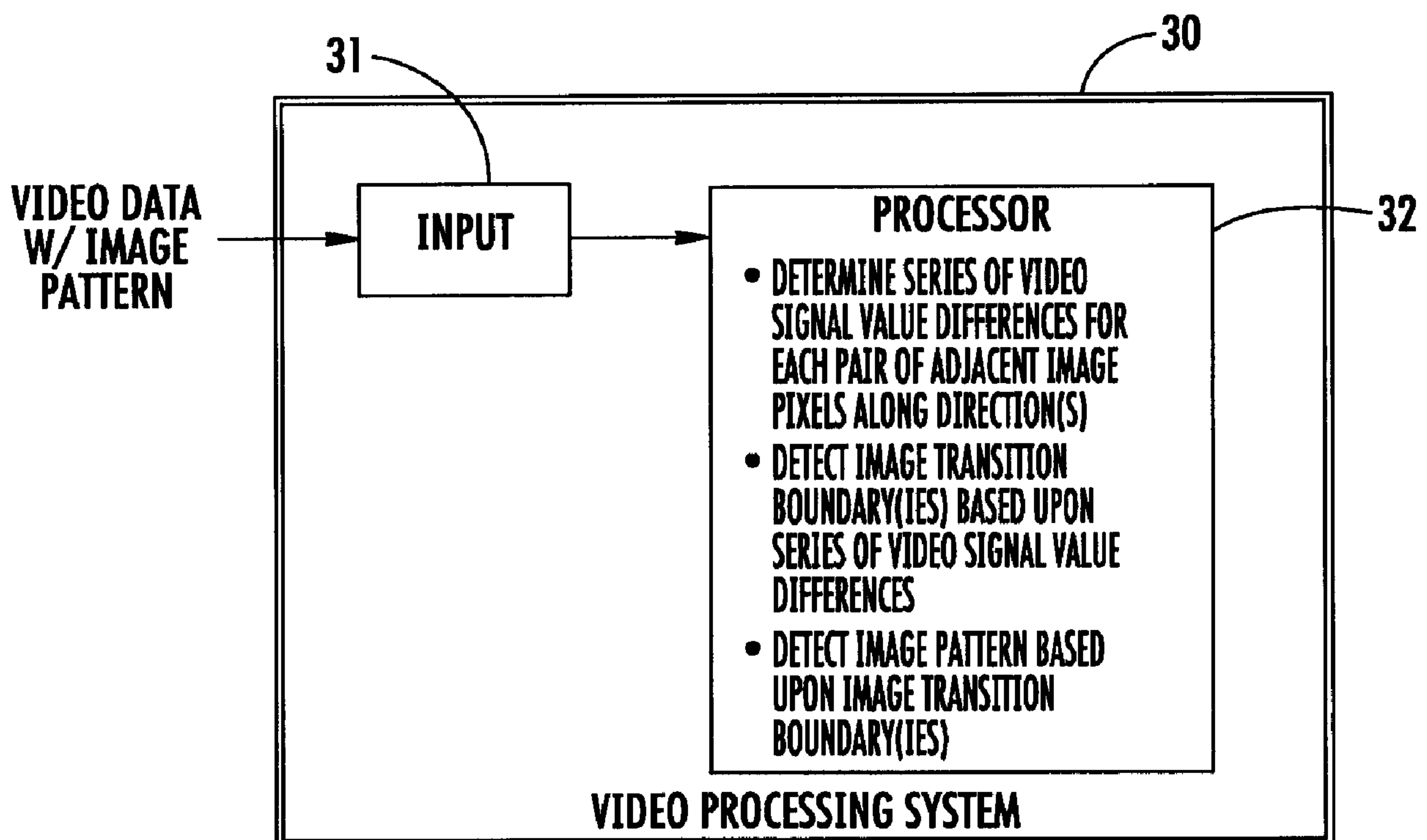
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(54) **Titre :** SYSTEME DE TRAITEMENT VIDEO FOURNISSANT LA DETECTION DE MOTIF D'IMAGE BASEE SUR LES FRONTIERES DE TRANSITION D'IMAGE ET METHODES CONNEXES

(54) **Title:** VIDEO PROCESSING SYSTEM PROVIDING IMAGE PATTERN DETECTION BASED UPON IMAGE TRANSITION BOUNDARIES AND RELATED METHODS



(57) **Abrégé/Abstract:**

A video processing system (30) may include an input (31) for receiving video data including video signal values for a corresponding plurality of image pixels and having an image pattern therein. The system (30) may further include a processor (32) coupled to the input for determining a series of video signal value differences for each pair of adjacent image pixels along at least one direction, detecting at least one image transition boundary based upon the series of video signal value differences, and detecting the image pattern based upon the at least one image transition boundary.

ABSTRACT

A video processing system (30) may include an input (31) for receiving video data including video signal values for a corresponding plurality of image pixels and having an image pattern therein. The system (30) may further include a processor (32) coupled to the input for determining a series of video signal value differences for each pair of adjacent image pixels along at least one direction, detecting at least one image transition boundary based upon the series of video signal value differences, and detecting the image pattern based upon the at least one image transition boundary.

**VIDEO PROCESSING SYSTEM PROVIDING IMAGE PATTERN
DETECTION BASED UPON IMAGE TRANSITION BOUNDARIES AND
RELATED METHODS**

5 The present invention relates to the field of video processing systems,
and, more particularly, to video image pattern detection systems and related methods.

 Test patterns are sometimes included in a video signal for calibrating
or troubleshooting the downstream signal path. The test patterns are typically
generated by test signal generators, and they allow vendors, viewers and television
10 stations to adjust their equipment for desired functionality. By way of example, such
test patterns may include an eight vertical color bar pattern, as well as the slightly
more complex Society of Motion Picture and Television Engineers (SMPTE) color
bar pattern. Such patterns may also be used to indicate that there is a problem or error
with the signal feed, or they may be used to indicate the beginning or end of a signal
15 feed.

 Accordingly, when processing broadcast video data it may often be
desired to detect the presence of such test patterns to ensure the accuracy of a received
video data. However, this task has traditionally been performed manually, which can
be cumbersome and relatively time consuming for video editors.

20 Various approaches have been developed for automatically
determining video signal attributes for different purposes. For example, U.S. Patent
No. 4,951,128 discloses a method for detecting correlation of a video signal having a
chrominance component by combining three successive line intervals of the video
signal to produce a first signal by obtaining the sum of the video signals of those three
25 line intervals, combining at least two of those three line intervals to produce a second
signal by obtaining the difference between the video signals of such two line intervals.
The method further includes detecting the absolute values of the first and second
signals, respectively, and determining the difference between the absolute values of
the first and second signals to produce a correlation indication signal.

Despite the existence of such approaches, further developments may be desirable to provide automated pattern recognition of test or other patterns in video data.

5 In view of the foregoing background, it is therefore an object of the present invention to provide a system and related methods for more readily identifying patterns within video data.

This and other objects, features, and advantages are provided by a video processing system which may include an input for receiving video data including video signal values for a corresponding plurality of image pixels and having
10 an image pattern therein. The system may further include a processor coupled to the input for determining a series of video signal value differences for each pair of adjacent image pixels along at least one direction, detecting at least one image transition boundary based upon the series of video signal value differences, and detecting the image pattern based upon the at least one image transition boundary.

15 Accordingly, the system may advantageously detect one or more image patterns, such as from among a plurality of different image patterns. By way of example, such image patterns may include a color bar pattern, pillar box pattern, letter box pattern, flat field pattern, single color frame pattern, etc. The processor may also generate an output identifying the image pattern from among the plurality thereof.

20 The processor may determine the series of video signal value differences for each pair of adjacent (e.g., directly adjacent) image pixels along a horizontal image direction and/or a vertical image direction. The image pattern may include a fixed image pattern over a plurality of image frames or fields. Additionally, the video signal values may include at least one of luminance and chrominance
25 values.

The processor may further advantageously determine whether the video data exceeds a blurriness threshold based upon the at least one image transition boundary. By way of example, the processor may determine whether the video data exceeds the blurriness threshold based upon determining a magnitude of the at least
30 one image transition boundary and comparing the magnitude to a blurriness threshold

magnitude. A memory may also be coupled to the input and the processor for storing the video data.

A related video processing method is for video data including video signal values for a corresponding plurality of image pixels and having an image pattern therein. The method may include determining a series of video signal value differences for each pair of adjacent image pixels along at least one direction. Moreover, the method may further include detecting at least one image transition boundary based upon the series of video signal value differences, and detecting the image pattern based upon the at least one image transition boundary.

FIG. 1 is a schematic block diagram of a video processing system in accordance with the invention.

FIG. 2 is a schematic block diagram of an alternative embodiment of the video processing system of FIG. 1.

FIGS. 3 and 4 are flow diagrams illustrating video processing method aspects of the present invention.

FIG. 5 is a video frame including a solid color bar pattern to be detected by the system of FIG. 1.

FIG. 6 is a graph of luminance magnitudes for the video frame of FIG. 5 showing transition boundaries therein.

FIG. 7 is a plot of horizontal and vertical boundary transition magnitudes for the video frame of FIG. 5.

FIG. 8 is a video frame including an SMPTE solid color bar pattern to be detected by the system of FIG. 1.

FIG. 9 is a graph of luminance magnitudes for the video frame of FIG. 8 showing transition boundaries therein.

FIG. 10 is a plot of horizontal and vertical boundary transition magnitudes for the video frame of FIG. 8.

FIG. 11 is a flow diagram illustrating blurriness detection method aspects of the present invention.

FIG. 12 is a plot of horizontal and vertical boundary transition magnitudes showing blurriness detection in accordance with the method of FIG. 11.

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout, and prime notation is used to indicate similar elements in alternate embodiments.

Referring initially to FIGS. 1 through 4, a video processing system 30 and corresponding method aspects are first described. The system 30 illustratively includes an input 31 for receiving video data including video signal values for a corresponding plurality of image pixels. By way of example, the video may be a digital video made up of frames of image pixels. The signal may be generated in digital form, or it may be a digitized analog signal (e.g., NTSC, etc.). The system 30 may be used with both interlaced and non-interlaced signals, as will be appreciated by those skilled in the art. Moreover, it should be noted that pixel values may be compared at the field or the frame level.

As discussed briefly above, video signal feeds in some instances will have an image pattern therein. In some cases the pattern may occupy most if not all of a video frame, such as in the case of color bar patterns. In other cases, the pattern of interest may occupy less than the entire screen or frame area, such as in the case of a letter or pillar box, as well as a flat field. Other examples include "watermarks" that are continuously displayed for some or all of a program duration. For example, such watermarks may include semi-transparent station or network logos.

It may be desirable to detect the presence of such patterns for a variety of reasons. For example, it may be desired to ensure that a given pattern is present in a played-out video feed (e.g., it has the proper water mark, it is formatted appropriately with letter box/pillar box, it begins or ends with an appropriate color bar

pattern, etc.). On the other hand, there may be situations where the presence of a pattern indicates a problem, such as a color bar pattern suddenly appearing during a video feed, for example, in which case it would be desirable to detect the existence of the problem without having to manually review a large video data set.

5 To this end, the processor **32** is illustratively coupled to the input and is for determining a series of video signal value differences for each pair of adjacent image pixels along at least one direction, at Blocks **40-41**. More particularly, the video signal values may be luminance and/or chrominance values for corresponding pixels, and each pair of pixels may be directly adjacent image pixels taken along
10 horizontal and/or vertical directions (e.g., rows and/or columns), at Block **41'**. The processor **32** may therefore detect image transition boundaries within the image based upon the series of video signal value differences, at Block **42**, and therefore detect the image pattern based upon the image transition boundary or boundaries, at Block **43**, thus concluding the method illustrated in FIG. 3 (Block **44**). More particularly, based
15 upon the number and/or location of luminance/chrominance transition boundaries, the processor **32** can determine whether a particular image pattern is present, and optionally whether the image is located correctly within the frame.

The image pattern may include a fixed image pattern over a plurality of image frames or fields, and the processor **32** may advantageously detect the fixed
20 image pattern. That is, the processor **32** may check to see that the image pattern remains fixed for a plurality of frames (such as in the case of a watermark, letter/pillar box, etc.), as intended, at Blocks **50'-51'**. However, it should be noted that it may not be necessary to check for the occurrence of a pattern over multiple frames in all embodiments, i.e., in some applications detection of an image pattern within a single
25 frame may be sufficient. Moreover, frames need not be checked in consecutive order, i.e., every other frame, every 10th frame, etc., could be checked for the presence of the pattern to advantageously conserve processing resources, as will be appreciated by those skilled in the art. If a desired pattern is not present as expected, an output may be generated indicating same, at Block **52'**, or, alternatively, indicating that the
30 desired image pattern is present, at Block **53'**.

In addition, the output may indicate which of a plurality of different image patterns is present in the video data, such as those noted above. Moreover, in certain circumstances the output may take the form of an alert for the operator, especially in the case where a pattern is unexpected and is indicative of a problem
 5 with the video data (e.g., color bars appearing within the video where they are not supposed to be).

Turning now additionally to FIGS. 5-7, the foregoing will be further understood with reference to an example in which a color bar pattern including eight vertical bars of solid colors which are, from left to right, a white color bar **51**, a
 10 yellow color bar **52**, a cyan color bar **53**, a green color bar **54**, a magenta color bar **55**, a red color bar **56**, a blue color bar **57**, and a black color bar **58**. In the present example, the processor **32** monitors both vertical and horizontal transitions in a frame, but in some embodiments one may be monitored without the other depending upon the particular patterns to be detected, as will be appreciated by those skilled in the art.

15 If the processor **32** detects that the frame includes no or minimal vertical transitions, but that it does include eight distinct or “strong” horizontal transitions, then the processor determines with a high degree of likelihood that the frame contains an eight-bar color pattern. In this regard, the processor **32** may compare the detected transitions to a known reference pattern, such that if expected
 20 transitions occur within a threshold magnitude and/or location within the frame, then the presence of the color bar image is detected.

More particularly, vertical transitions may be calculated by comparing the difference in luminance (and/or chrominance in some embodiments) between the same pixels across two consecutive lines or rows. Then, the absolute value of the
 25 difference is taken and the result accumulated for the same x location across all lines of the frame as follows:

$$Vt(y) = \sum \text{abs} (p(x,y-1) - p(x,y)), \quad (1)$$

30 for x = 1 to a number of pixels in the line.

Similarly, horizontal transitions may be calculated by comparing the difference in luminance between the same pixels across two consecutive pixels in the same line. Then, the absolute value of the difference is taken and the result accumulated for the same y location across all pixels in the line as follows:

5

$$Ht(x) = \sum \text{abs}(p(x-1,y) - p(x,y)), \quad (2)$$

for $y = 1$ to a number of lines in frame. Preferably, Vt is calculated for all x locations in the frame (number of pixels in a line), and Ht is calculated for all Y locations in the frame (number of lines in a frame), although all locations need not necessarily be checked in all embodiments depending upon the given image pattern that is being checked for (e.g., a watermark may only require checking in a lower corner of the frame).

The corresponding luminance plot **50''** for the eight color bar pattern **50** is shown in FIG. 6, and the corresponding Ht and Vt plots **50H''** and **50V''** are respectively shown in FIG. 7. In these figures, the various color bar luminance levels and magnitudes are indicated with the same reference numeral used in FIG. 5, but with prime and double prime notation, respectively. As may be seen, there are eight distinct transitions in the solid color bars. Due to the fact that all lines in the exemplary frame are identical, the Ht plot has eight distinct transitions **51''-58''** (seen as impulses in FIG. 7), while Vt has no transitions since all of the lines will be identical (i.e., all pixels in each column have the same luminance values, so the sum of their differences will be zero).

Referring now additionally to FIGS. 8-10, another image pattern detection example is provided for an SMPTE color bar pattern **60**. The corresponding luminance graph **60'** shows that there are eight major transitions in the SMPTE color bars, but also that there are other minor transitions as well. The corresponding Ht and Vt plots **60H''** and **60V''** are shown in FIG. 10. Since there are vertical transitions in this pattern as well, the magnitude plot for Vt is not flat as in the prior example.

Again, the values plotted in FIG. 10 are obtained using formulas (1) and (2) above, although other formulations may be possible in other embodiments.

Turning now to FIGS. 11 and 12, upon determining the above-noted transition boundaries within an image, the boundaries may also advantageously be used for detecting blurriness of the image. Generally speaking, a blurry image will not have a sharp contrast, or transition, between different colors in the image. Taking the example of FIG. 12 where Ht and Vt plots **80H**, **80V** are shown for a blurry image, upon determining the magnitude of image transition boundaries within a given image frame, at Block **71** (e.g., using equations (1) and (2), above), the processor **32** may then determine whether the magnitude(s) exceed a respective blurriness threshold **81V**, **81H**. It should be noted that these thresholds **81V**, **81H** may be different in some embodiments, or they may be the same.

In accordance with one example, the greatest or maximum transition values (i.e., the largest Ht and Vt magnitude values **82H** and **82V**) are compared with the blurriness thresholds **81V**, **81H**, and if both (or just one, depending on the given implementation) of these values is not above its respective threshold then the image is determined to be a blurry image. If this is the case, then the appropriate output/alert may be generated, and corrective action may be taken in some embodiments, by the processor **32**, as will be appreciated by those skilled in the art. However, other approaches for comparing the Ht and/or Vt values to the threshold may be used, as will be appreciated by those skilled in the art. Also, different blurriness thresholds may be used depending upon the given implementation and video type, as will also be appreciated by those skilled in the art.

In some embodiments, it may be desirable to not only count the transitions, but to also apply a threshold to exclude minor transitions as well as noise in the video, as will further be appreciated by those skilled in the art. As noted above, the Ht and Vt calculations may also advantageously be used to detect various other image patterns, such as pillar boxes, letter boxes, flat fields, and black (or other color) frames.

In particular, for a pillar box the beginning and end values of Ht will be minimal values, and the active area in between will change with content. For a letter box, the beginning and end values of Vt will be of minimal value, and the active area in between will change with content. For flat fields, there will be two transitions
5 from blanking to flat field and back to blanking for both Vt and Ht. A black frame will have no significant transitions in either Vt or Ht. Once again, other unique shapes such as watermarks, etc., may also be determined or detected using this approach, as will be appreciated by those skilled in the art

Referring additionally to FIG. 2, an alternative embodiment of the
10 system 30' illustratively includes a memory 33' for storing received video data prior to processing by the processor 32'. By way of example, the system 30' may be implemented as a media analysis server used to process video data "offline," i.e., not in real time, during the production and editing process. One exemplary media analysis server in which the above-described features may advantageously be
15 implemented is the Videotek® QuiC™ media analysis server from the Harris Corporation, Assignee of the present application. However, the above-described techniques may be implemented using other platforms, and may also be performed on real-time or live broadcast video data. In this regard, it should be noted that reference to a "processor" herein may include both hardware and software components,
20 including discrete components as well as microprocessors and associated memories, as will be appreciated by those skilled in the art.

CLAIMS

1. A video processing system comprising:
 - an input for receiving video data comprising video signal values for a corresponding plurality of image pixels and having an image pattern therein, wherein the plurality of image pixels form a plurality of frames with an unknown image; and
 - a processor coupled to said input and configured to, without manual review of the video signal values, at least:
 - calculate a series of difference values between video signal values for each pair of adjacent image pixels along at least one direction;
 - detecting at least one image transition boundary based upon the series of video signal value differences;
 - detecting the image pattern based upon the at least one image transition boundary, wherein the image pattern comprises a given image pattern of a plurality of different image patterns; and
 - generate an output identifying the given image pattern of the plurality of image patterns.
2. The video processing system of Claim 1 wherein said processor is configured to determine the series of differences for each pair of adjacent image pixels along a horizontal image direction and a vertical image direction.
3. The video processing system of Claim 1 wherein the image pattern comprises a fixed image pattern over a plurality of image frames or fields; and wherein said processor is configured to detect the fixed image pattern.
4. The video processing system of Claim 1 wherein the image pattern comprises a color bar pattern; and wherein said processor is configured to detect the color bar pattern.
5. A video processing method for video data comprising video signal values for a corresponding plurality of image pixels and having an image pattern therein, wherein

the plurality of pixels form a plurality of frames with an unknown image, the method comprising:

- using a processor to, without manual review of the video signal values at least:
 - calculating a series of difference values between video signal values for each pair of adjacent image pixels along at least one direction;

- detecting at least one image transition boundary based upon the series of value differences;

- detecting the image pattern based upon the at least one image transition boundary, wherein the image pattern comprises a given image pattern of a plurality of different image patterns; and

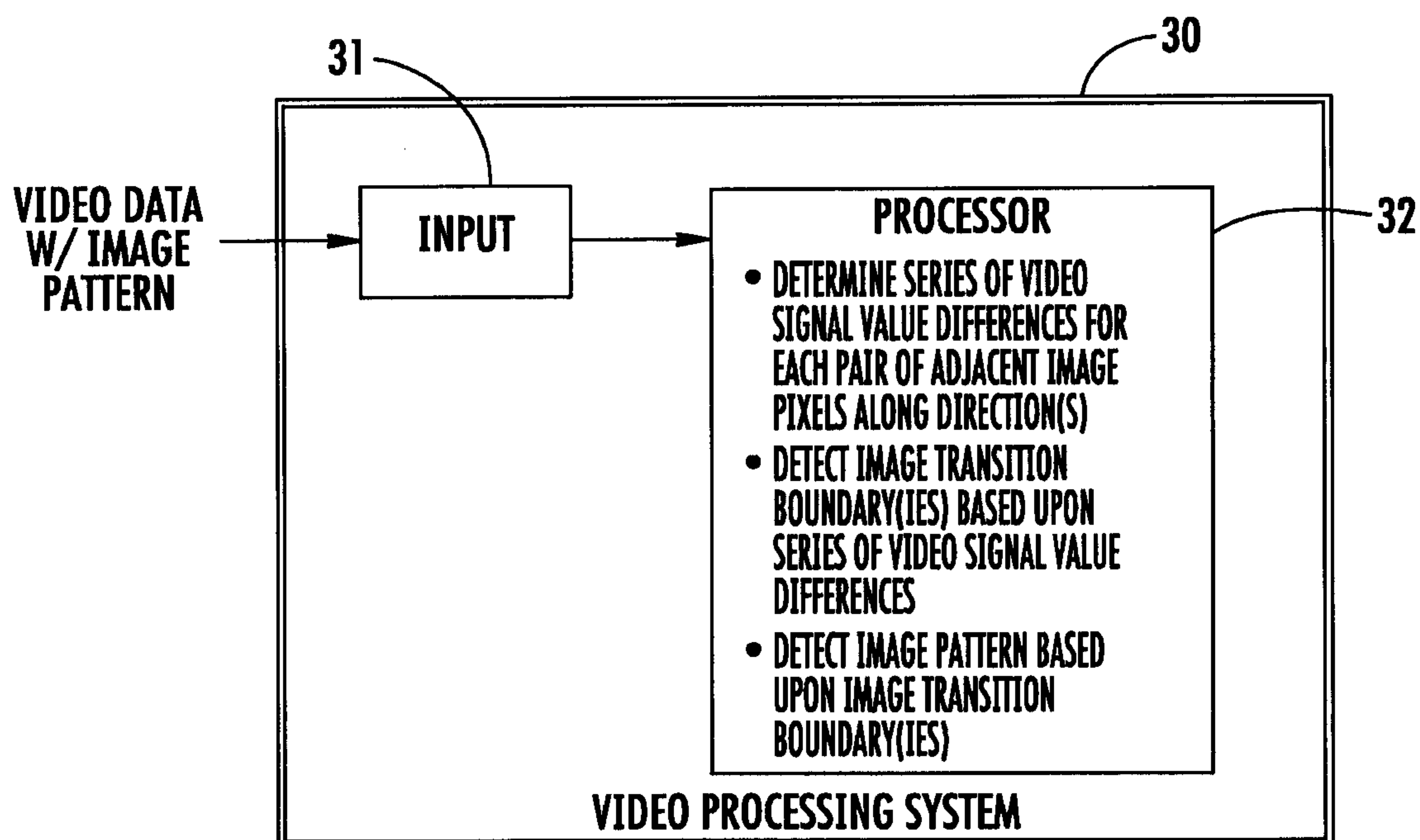
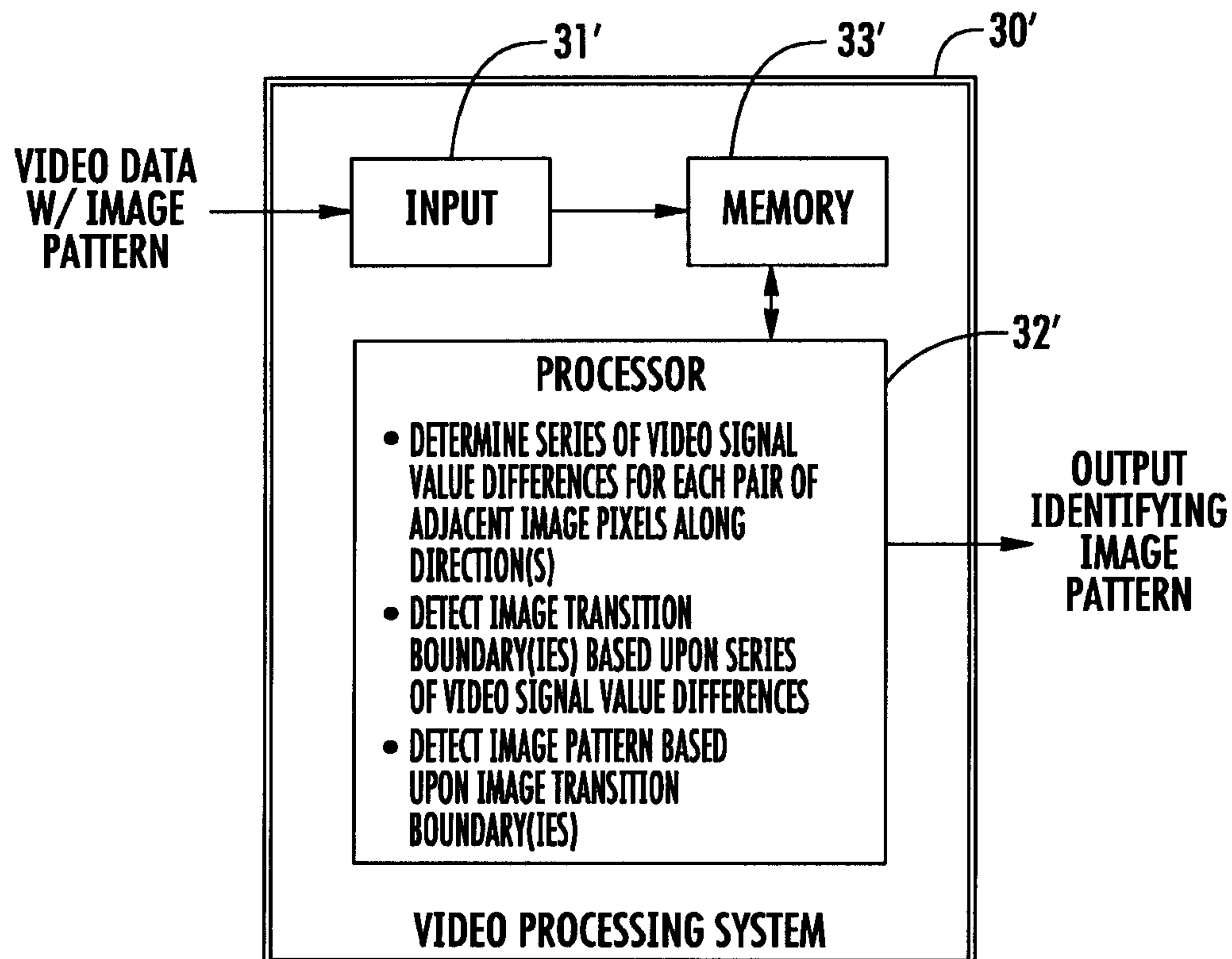
- generate an output identifying the given image pattern of the plurality of image patterns.

6. The method of Claim 5 wherein determining the series of difference values comprises determining the series of difference values for each pair of adjacent image pixels along a horizontal image direction and a vertical image direction.

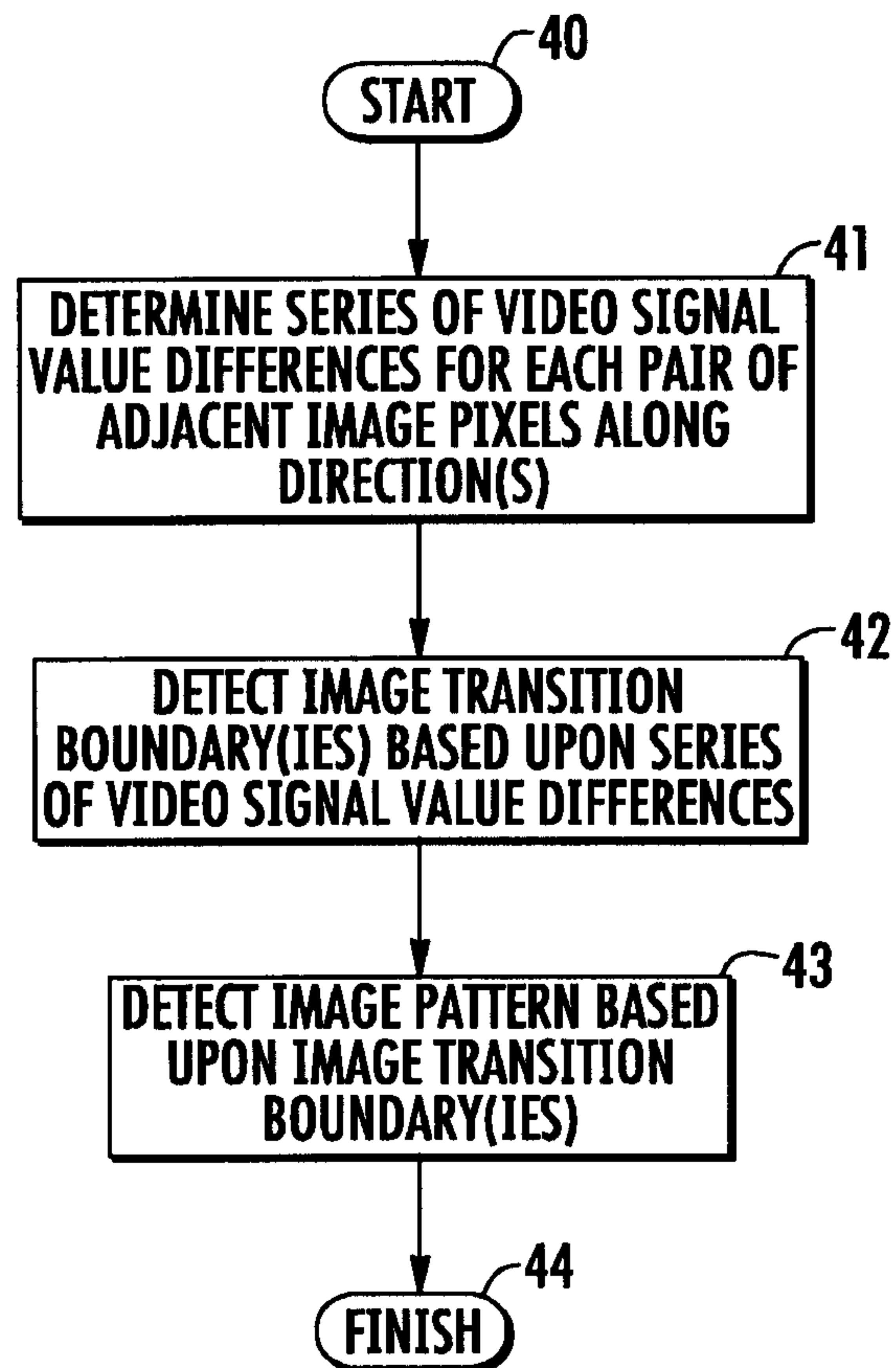
7. The method of Claim 5 wherein the image pattern comprises a fixed image pattern over a plurality of image frames or fields; and wherein detecting the image pattern comprises detecting the fixed image pattern.

8. The method of Claim 5 wherein the image pattern comprises a color bar pattern; and wherein detecting the image pattern comprises detecting the color bar pattern.

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**FIG. 1****FIG. 2**

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**FIG. 3**

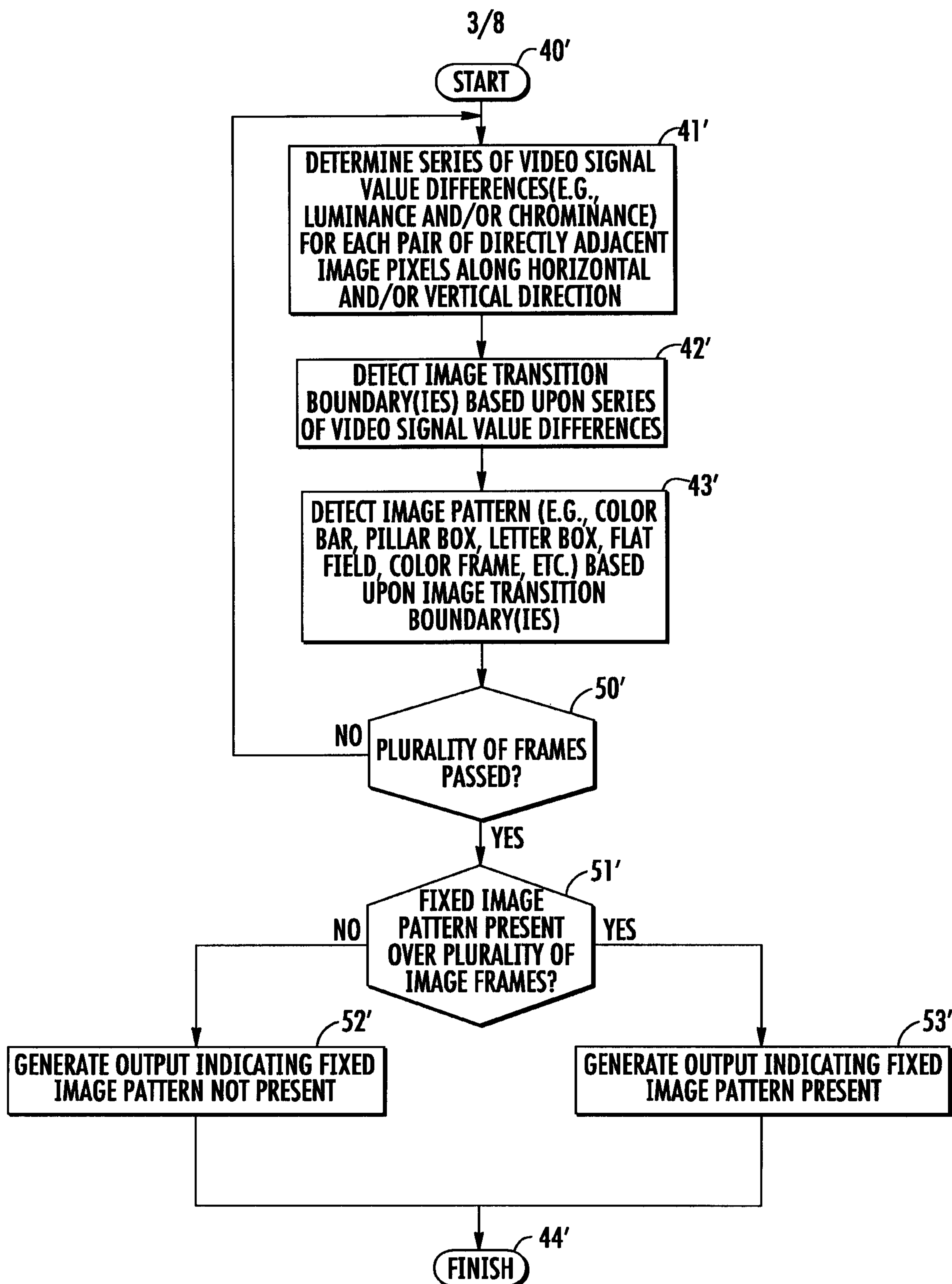


FIG. 4

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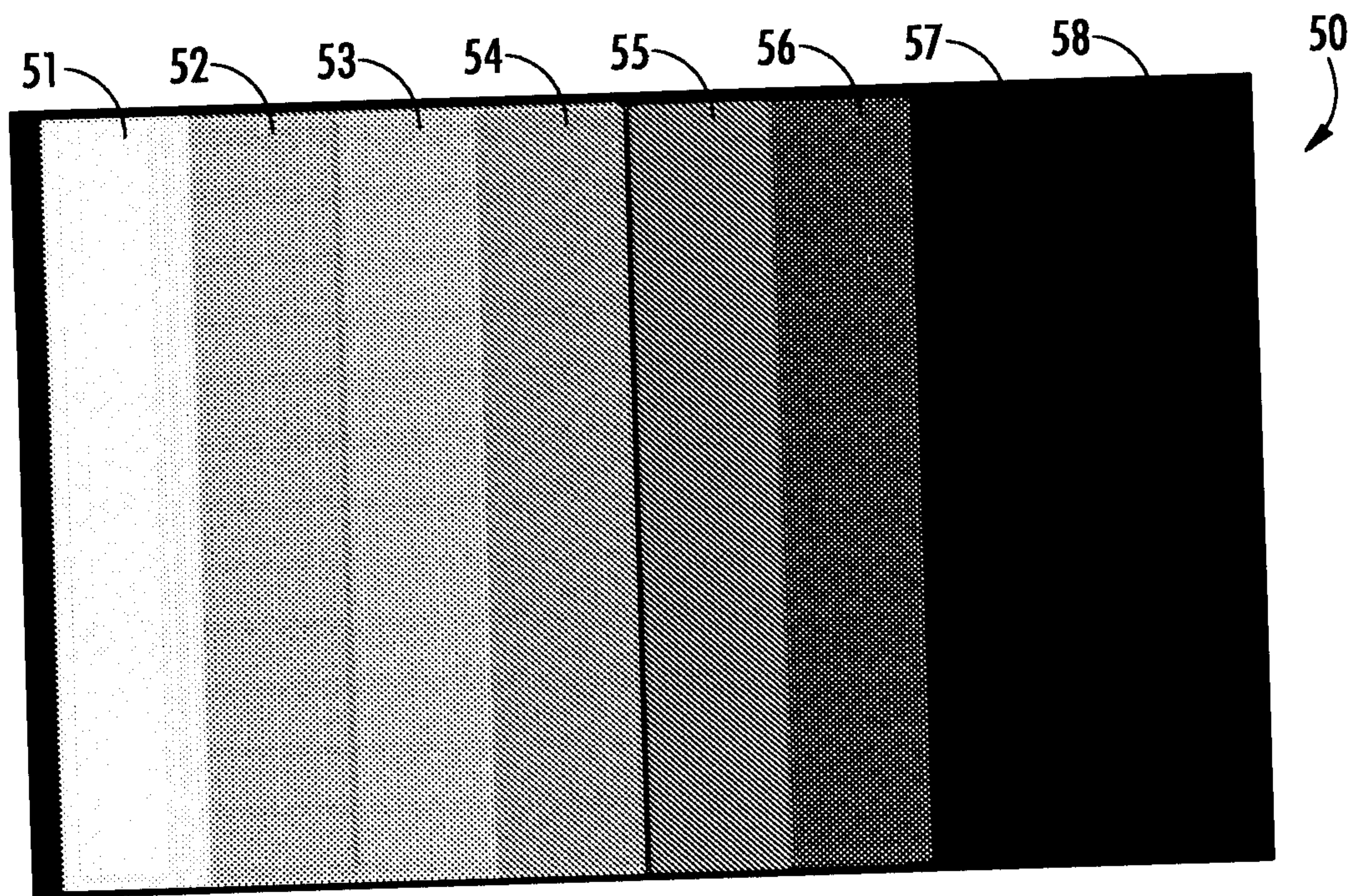


FIG. 5

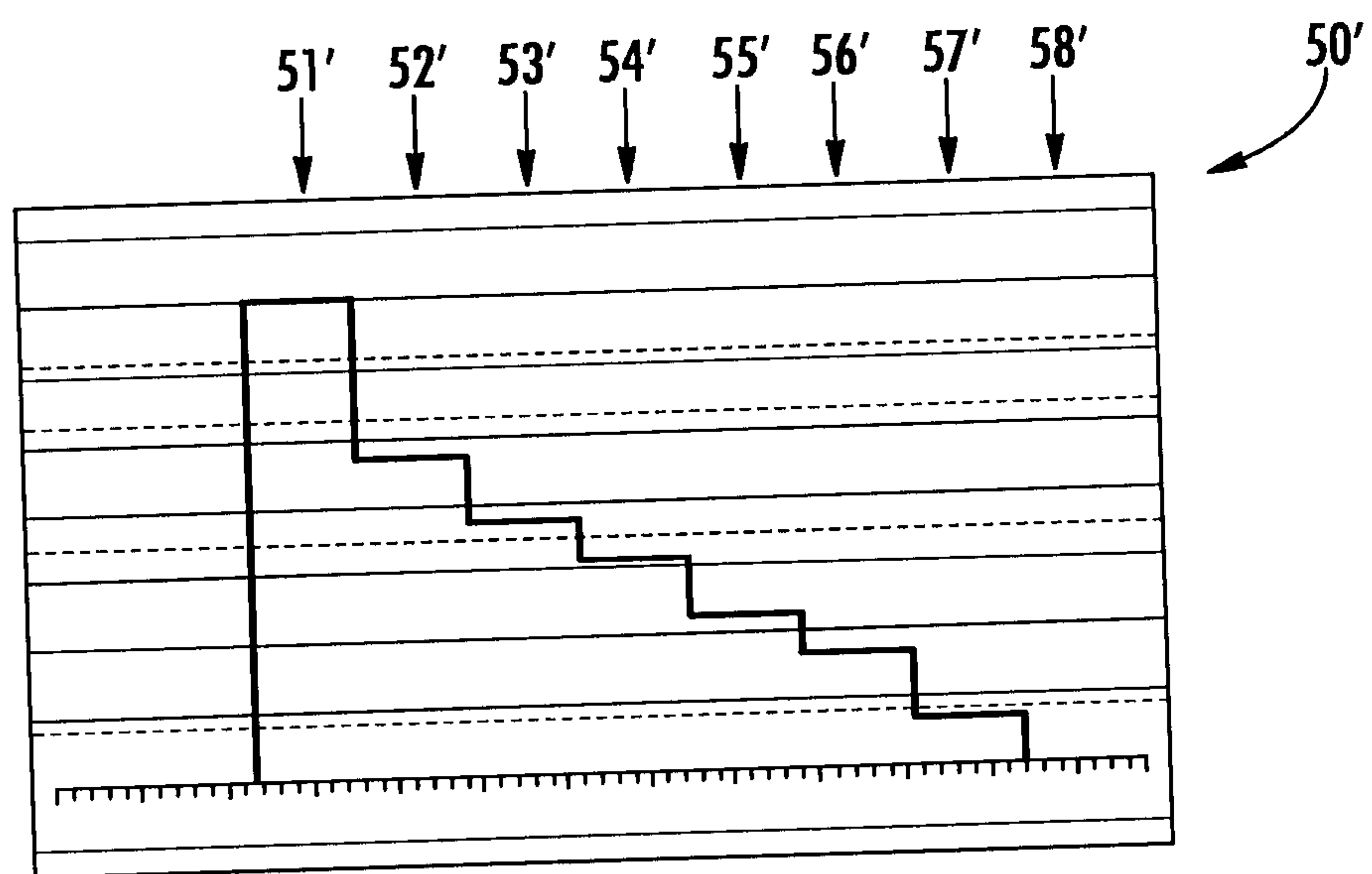


FIG. 6

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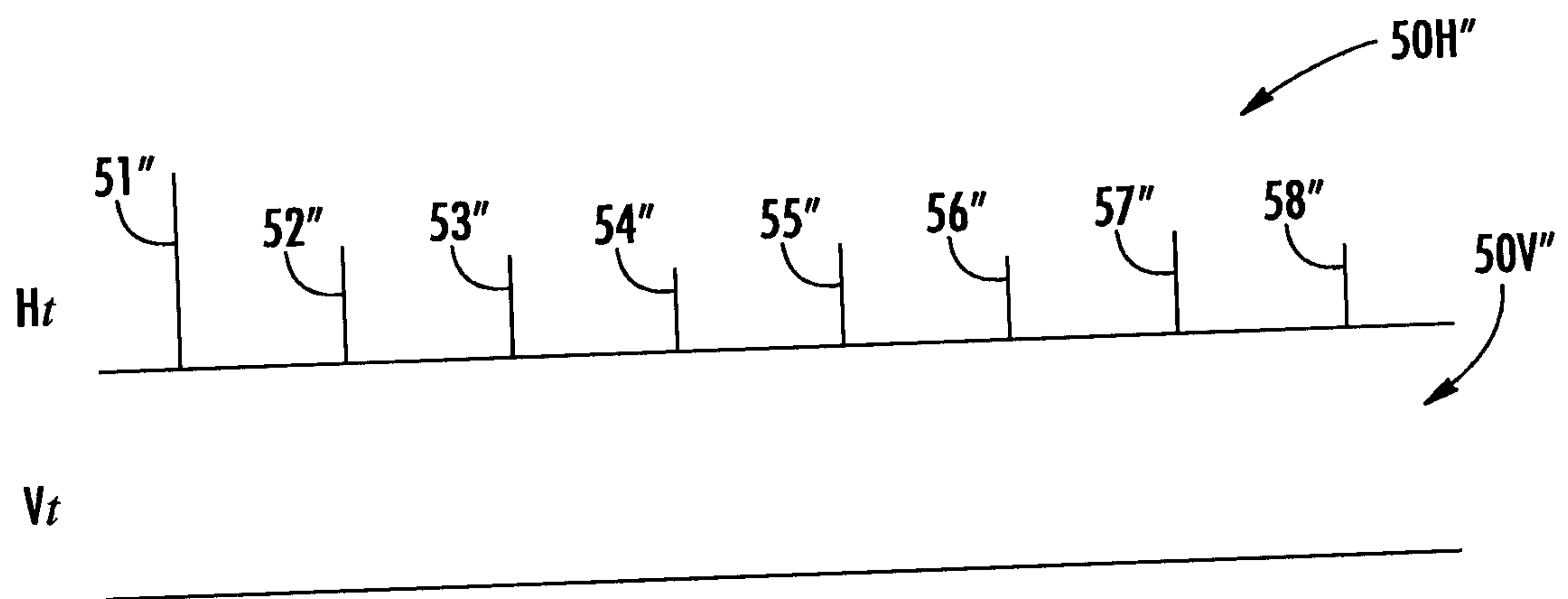


FIG. 7

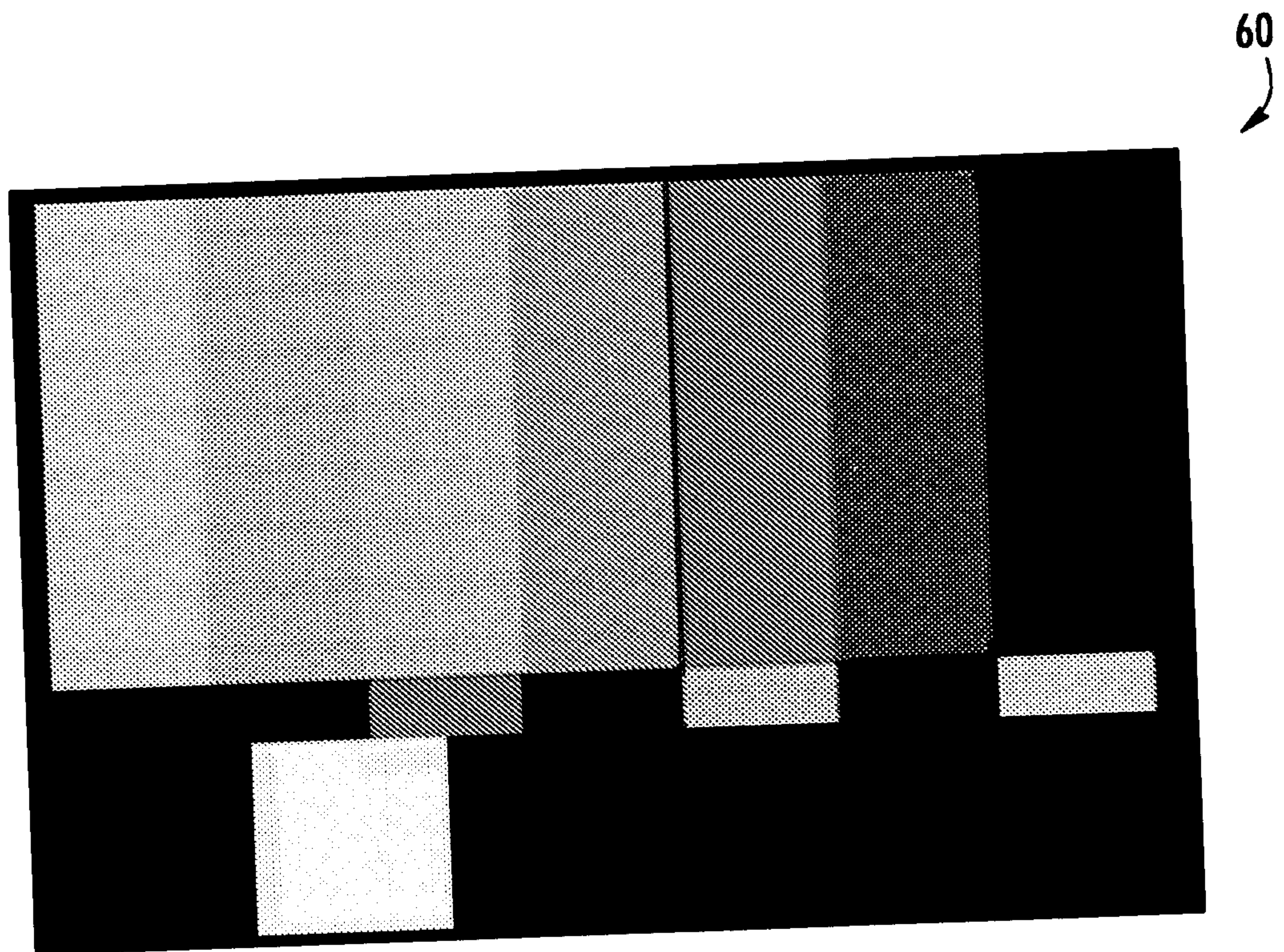


FIG. 8

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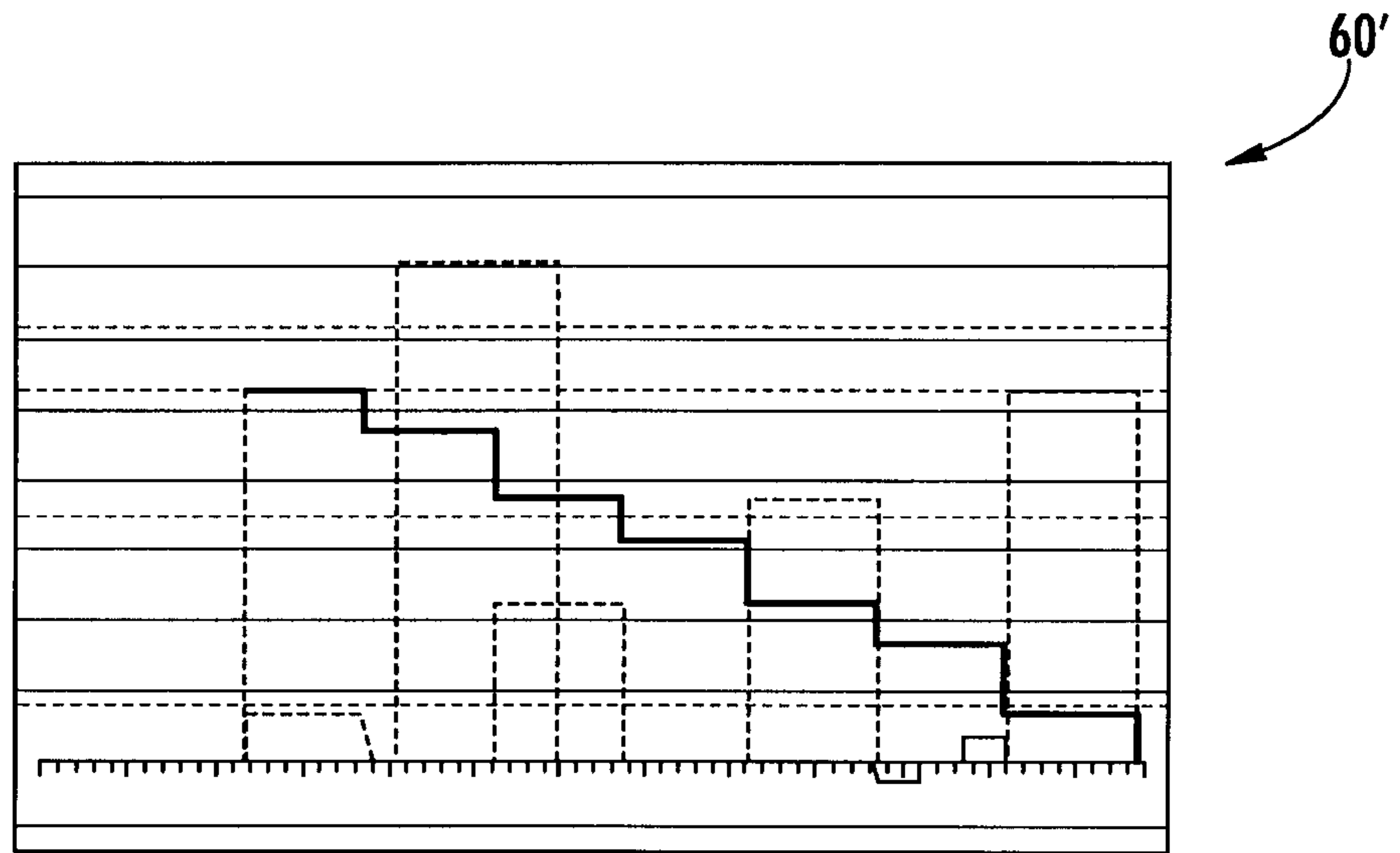


FIG. 9

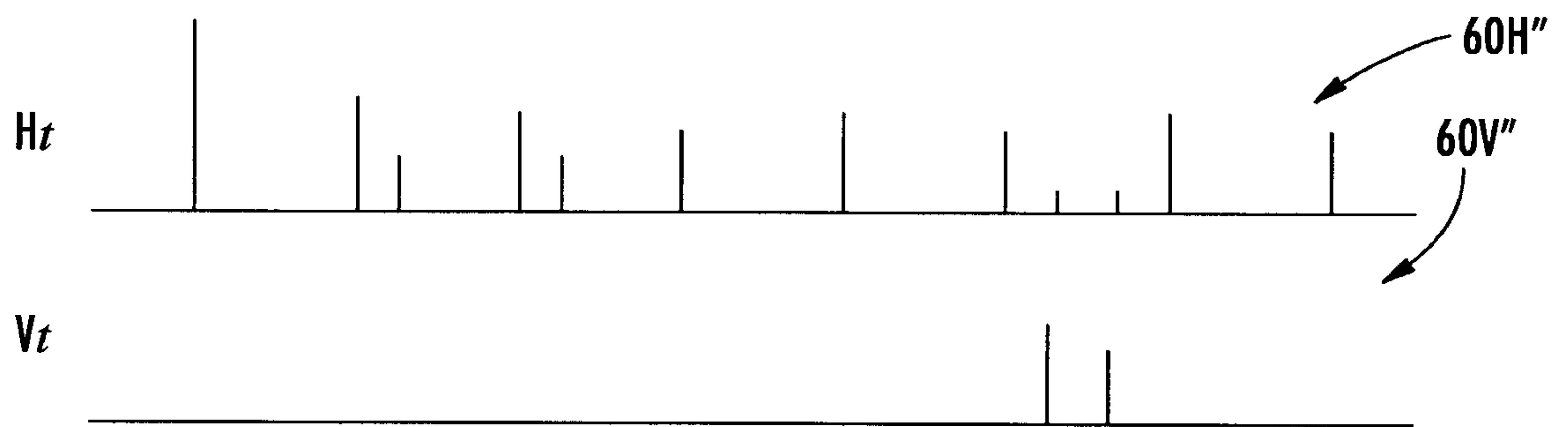


FIG. 10

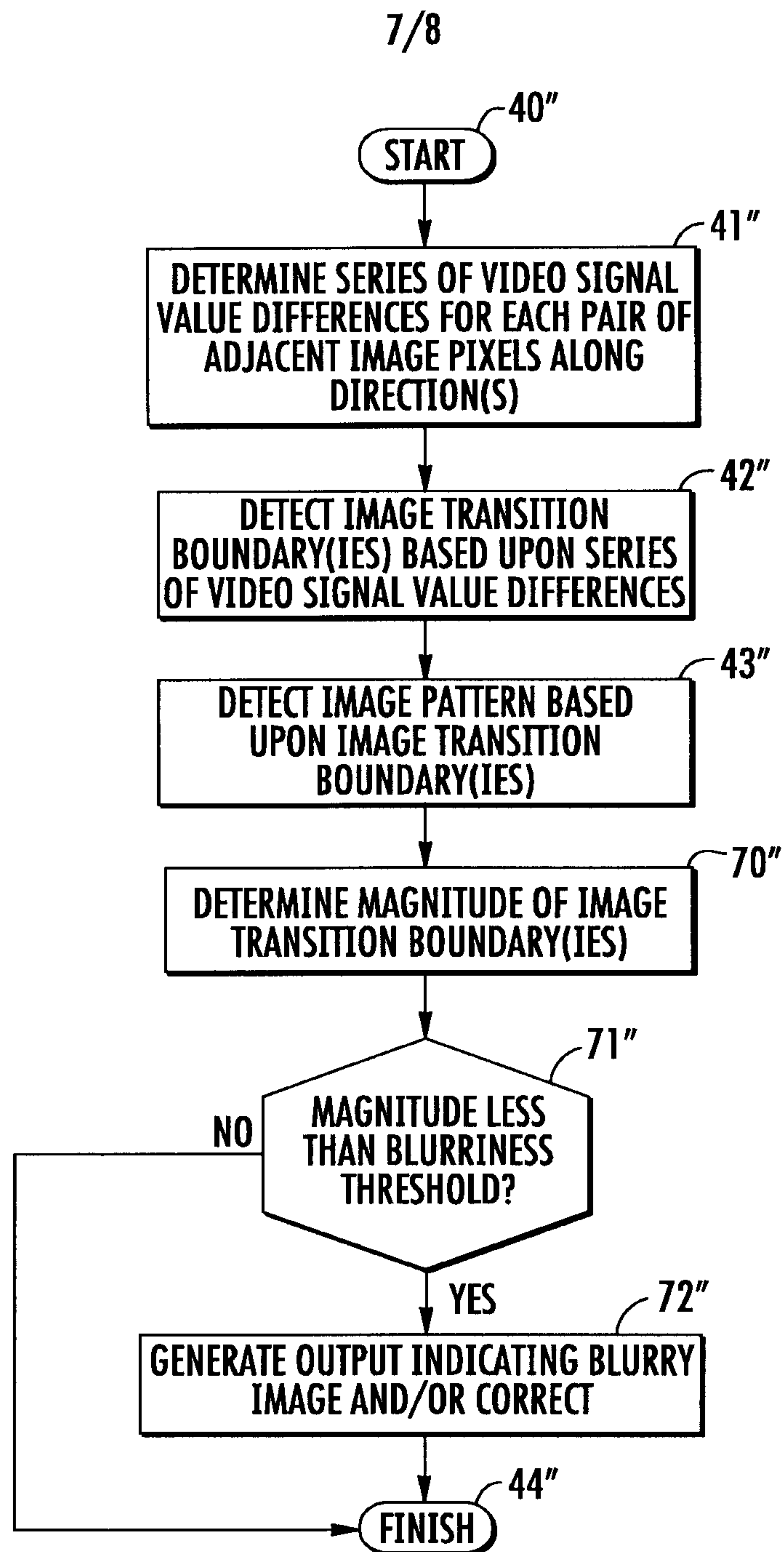


FIG. 11

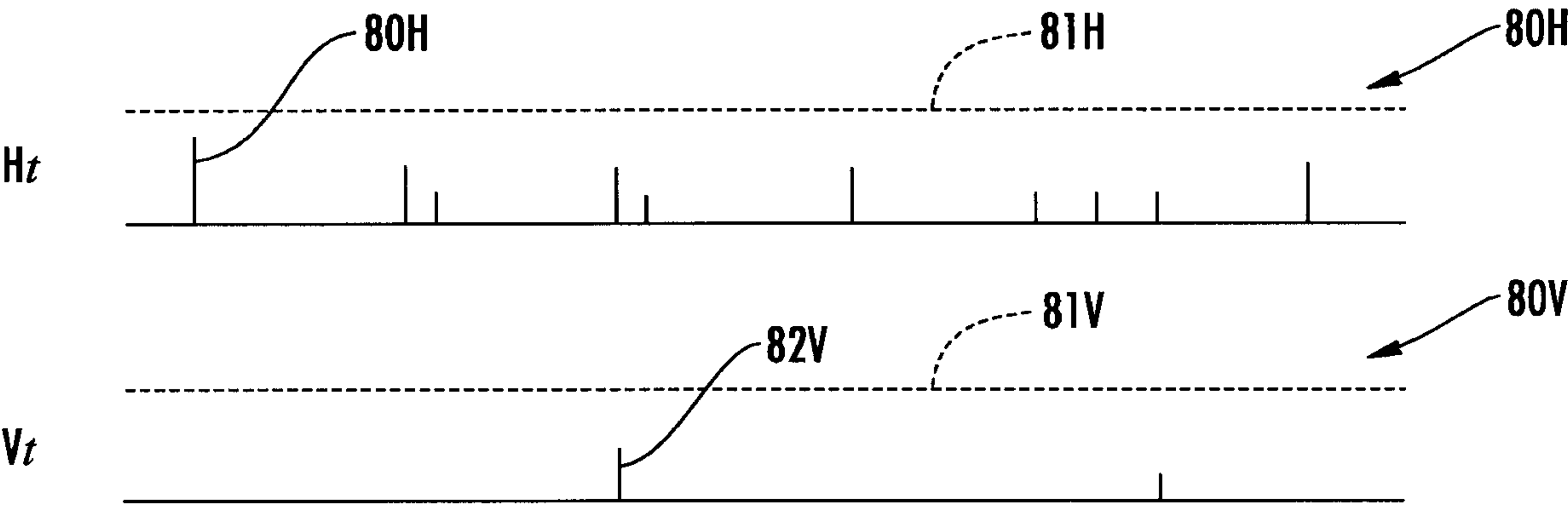


FIG. 12

