United States Patent

[11] 3,610,822

[72] Inventors William Ellis Ingham
12 Kent Avenue, Ealing, London W. 13;
Robert Justin Froggatt, 11, Thorncliff Road, Norwood Green, Southall Middlesex;
Christopher Archibald Gordon Le May, 20 St. Mary's Crescent, Osterley, Middlesex, all of England

[21] Appl. No. 807,886
[22] Filed Mar. 17, 1969
[45] Patented Oct. 5, 1971
[32] Priority Mar. 20, 1968
[33] Great Britain
[31] 13417/68

[54] **INTRUDER DETECTION APPARATUS**
8 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **178/6.8,** 178/DIG. 33
[51] **Int. Cl.** **H04n 7/18**
[50] **Field of Search** 178/6, 6.8

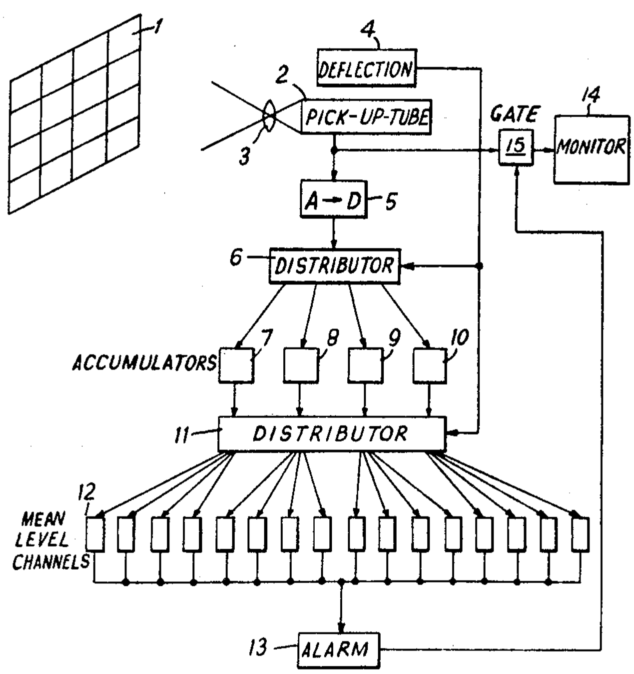
[56] **References Cited**

UNITED STATES PATENTS

2,016,036	10/1935	Fitzgerald	178/7.1 X
3,049,588	8/1962	Barnett	178/6
3,114,797	12/1963	Williams	178/6.8
3,336,585	8/1967	Macovski	340/258
3,476,947	11/1969	Burney	250/224
3,488,436	1/1970	Burney	178/6.8
3,507,992	4/1970	Foote	178/6.8

Primary Examiner—Robert L. Griffin
Assistant Examiner—Richard K. Eckert, Jr.
Attorneys—William W. Downing, Jr. and Fleit, Gripple & Jacobson

ABSTRACT: A pickup tube repetitively scans a region so as to produce video signals dependent on radiation received from the region, and operating means produce a plurality of second signals which are dependent on changes in radiation from one scan to another from respective portions of the region. Alarm means produce an alarm signal when any of the second signals exceeds a threshold individual to the respective portion. The shapes of each of the portions may be varied and the second signals may be weighted. A plurality of pickup tubes may be provided each arranged to survey a different region, the pickup tubes being sequentially monitored by the operating means. In another embodiment two pickup tubes are provided one having a longer lag than the other, and the video signals derived from the two tubes for the respective portions of the region compared to produce the second signals.



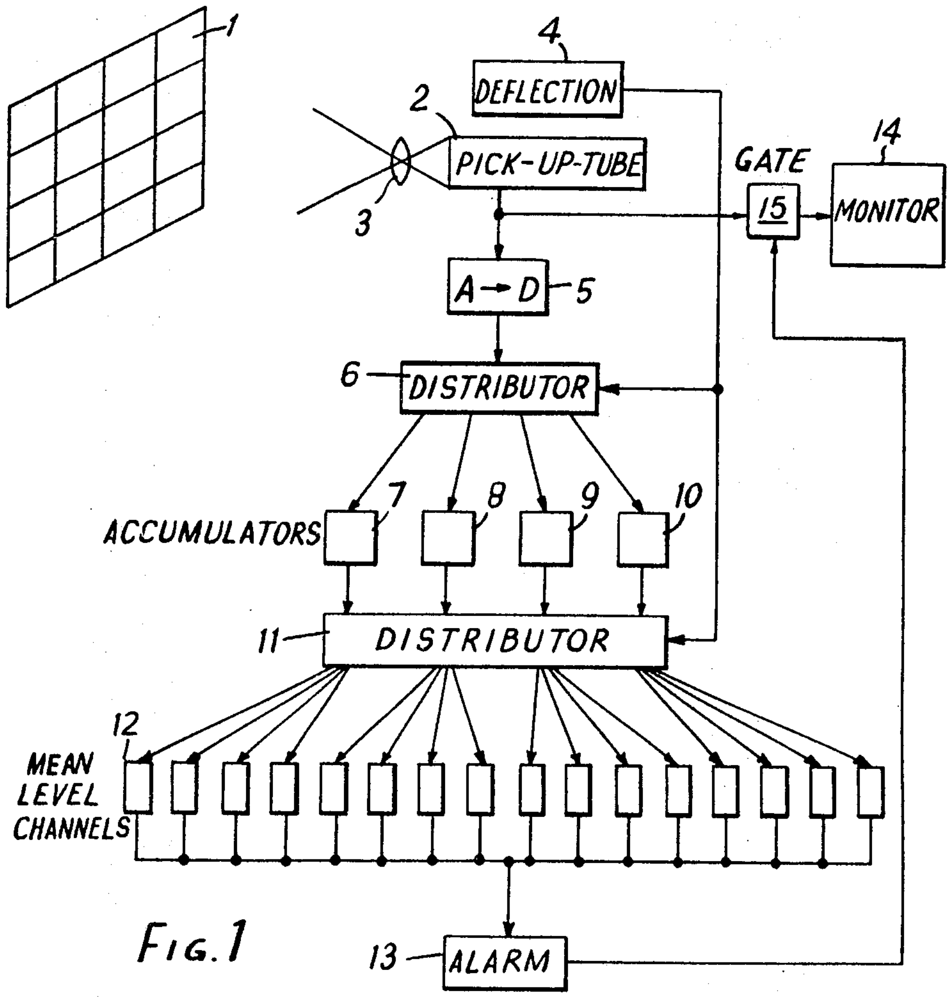

1
4
DEFLECTION
2
PICK-UP-TUBE
3
GATE
14
15
MONITOR
A→D
5
6
DISTRIBUTOR
7
8
9
10
ACCUMULATORS
11
DISTRIBUTOR
12
MEAN
LEVEL
CHANNELS
13
ALARM

FIG. 1

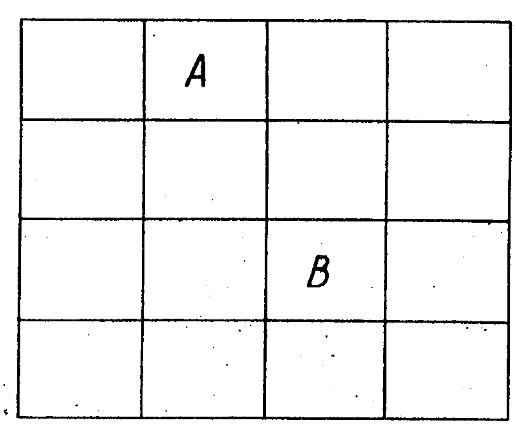

A
B

FIG. 2.

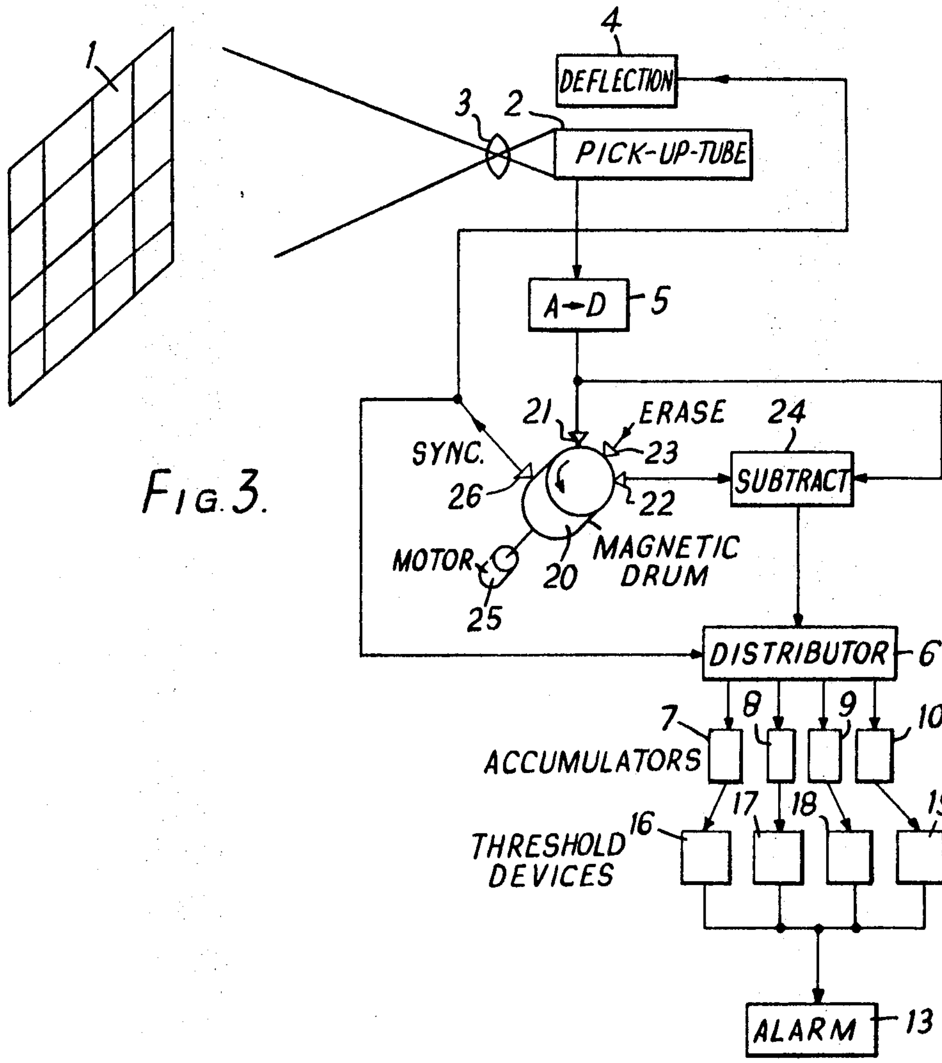


FIG. 3.

FIG. 4.

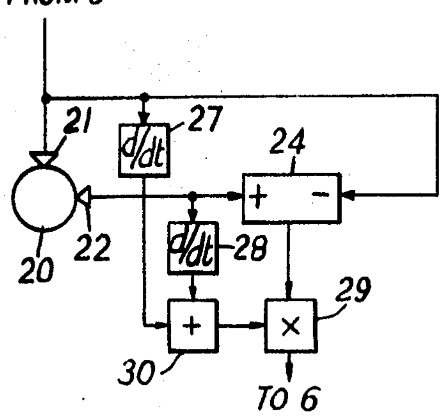
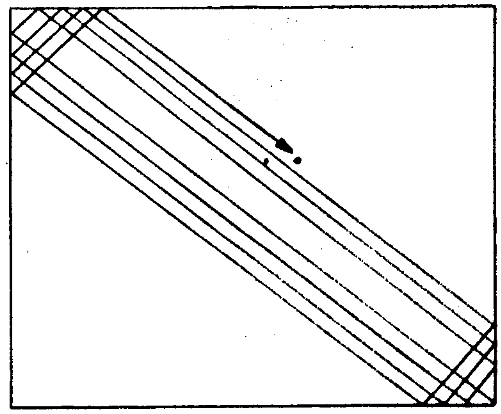


FIG. 5



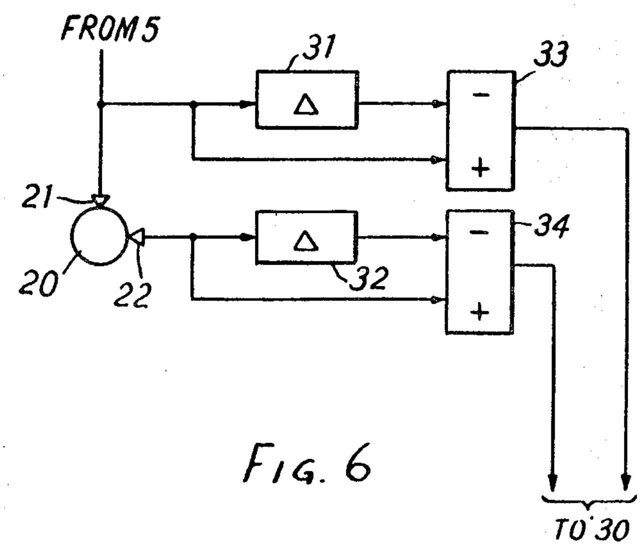

FROM 5
31
33
Δ
−
+
21
20
22
Δ
32
−
34
+
TO 30

FIG. 6

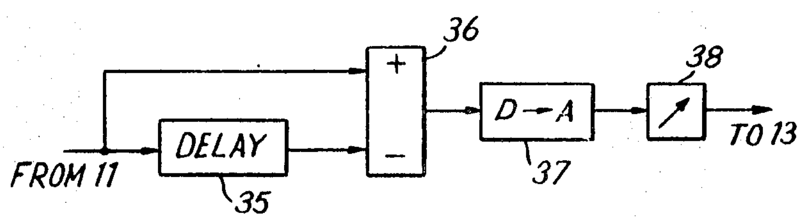

36
+
38
DELAY
−
D→A
TO 13
FROM 11
35
37

FIG. 7

INTRUDER DETECTION APPARATUS

The present invention relates to apparatus for detecting the presence of an intruder in a region to be protected.

It has been proposed to provide a surveillance system for the security of classified areas and prisons for example, but such systems have the disadvantage that an operator is required to watch one or possibly several monitors to which the images of the region under surveillance are relayed, for example, by closed circuit television. To relieve the operator of the onerous task of observing all of the monitors all of the time it has been proposed to provide intruder detecting means which includes means for smoothing the video signal from a pickup tube so as to produce a signal representing the mean intensity of the radiation from the region to which the pickup tube responds and an intruder in that region will produce a small change in the mean level of radiation from the region which can be detected by a suitable threshold circuit. However, because an intruder will inevitably represent only a small portion of the region surveyed by the pickup tube the threshold level has to be set very accurately and maintained if the small change is to be detected and if the apparatus is set up so as to be responsive to such small changes, false alarms can easily be produced for example, by swaying trees.

It is an object of the present invention to provide movement detection apparatus which may conveniently be added to a closed circuit television surveillance system to give warning of the likely presence of an intruder, but one in which the likelihood of false alarms is reduced.

According to the present invention there is provided apparatus for detecting movement in a region, comprising

a. at least one pickup tube arranged to repetitively scan the region to produce video signals dependent on radiation received from said region,

b. means for operating on said video signals for deriving a plurality of second signals which are dependent on changes from one scan to a later scan in the radiation from respective portions of said region,

c. means for passing each second signal to a threshold circuit having a threshold individual to the respective portion, and

d. means for producing an alarm signal when any of said second signals exceeds a respective threshold.

In the two preferred examples of the present invention the video signals from a television type pickup tube are operated on so as to derive the video signal contributions from separate portions of the field of view of the pickup tube, and the contributions from each portion of the field of view are processed to detect a change of state in either of the ways subsequently to be described. If such a change is detected the magnitude of which exceeds a threshold which is determined independently for the different portions of the field of view, then an alarm indication is produced. Because the threshold is set independently for the different portions of the field of view it is possible to isolate those portions which are subject to a lot of background movement due to for example, the movement of trees, from those where the background is more or less constant, so that in these latter areas a small movement may be more easily detected. In addition, because of the division of the field of view in to a number of portions the change produced by the presence of an intruder is a larger proportion of the signal from that portion of the field than it would be as a proportion of the whole field.

In order that the invention may be fully understood and readily carried into effect, it will now be described with reference to FIGS. 1, 2, 3, 4, 5, 6 and 7 of the drawings accompanying the specification of which:

FIG. 1 is a diagram of one example of apparatus according to the present invention,

FIG. 2 is a diagram to be used in explaining the operation of the apparatus shown in FIG. 1,

FIG. 3 is a diagram of apparatus according to another example of the invention,

FIG. 4 shows a modification of the apparatus shown in FIG. 3,

FIG. 5 is a diagram to be used in explaining a further modification of the apparatus shown in FIG. 3,

FIG. 6 shows an alternative further modification of the apparatus shown in FIG. 3, and

FIG. 7 is a diagram to be used in further explaining part of the apparatus shown in FIG. 1.

Referring initially to FIG. 2, the large rectangle corresponds to the boundary of the field of view of a pickup tube and as shown for the purpose of illustration only this is divided into sixteen small rectangular portions each having an area of one-sixteenth of that of the large rectangle. As explained above, if the portion A includes a tree which is blown about by the wind, then the part of the video signal representing this portion will be subject to a number of small changes continuously, and in accordance with the invention the threshold for this portion is set to a relatively high value so that false alarms are not produced as a result of the movement of the tree. In another portion, such as for example B, suppose that the background is stable so that the video signals show substantially no change from one field scan to the next, and therefore the threshold for this portion can be made very small so that the entry of an intruder into this portion would more readily be detected than if the threshold necessary to avoid false alarms from the portion A had been used for all of the portions of the field of view. It will be appreciated that in some arrangements of the apparatus it may be more desirable to make comparison not between one field scan and the next but between one field scan and a subsequent one say N field scans later so as to ensure detection only of significant movements. Of course, if an intruder had entered the portion A then his chances of detection are much lower owing to the higher threshold of this portion, but nevertheless owing to the fact that the portion A is of smaller area than the entire field of view the chances of detection of an intruder are greater than if the mean intensity of radiation from the whole field of view was monitored to detect the intruder. It will be appreciated that the division of the field of view into a number of rectangular portions all of the same size is only one example of a suitable subdivision. Other subdivisions may alternatively be used and not only may the shapes of the portions be other than rectangular but they need not necessarily be all of the same size.

Referring now to FIG. 1 the region to be protected is represented by the grid 1 symbolizing the division into 16 portions, and an image of this region is focused on the target of the pickup tube 2 by lens 3. The pickup tube 2 is provided with deflection circuits 4 which cause the electron beam of the tube to scan an electron beam in a conventional television raster over the target of the tube 2 to produce a video signal which is applied to the analogue to digital converter 5. The converter 5 operates sufficiently rapidly to produce successive digital outputs each of three binary digits at a frequency approaching that corresponding to the smallest resolvable detail of the pickup tube. The digital signals from the converter 5 are applied to distributor 6 which divides the digital signals among four accumulators 7, 8, 9 and 10 under the control of signals from the deflection circuits 4. Each of the four accumulators 7, 8, 9 and 10 corresponds to a column of four portions of the region but is allowed to accumulate only the digitized video signal components corresponding to a single portion at a time. A second distributor 11 also controlled by the deflection circuits 4 applies the accumulated totals from the accumulators 7, 8, 9 and 10 to respective ones of corresponding sets of four of the channels 12 in such a way that each of the 16 channels 12 corresponds to a respective portion of the region. In each of the channels 12 the incoming total from an accumulator is compared with the total from a previous scan of the region made, for example one field scan earlier, and if the difference exceeds a threshold level an output signal is produced which is applied to an alarm circuit 13. A suitable arrangement for effecting this is shown in FIG. 7 which shows in block diagrammatic form just one of the channels 12. The accumulated total from, one of the accumulators 7, 8, 9, or 10 corresponding to one of the 16 portions is applied from distributor 11 as an input both to a delay 35 of one field scan and to subtractor 36. The output of delay 35 is applied as the other input to subtractor 36. Thus the output of subtractor 36 comprises a digital signal which is the difference between the accumulated total from one scan and a scan one field scan earlier. Alternatively delay 35 may be such that it delays an accumulated total several field scans, so as to ensure detection only of significant movements. The difference signal from subtractor 36 is passed through a digital to analogue converter 37, and thence to a threshold circuit 38 which includes means for detecting whether the magnitude of the analogue difference signal exceeds a threshold, when it provides an output to alarm circuit 13. Threshold circuit 38 can include for example rectifying circuits which feed a current to a transistor switch, any current exceeding a threshold closing said switch so that an output is provided to alarm circuit 13. Each threshold circuit 38 also includes adaptive means for setting the threshold level independently to such a value that the false alarm rate from its respective portion is acceptably low.

Also as shown in FIG. 1, but not necessarily included in all examples of apparatus according to this or any other example of the invention, is a monitor 14 to which the video signals from the pickup tube 2 are applied via a gate 15 in response to operation of the alarm 13, so that when a disturbance sufficient to actuate the alarm 13 occurs the gate 15 is opened and the scene as viewed by the pickup tube 2 is relayed to the monitor 14 for observation by the operator. In an alternative arrangement the monitor 14 may be permanently connected to the pickup tube 2 and a light operated in response to the operation of the alarm circuits 13 to draw attention to the monitor. Some means may be provided on the monitor 14 to indicate the portion of the region under observation from which the alarm signal is derived.

The apparatus shown in FIG. 1 may be modified so that the video signals are weighted in a particular way and the weighted signals from a portion combined to produce a signal which represents say the position of the centroid of the portion (with respect to radiation intensity) or the movement of the centroid of the portion about a particular axis. Alternatively, each portion may be divided into two parts and the total intensity from one part subtracted from the total intensity from the other part to produce the signal from the particular portion.

In another example of the invention the video signals from the pickup tube 2 are compared with video signals derived during a previous scan of the region and the alarm operated in response to a significant change in any portion of the region. Such an arrangement is shown in FIG. 3 where the same reference numerals are used for components which are common with the example shown in FIG. 1.

In FIG. 3 the video signals from the pickup tube 2 produced in response to deflection of the electron beam by the circuits 4 are again digitized by an analogue to digital converter 5, but in this case they are applied to writing head 21 cooperating with a magnetic drum 20 so as to record the video signals on the drum. In practice, as the digital signal consist of words of say three bits these are preferably written in parallel by three adjacent heads on three adjacent tracks of the drum 20. The video signals recorded on the drum 20 are read by the reading head 22 and applied to one input of a subtractor 24, the other input of which receives the signals directly from the converter 5. The rate of rotation of the drum 20 and the positioning of the heads 21, 22 are so arranged that the signals derived during one field scan of the target of the tube 2 are reproduced by the head 22 in synchronism with the signals derived from the pickup tube during the next field scan. Thus, the output of the subtractor 24 has a succession of digital signals representing the change in the scene as viewed by the pickup tube 2 during one field scan and these digital signals are distributed by the distributor 6 to the accumulators 7, 8, 9 and 10 under the control of synchronizing signals derived from another track of the drum 20 by the head 26. The synchronizing signals are also used to synchronize the operation of the deflection circuits 4. The drum 20 is rotated by a motor 25 and an erasing head 23 is provided between the reading head 22 and the writing head 21 to erase the previously stored information just prior to the writing of the next information.

As before the accumulators 7, 8, 9 and 10 are each allowed to accumulate a total corresponding to one portion of the region and the total is applied to a respective one of the threshold devices 16, 17, 18 and 19 which produces an output signal when the total difference signal from the accumulator exceeds a threshold value. The output signals of the threshold devices 16, 17, 18 and 19 are applied to an alarm circuit 13. So as to enable a different threshold value to be used for each portion of the region under surveillance different threshold values must be available for the threshold devices depending upon the portion of the region to which the total in the accumulator being fed to the particular threshold device at the time corresponds, the necessary circuits for effecting this change of threshold are not shown in the FIG. as they may follow conventional digital computer techniques. As before the setting of the thresholds may be adaptive.

The arrangement described above with reference to FIG. 3 simply produces a measure of the difference between the portion of the region in one field scan and the same portion of the region in the next field scan and to avoid spurious alarm signals it is desirable that the threshold values are not set too low. However, the threshold values could be reduced without causing an increased number of spurious false alarms to be signalled by the alarm circuit 13 if this circuit is made responsive only to a progression of disturbances exceeding the thresholds across the region from one portion to another; logic circuits for effecting this could be included in the alarm circuits 13. Signals exceeding the thresholds in any one portion, or in portions located at random would not then cause the alarm to be given. This could also be applied to the arrangements of FIG. 1.

Moreover the examples of apparatus according to the present invention as so far described are operating on only one pickup tube, but it is possible that they may be arranged so as to operate sequentially on each of a plurality of pickup tubes each one of which surveys a different region. In such arrangements only one display monitor would be required which would display that region in which an intruded portion caused the alarm to be operated.

A modification may be made to the apparatus shown in FIG. 3 to weight the differences from the subtractor 24 in such a way as to make the apparatus substantially more sensitive to coherent movement of a body within one portion of the region. The weighting is achieved by multiplying the difference signals from the subtractor 24 by the sum of the first derivatives with respect to time of both the video signal from the converter 5 and the video signal from the head 22. The theoretical basis for this weighting is fully described in copending U.S. Pat. application Ser. No. 753,282. This modification is shown in FIG. 4 which shows just the modified part of the apparatus of FIG. 3 using the same references for components common to both figures. In FIG. 4 the signals from the converter 5 in addition to being applied to the head 21 and the subtractor 24 are also applied to a differentiator 27. The signals read from the drum 20 by the head 22 as well as being applied to one input of the subtractor 24 are applied to a differentiator 28. The signals representing the first derivatives with respect to time produced by the differentiators 27 and 28 are added together in adder 30 and used to multiply the difference signals from the subtractor 24 in the multiplier 29. The output signals from the multiplier 29 which are also in digital form are the weighted differences between the two video signals and are applied to the distributor 6 for handling as described above with respect to FIG. 3.

The modification shown in FIG. 4 has the effect of summing error signals due to coherent movement of a body horizontally across the region, but it is not sensitive to movement vertically within the region because the differences arising as a result of up or down movement of a body in this way affect different lines of the scan (this is assuming a conventional raster with a horizontal line scan). However, this difficulty can be overcome by the use of an orthogonal scanning technique as shown in FIG. 5 and described in the aforesaid specification in which the field of view is scanned by two sets of diagonal lines inclined more or less at right angles to one another. With such a scan the circuit arrangement described above with respect to FIG. 4 is sensitive to coherent movement of a body along both directions of the scanning lines and therefore movement of a body over the region in any direction can be more easily detected. Of course, if such a modified scan is used it is necessary that any monitor responding to video signals from the pickup tube 2 must have the same type of scan. Alternatively the output from multiplier 29 in FIG. 4 may also be used to control the scan raster of pickup tube 2 via deflection circuits 4 so as to make the image from pickup tube 2 agree with the image stored on drum 20, despite either spurious movements in the region 1 or drifts in the scanning circuits of pickup tube 2. In this case it is not necessary to provide updated information to drum 20 via head 21 every field scan. The theoretical basis for this is also described in the aforesaid specification.

If it is still desired to use only a conventional television scan raster and yet to render the apparatus substantially more sensitive to coherent movements in the vertical direction as well as the horizontal a modification can be made in which the differentiators mentioned above in the case of vertical movements, include one scan line delays and subtractors. Thus a one line delay is placed in the signal path of both the video signal direct from the converter 5 and the video signal from the head 22, and their outputs subtracted from their respective inputs one line later. These differences are a measure of the rate of change with respect to time of the signal in the vertical direction, derived from a finite difference between adjacent lines instead of the actual time derivative. This modification is shown in FIG. 6 which shows just the modified part of the apparatus of FIG. 4, using the same references for components common to both figures. Video signals from the converter 5 and the head 22 are passed through line delays 31 and 32 respectively and thence to subtractors 33 and 34 respectively in which they are subtracted from that input to the respective delay which arrives one line later. The two differences are added in adder 30 and the sum multiplied in multiplier 29 by the difference signals derived from subtractor 24 as in FIG. 4.

In yet another example of the invention, two pickup tubes are used one having a longer lag than the other, and the video signals derived by the same scanning waveforms from the two tubes are compared. If there is no change in the field of view the outputs of the two pickup tubes will be the same, a servomechanism being included if necessary to correct minor differences between the scans of the two tubes. Any major change in the field of view however, will affect the output of one pickup tube before that of the other and will appear as a difference signal.

Although the invention has been described with reference to specific examples, it will be appreciated that it is not limited to these examples and other apparatus using the invention will be evident to those skilled in the art. Furthermore the portions of the regions under survey can have shapes which are adaptive to suit different conditions, for the following criteria: that the mean brightness level from each portion shall be the same and that all spurious movement can be contained within one portion.

What we claim is:

1. Apparatus for detecting movement in a region, comprising:

a. at least one pickup tube arranged to repetitively scan the region to produce video signals dependent on radiation received from said region,

b. means for operating on said video signals for deriving a plurality of second signals which are dependent on changes from one scan to a later scan in the radiation from respective portions of said region,

c. means for passing each second signal to a threshold circuit having a threshold individual to the respective portion, and

d. means for producing an alarm signal when any of said second signals exceeds a respective threshold.

2. Apparatus according to claim 1 including a plurality of television pickup tubes each arranged to survey a different region, and means for sequentially monitoring said pickup tubes by said operating means.

3. Apparatus according to claim 1 wherein said operating means include means for distributing contributions to said video signals from separate portions to channels, respectively representing said portions of the region, means for accumulating contributions in each channel, and means for comparing the accumulated contributions in each channel derived during one scan with contributions accumulated during an earlier scan to produce the respective second signal.

4. Apparatus according to claim 1 wherein said operating means include means for comparing contributions to said video signals from separate portions derived during different scans so as to produce difference signals, and means for accumulating the separate difference signals so as to produce said second signals.

5. Apparatus according to claim 1 including two pickup tubes, one having a longer lag than the other, and wherein said operating means includes means for comparing the video signals derived from the two tubes for the respective portions of the region to produce said second signals.

6. Apparatus according to claim 1 including means operative to response to the production of an alarm signal for causing the region surveyed to be displayed on a monitor.

7. Apparatus according to claim 4 including means for weighting said second signals.

8. Apparatus according to claim 7 including means for producing signals related to the rates of change with respect to time of said contributions to said video signals derived during different scans, means for summing said signals related to the rates of change to produce sum signals, and means for weighting each difference signals by means of the respective sum signal.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,610,822 Dated October 5, 1971

Inventor(s) William Ellis Ingham, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title page, between lines 10 and 11, insert

-- [73] Assignee Electric & Musical Industries Limited
Hayes, Middlesex, England --

Signed and sealed this 11th day of July 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
☆ U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334