

[54] COMB EFFECT ELIMINATION

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[51] Int. Cl. H04n 5/84
[58] Field of Search 178/DIG. 3, 6.7 A, 7.4

[56] References Cited
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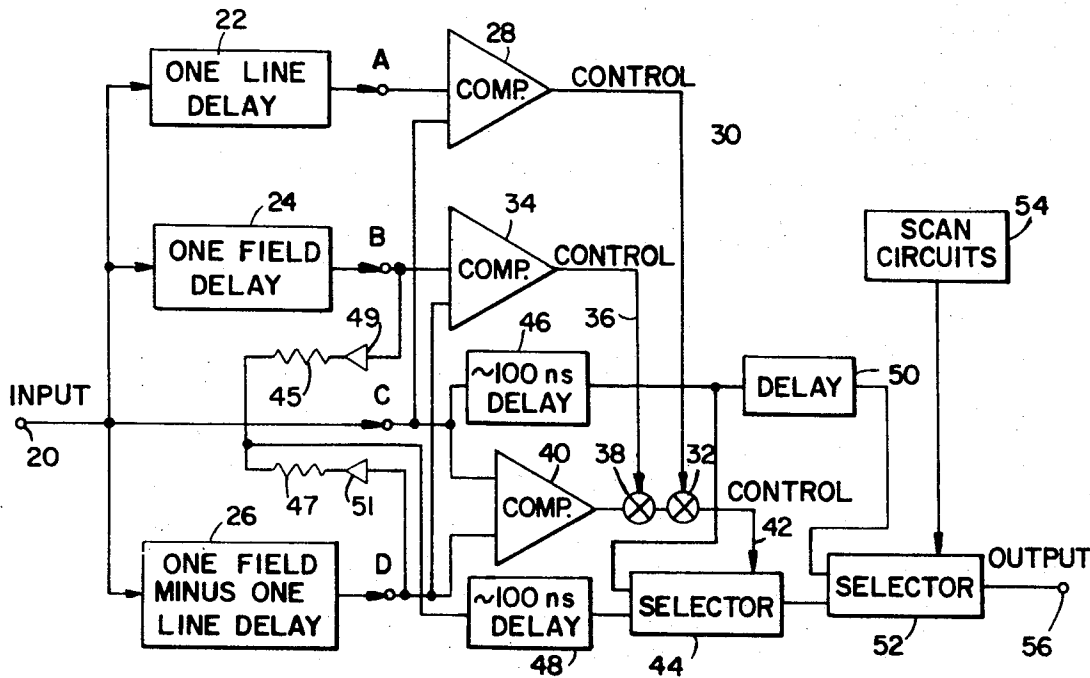
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[57] ABSTRACT

The so-called "comb effect" in the recording of video pictures on film, caused by the lateral displacement of a moving object against a contrasting background during the time interval between an odd-field scan and the corresponding even-field scan interlaced with the odd-field scan to form a frame of the video picture, is eliminated by comparing each line of the even-field scan (the prime line) with the preceding even-field line and with the preceding odd-field line, and comparing the preceding odd-field line with the following odd-field line. If the comparisons show identity between the pair of even-field lines and between the pair of odd-field lines, but a difference between the prime line and the odd-field line, the circuit substitutes adjacent odd-field information for the prime line information; otherwise the circuit transmits the prime line unchanged. During the odd-field scan, all lines are transmitted without change.

8 Claims, 4 Drawing Figures



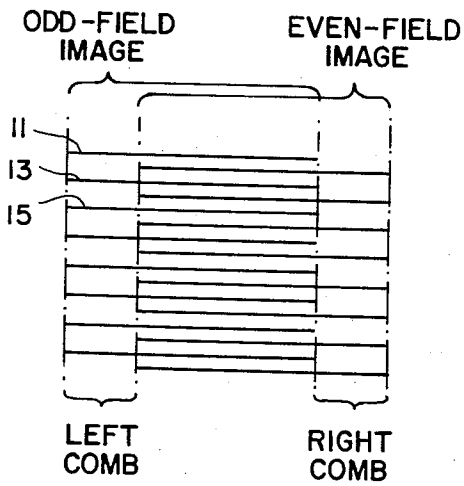


FIG_1

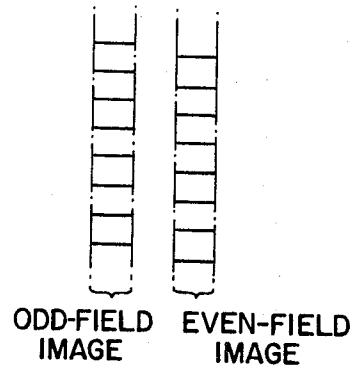


FIG_2

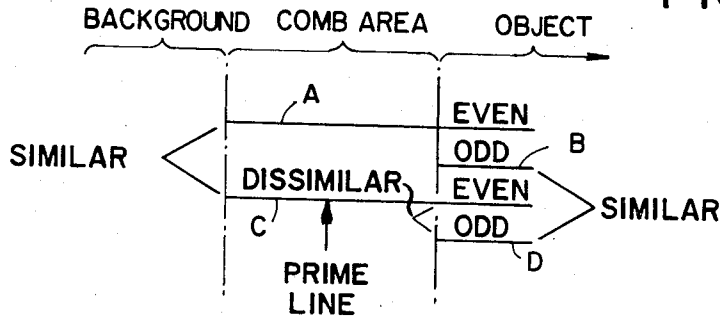


FIG_3

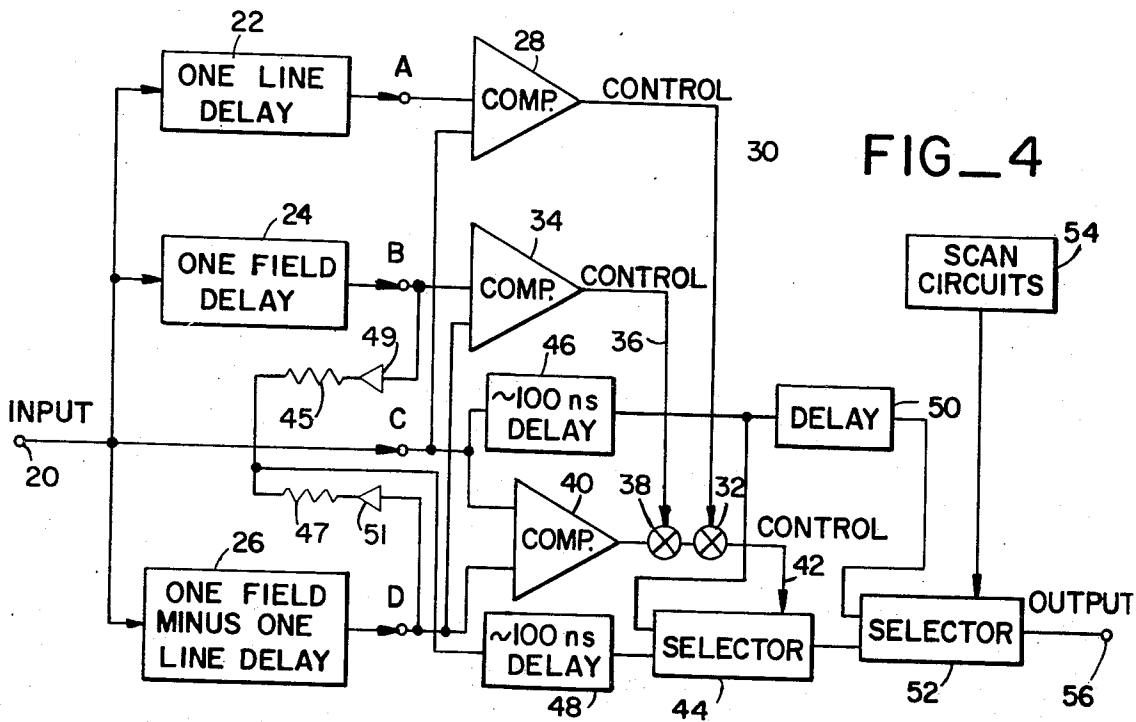


FIG_4

COMB EFFECT ELIMINATION

BACKGROUND OF THE INVENTION

In the recording of video pictures on film, a generally horizontal movement of an object having a pronounced, generally vertical edge tends to produce a so-called comb effect in the picture because of the simultaneous presentation of two image fields displaced from one another in time. This comb effect is due to the fact that the standard video picture is composed of an interlaced pattern in which all the lines of one parity (e.g. the odd lines) are scanned first, and all the lines of the opposite parity (e.g. the even lines) are scanned thereafter. Each frame of the picture is thus composed of two interlaced time-separated fields of opposite parity.

In the standard video system, the time separation between successive field scans is 1/60 second. This time is long enough for an object in a reasonably active scene to move a very noticeable distance, so that the object appears in different positions in the odd lines and in the even lines of the picture, which are presented simultaneously in the viewing of the film. The visual effect produced in a very sharp picture is an annoying serration of the moving edge which looks like the teeth of a fine comb. This problem does not exist in pure video applications because of the sequential presentation of the fields in their proper time relationship.

One way of overcoming the comb effect would be to produce the signal for the even-field scan from a continuous interpolation between the odd lines on each side of the even line being scanned. This approach, however, is not practical for high-resolution systems because it cuts the vertical resolution in half. Consequently, a more sophisticated approach was needed.

SUMMARY OF THE INVENTION

The comb effect elimination technique of this invention is based on restricting the corrective methods to those portions of the image in which motion is detected. In its most basic form, the inventive technique involves selecting, first of all, one field of each frame of the video image as the dominant or primary-parity field. The other field then becomes the secondary-parity field and is replaced by information derived from the primary-parity field whenever an image element of a secondary-parity line is inconsistent with the corresponding image element of an adjacent primary-parity line. If the odd field is chosen as the dominant or primary-parity field, the basic principles of the invention may be carried out by simply comparing each even line with an adjacent odd line. If there is a difference between the compared lines, the circuit substitutes an interpolation of the next preceding and following odd-line signals for the even-line signal as long as the difference lasts.

Although this basic technique is useful and satisfactory to a degree, it still detracts from vertical sharpness because it is incapable of distinguishing between a comb and a horizontal interface. However, the detraction occurs substantially only in moving portions of the picture, where sharpness is much less critical than in the stationary portions.

In accordance with the preferred embodiment of the invention, three image parameter comparisons are

made instead of just one. The first comparison is between the secondary-parity prime line (e.g. an even line) and an adjacent secondary-parity (i.e. even) line. The second comparison is between the two primary-parity (i.e. odd) lines adjacent to the prime line. The third comparison is between the secondary-parity (i.e. even) prime line and an adjacent primary-parity (i.e. odd) line.

If a comb-effect situation is present, the first and second comparisons must each show identity (otherwise a horizontal interface is present); while the third comparison must show a difference (otherwise no comb is present). Only while all three conditions are true is interpolation of adjacent opposite-parity (i.e. odd) lines substituted for the prime line. Although a single odd line may be substituted for the prime line in the motion areas, an interpolation is preferable because it softens the step effect prone to appear along a diagonal interface.

The disadvantage of the preferred method is that the comb effect must occur over a minimum of 4 lines before it can be eliminated. However, experience has shown that the comb effect does not become annoyingly noticeable unless it occurs over a substantial number of lines.

In processing a color video signal, the comb elimination has to be done separately in the luminance channel and in the chroma channel, as the phase relationship of the chroma signal between adjacent lines of the same parity requires a 180° phase inversion of one of the signals in each of the first and second comparison steps.

It is therefore the object of this invention to provide a method of eliminating the comb effect in video images recorded on film.

It is another object of the invention to provide a method of the type described in which information derived from at least one primary-parity line of an interlaced scan is substituted for corresponding information of an adjacent secondary-parity line whenever relative motion between the two lines is detected.

It is a further object of the invention to provide a method of the type described in which a line of an interlaced scan is substituted for an adjacent line of opposite parity when, and only when, the mutual relationships of a group of four adjacent lines are such as to indicate the presence of a comb.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a scan diagram illustrating the comb effect; FIG. 2 is a scan diagram illustrating a double-image comb effect;

FIG. 3 is a scan diagram illustrating the comparisons involved in the preferred embodiment of the method of this invention; and

FIG. 4 is a block diagram illustrating an electrical circuit for carrying out the method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The so-called comb effect phenomenon is illustrated in FIG. 1. In that figure, it is assumed that a black object in the picture is moving from left to right against a white background. During the odd-field scan, the object is essentially in the position labeled "odd-field image," and it is traced in the picture by the odd scan

lines 11, 13, 15, etc. By the time the even-field scan reaches the object 1/60 second later, the object has moved to the position labeled "even-field image," where it is traced in the picture by the even scan lines 12, 14, 16, etc. As a result, when both fields are presented simultaneously as a single frame of movie film, the picture of the black object is bordered on each side by a comb area in which the black lines of the object alternate with the white lines of the background.

If the object is thin and moves quite fast (e.g. in a scene showing a golf club being swung), the comb effect can degenerate into a double image, as illustrated in FIG. 2.

A simple interpolation technique in which each even line is replaced by an interpolation of the odd line above it and the odd line below it certainly gets rid of the comb effect. On the other hand, the resulting 50 percent loss of vertical resolution causes the picture to look soft or out-of-focus, and the simple interpolation technique is therefore unusable in those high-quality applications in which the comb effect causes a problem to begin with.

The basic concept of the invention resides in using interpolation (or any other kind of line substitution) only in those areas of the picture where motion between fields actually occurs. In this manner, the sharpness of the picture is preserved everywhere except at the moving interface itself, where the inherent blur of the motion makes the lack of sharpness rather unnoticeable.

The basic concept can be carried out by detecting any difference between a secondary-parity prime line being scanned and an adjacent primary-parity line, and substituting for the prime line signal, whenever a difference is detected, a signal derived from one or more primary-parity lines. However, this concept alone does not prevent the loss of sharpness of stationary horizontal edges in the picture because such edges produce the same difference between adjacent lines as the comb effect does.

It is consequently necessary, in order to effectively carry out the inventive concept, to provide a distinction between a comb and a stationary horizontal edge. A preferred method of making such a distinction is illustrated in FIG. 3. In that figure, C is the prime line being traced. If a comb is present between the vertical dot-dash lines of FIG. 3, the following relationships will be true in the comb area: (1) Line C will be similar to line A (both are black); (2) line D will be similar to line B (both are white); and (3) line C will be dissimilar to line D (C is black and D is white).

In the background area to the left of the comb area in FIG. 3, relationship (3) is false: all lines are white. In the object area to the right of the comb area, relationship (3) is also false: all lines are black. If a horizontal edge is present between lines A and C, relationship (1) is false; if a horizontal edge is present between lines B and D, relationship (2) is false.

The circuit of FIG. 4 is designed to substitute a 50-50 mixture of lines B and D for line C when, and only when, all three of the above relationships are true. The video signal is continuously presented to input 20, from where it is delayed by one line interval in delay line 22 to produce line A; by one field interval in delay line 24 to produce line B; and by one field interval

minus one line interval in delay line 26 to produce line D. The undelayed video signal from input 20 produces the prime line C.

The truth of relationship (1) is established by comparing lines A and C in comparator 28. Any difference (regardless of sign) between lines A and C produces a control signal 30 proportional to that difference. Control signal 30 is applied to gate 32 for a purpose hereinafter described. Similarly, the truth of relationship (2) is established by comparator 34, which produces a control signal 36 applied to gate 38.

The truth of relationship (3) is established by comparator 40, which compares lines C and D. Comparator 40 translates any difference (regardless of sign) between lines C and D into a control signal 42 proportional to that difference. The control signal 42 is applied to selector 44 for a purpose hereinafter described.

Gates 32, 38, and selector 44 are adjusted so that they will not be actuated unless their control signals indicate a disparity of sufficient magnitude to cause a visible comb effect in the picture.

The selector 44 has two inputs from which it can select. The upper input in FIG. 4 is the prime line C. The lower input is a 50-50 mixture of lines B and D (the two odd lines adjacent to line C) produced by resistors 45, 47 fed through clamping amplifiers 49, 51.

Delay lines 46, 48 are provided to allow time for the control signal 42 to operate selector 44 before the line increment or image element which caused a selection to be made arrives at selector 44. Delay line 50 merely compensates for the inherent circuit delays of selector 44 and mixer components 45, 47, 49, 51 so as to assure time coincidence between the two inputs to parity selector 52.

It will be noted that a difference between lines C and D, i.e., the truth of relationship (3), results in the presence of a control signal 42. Control signal 42 is arranged to operate selector 44 to select its lower input, i.e. the combination of lines B and D, for transmission to selector 52. In the absence of any control signal 42, selector 44 selects its upper input, i.e., line C, for transmission to selector 52.

As long as relationships (1) and (2) are true, control signals 30 and 36 are absent. In that condition, gates 32 and 38 are conductive and permit the unhindered passage of control signal 42 when it appears. If, however, either relationship (1) or (2) is false, gate 32 or 38 is actuated by control signal 30 or 36 to block control signal 42 from reaching selector 44. In this manner, the combination of lines B and D is substituted for the prime line C when, and only when, relationships (1), (2) and (3) are all true, and the presence of a comb is thus determined.

If the odd field is to be the dominant or primary-parity field, as has been assumed in the above example, no even or secondary-parity line must ever be substituted for an odd prime line. Consequently, parity selector 52 is operated by the scan circuits 54 to select its upper input (i.e., always line C) during odd-field scans, and its lower input (i.e., the combination of lines B and D in comb areas, and line C elsewhere) during even-field scans.

The net effect of the circuitry of FIG. 4 is that the video signal appearing at output 56 is essentially equal in sharpness to the video signal at input 20, but with the

combs removed. The only disturbance remaining in the picture at output 56 is a slight blur at each end of a horizontally moving vertical interface, but due to the motion of the interface, this slight blur is not visually noticeable even on a large-screen display.

What is claimed is:

1. A method for eliminating the comb effect in interlaced-scan video pictures recorded on motion picture film, comprising the steps of:

- a. selecting one of said interlaced scans as the primary-parity scan;
- b. detecting differences between adjacent scan lines of opposite parity; and
- c. substituting for the secondary-parity line a line derived from adjacent primary-parity line information whenever a difference is detected.

2. The method of claim 1, in which said differences are relative motion.

3. A method for eliminating the comb effect in interlaced-scan video pictures recorded on motion picture film, comprising the steps of:

- a. selecting one of said interlaced scans as the primary-parity scan, the other scan being the secondary-parity scan;
- b. detecting substantial similarity between a secondary-parity prime line being scanned and an adjacent secondary-parity line;
- c. detecting substantial similarity between the two primary-parity lines adjacent to said prime line;
- d. detecting substantial dissimilarity between said prime line and an adjacent primary-parity line; and
- e. substituting picture information derived from at least one of said primary-parity lines for corresponding prime-line picture information when and only when said similarities and dissimilarity are detected.

4. A comb effect elimination circuit, comprising:

- a. a source of video signals;
- b. first, second and third delay means for delaying

said video signals by one line interval, one field interval, and one field interval minus one line interval, respectively;

- c. first comparator means for comparing said video signals and the output of said first delay means, and for producing a first control signal in response to a difference therebetween;
- d. second comparator means for comparing the outputs of said second and third delay means, and for producing a second control signal in response to a difference therebetween;
- e. third comparator means for comparing said video signal and the output of said third delay means, and for producing a third control signal in response to a difference therebetween;
- f. output means; and
- g. selector means operatively responsive to said control signals for selectively conveying to said output means said video signal or a signal derived from the output of at least one of said second and third delay means.

5. The circuit of claim 4, in which said selector means is operatively responsive to the presence of said third control signal and the absence of said first and second control signals.

6. The circuit of claim 5, further comprising gate means responsive to the presence of said first and second control signals, respectively, to block transmission of said third control signal to said selector means.

7. The circuit of claim 4, in which said selector means selectively conveys said video signal or a combination of the outputs of said second and third delay means.

8. The circuit of claim 4, further comprising additional selector means arranged to convey to said output means said video signal during the scan of a field of one parity, and the output of said first-named selector means during the scan of a field of the opposite parity.

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