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Metzger

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[54] **SCANNING APPARATUS RESPONSIVE TO THE MOVEMENT OF IMAGE BEARING MEDIA**

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[21] Appl. No.: **251,334**

[22] Filed: **May 8, 1972**

Related U.S. Patent Documents

Reissue of:

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Filed: **Aug. 3, 1970**

[51] **Int. Cl.**^{2} **H04N 5/36; H04N 5/86**

[52] **U.S. Cl.** **358/54**; 358/216

[58] **Field of Search** .... 178/5.2 D, 7.1, 7.2, 178/DIG. 28; 358/54, 214, 215, 216

[56] **References Cited**

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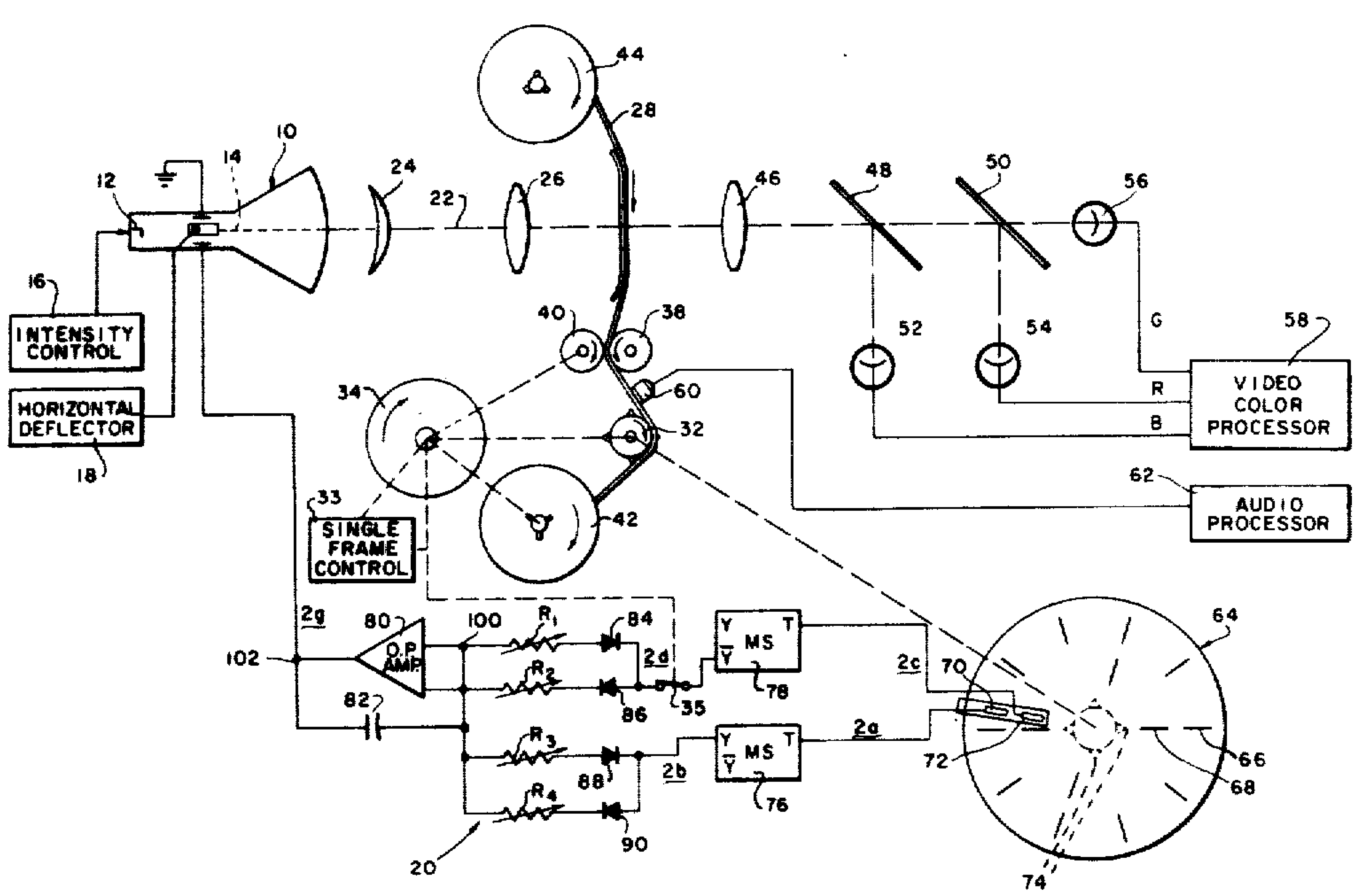
Primary Examiner—Robert L. Richardson
Attorney, Agent, or Firm—W. F. Noval

[57] **ABSTRACT**

The frames of a continuously moving image bearing medium are scanned in a raster pattern to produce an image signal representative thereof, the raster pattern being generated in accordance with the detected rate of movement of the image bearing media. The rate of movement may be detected from the movement of sprocket holes or indicia associated with image bearing frames on the information bearing media or from the synchronized rotation of a disc bearing indicia and synchronized with the movement of the information bearing media. Signals are developed from the detected sprocket holes or indicia that establish the repetitive rate of production of the raster pattern and control the positioning of the raster pattern in synchronism with the movement of the image frames of the information bearing media. The signal representative of the repetitive rate of production of the raster pattern is developed when a single image frame is to be scanned.

22 Claims, 8 Drawing Figures



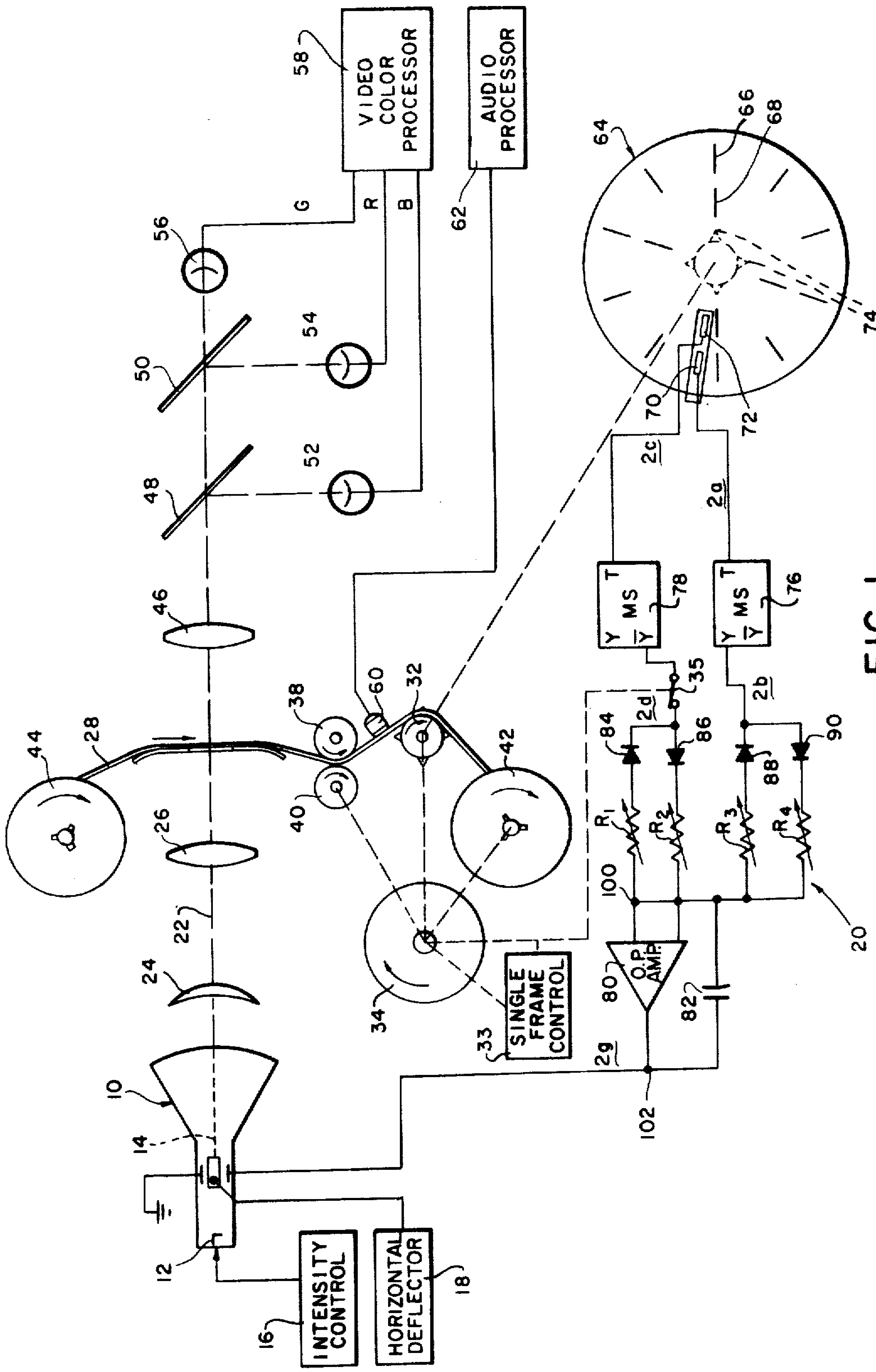

VIDEO COLOR PROCESSOR
AUDIO PROCESSOR
SINGLE FRAME CONTROL
INTENSITY CONTROL
HORIZONTAL DEFLECTOR
O.P. AMP
MS
MS
G
R
B
R1
R2
R3
R4

FIG. 1

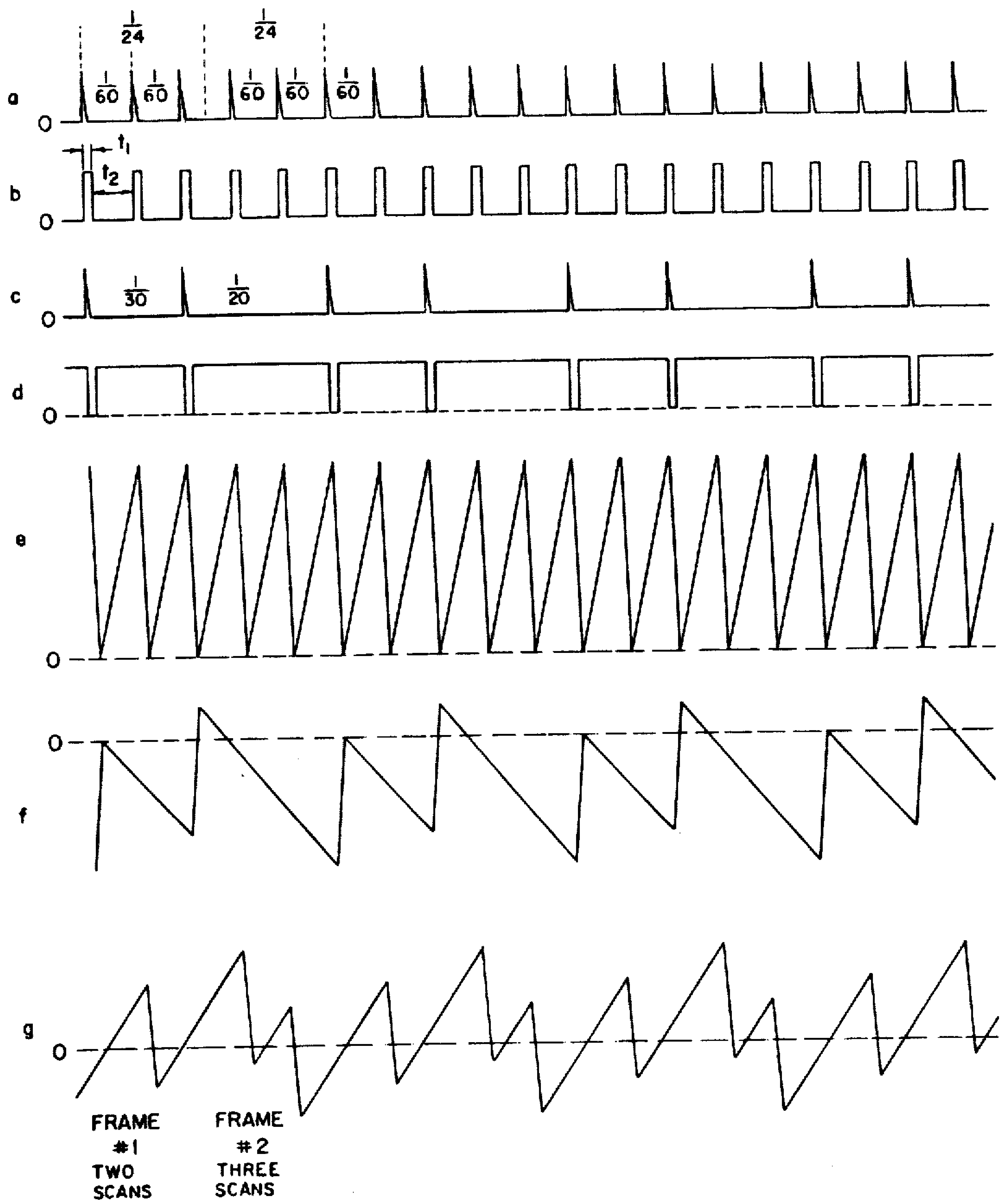

1/24
1/24
1/60
1/60
1/60
1/60
1/60
a
0
t_1
t_2
b
0
c
0
1/30
1/20
d
0
e
0
0
f
g
0
FRAME #1 TWO SCANS
FRAME #2 THREE SCANS

FIG. 2

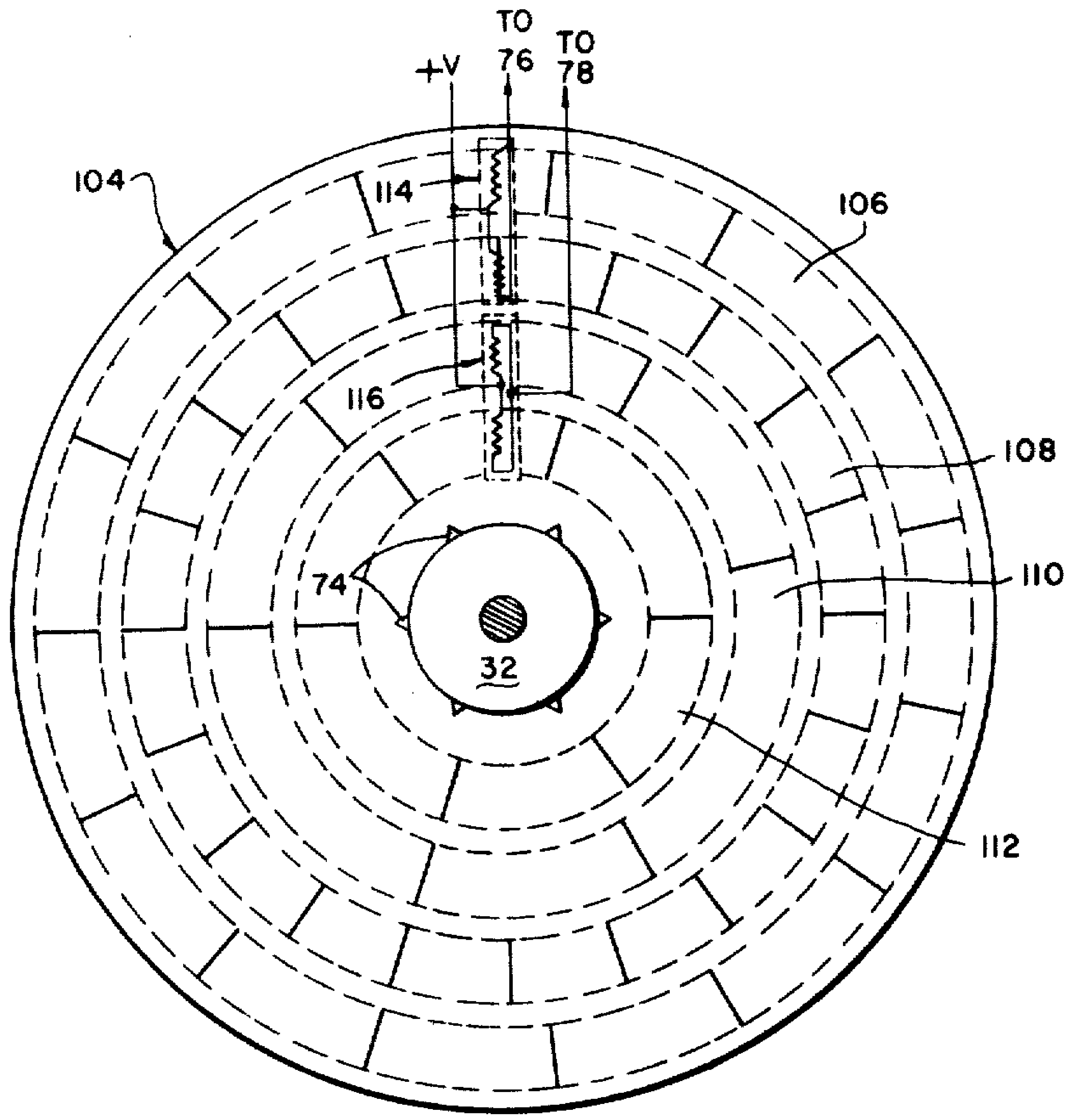
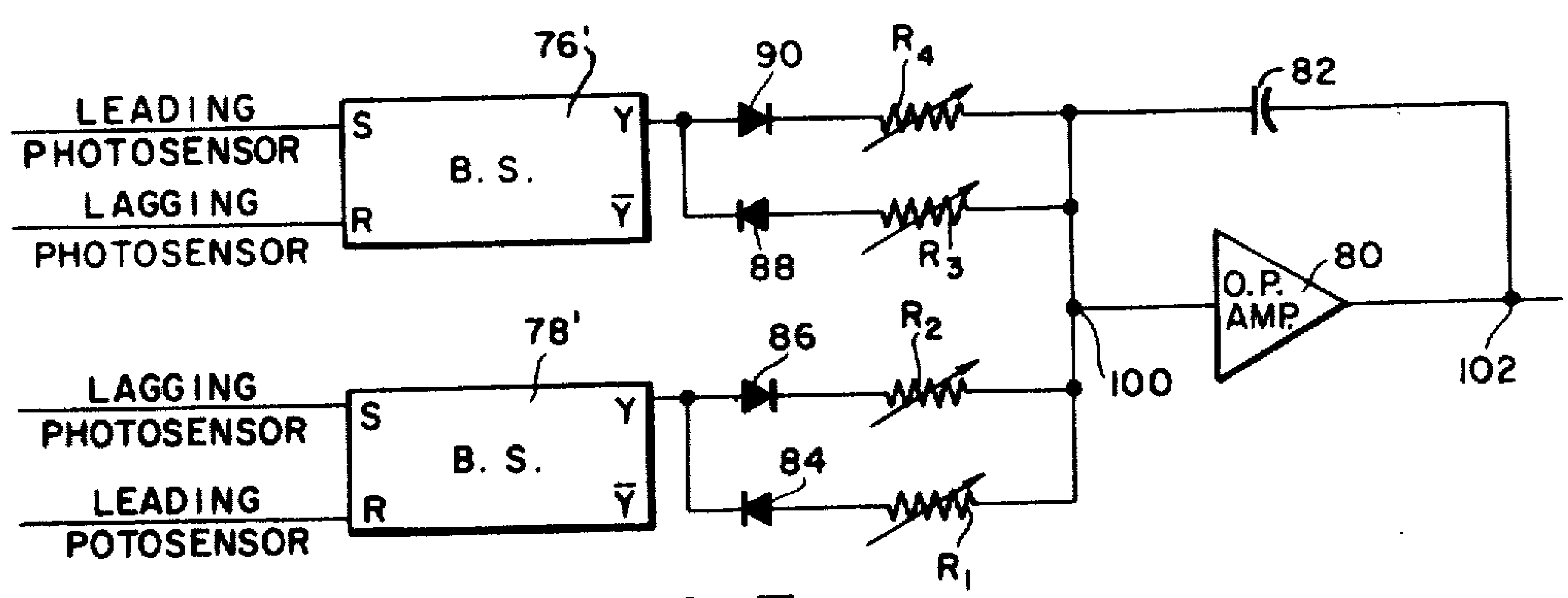

TO
76
TO
78
+V
104
114
106
116
108
74
110
32
112

FIG. 3


LEADING
PHOTOSENSOR
LAGGING
PHOTOSENSOR
76'
S
R
B. S.
Y
$\bar{Y}$
90
R_4
88
R_3
82
80
O.P.
AMP.
100
102
78'
LAGGING
PHOTOSENSOR
LEADING
POTOSENSOR
S
R
B. S.
Y
$\bar{Y}$
86
R_2
84
R_1

20

FIG. 7

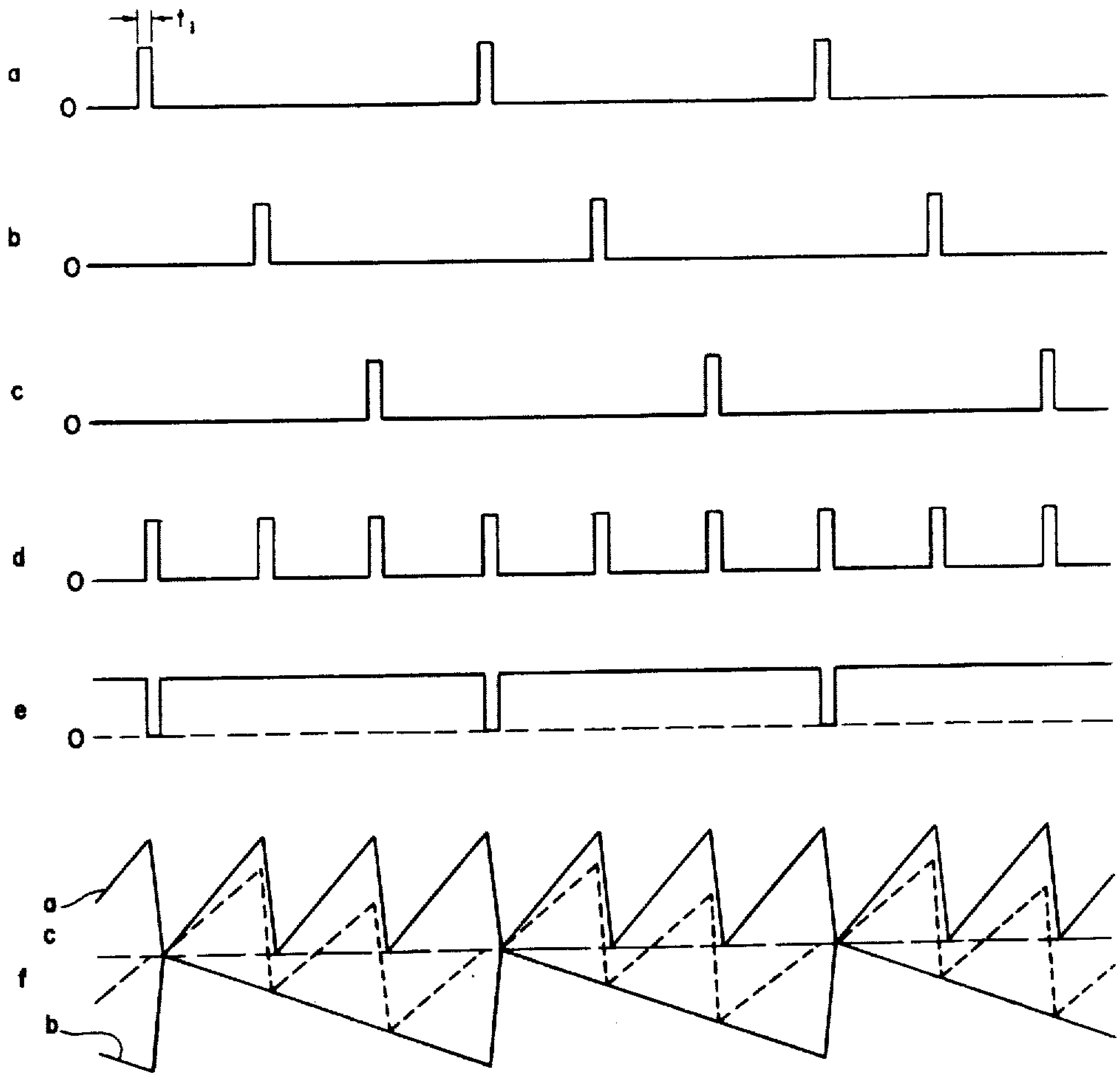

t1
a
0
b
0
c
0
d
0
e
0
a
c
f
b

FIG. 6

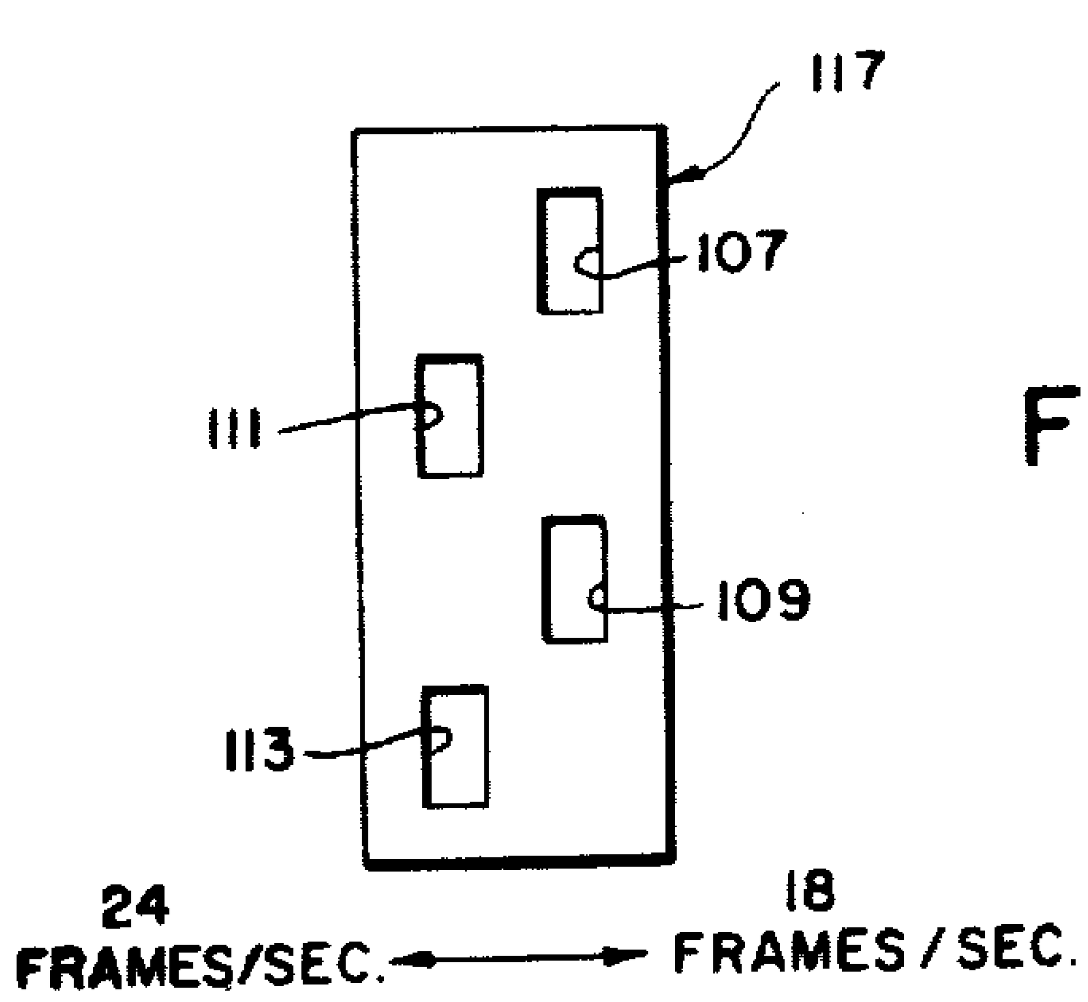

117
107
111
109
113
24
FRAMES/SEC.
18
FRAMES / SEC.

FIG. 4

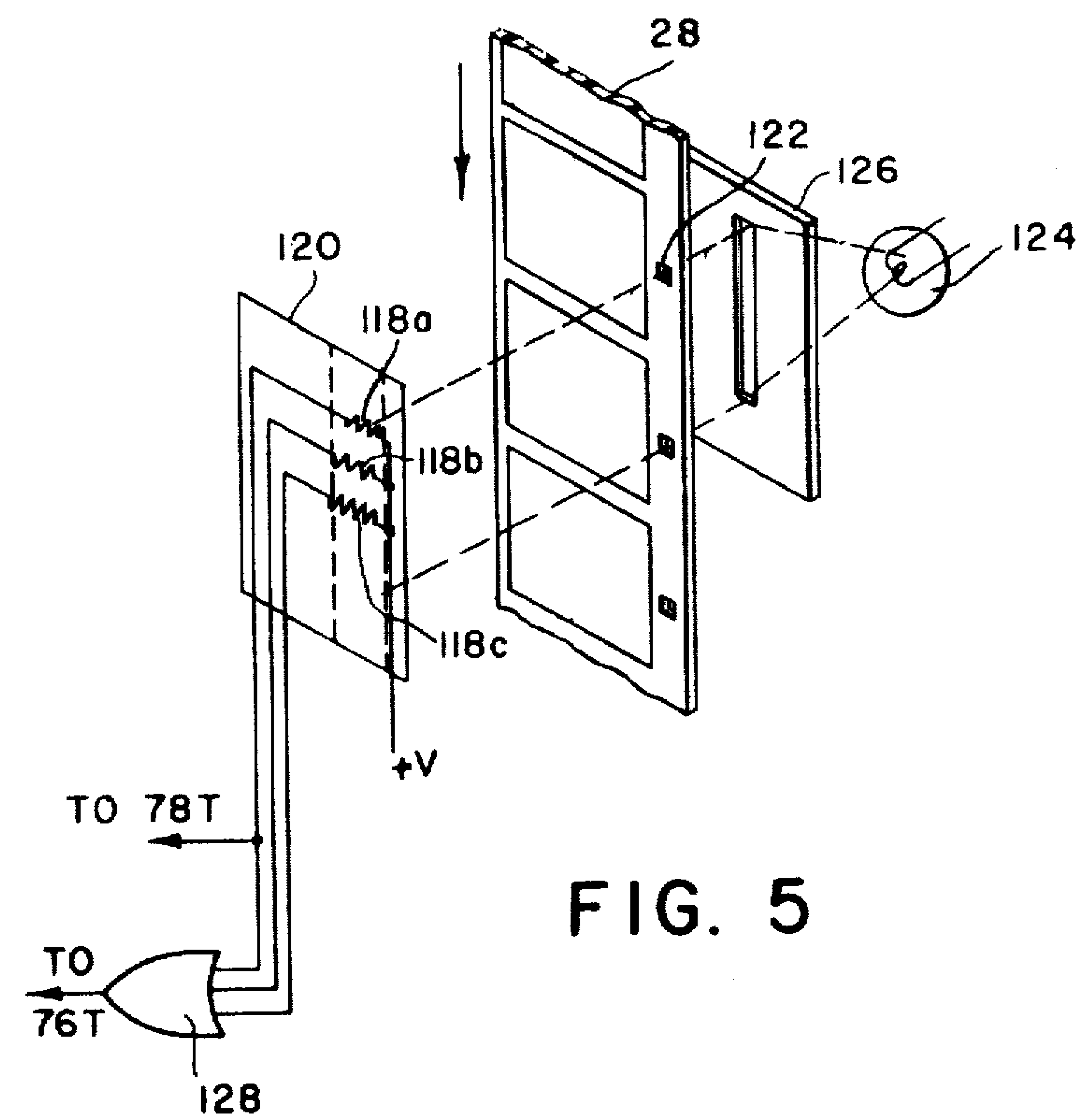

28
122
126
124
120
118a
118b
118c
+V
TO 78T
TO
76T
128

FIG. 5

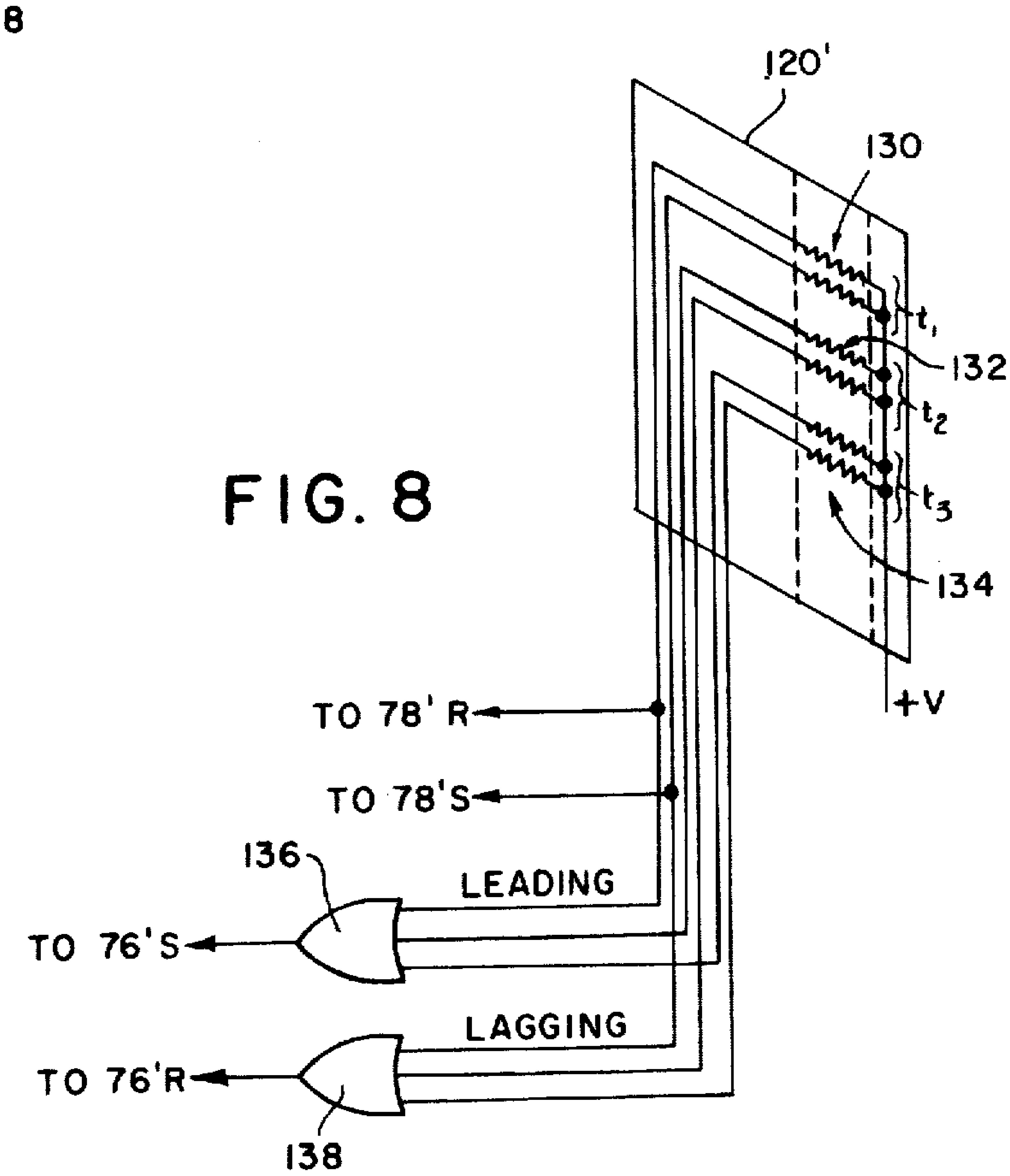

120'
130
t_1
132
t_2
t_3
134
+V
TO 78' R
TO 78'S
136
LEADING
TO 76'S
LAGGING
TO 76'R
138

FIG. 8

SCANNING APPARATUS RESPONSIVE TO THE MOVEMENT OF IMAGE BEARING MEDIA

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to scanning continuously moving information bearing media to produce an image signal and, more particularly, to scanning continuously moving or stationary motion picture film frames to produce television signals therefrom, the scanning rate being responsive to the rate of movement of a motion picture film.

2. Description of the Prior Art

In telecine transmission systems, flying spot scanning devices have often been used to scan the frames of motion picture film in a scanning raster pattern to produce interlaced television fields representative of the scanned image frames. The scanning raster pattern light beam is modulated by the image pattern of the film frame, and the modulated light is detected and transformed into a video signal by photoresponsive devices. The transmitted video signal controls the electron beam of the television receiver tuned to the transmitting station to reproduce the motion picture film frame on the television screen. Since it is desirable that the motion picture film be moved continuously and transversely to the beam of light produced by the flying spot scanning device at its normally projected frame rate, it is necessary to deflect the scanning light beam in the direction of movement of the film at the field rate frequency. Therefore the frame area of the film scanned remains constant for each scanning field, and each frame is scanned by an integral number of scanning fields.

Prior art systems have used optical image splitting apparatus or mechanical light directing apparatus to deflect the scanning beams at the same point on the film frame during each scanning field. These systems are relatively cumbersome and subject to mechanical failure.

Further prior art systems contemplate the use of apparatus for applying a signal having an irregular amplitude, sawtooth wave form to the vertical deflecting coils of the flying spot scanning device to deflect the scanning light beam in the direction of film movement. Such systems may be, relatively expensive, and in many instances, are not directly synchronized to the actual rate of movement of the film frames.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to produce television field signals by scanning the frames of motion picture film moving continuously at a predetermined frame rate.

Another object of the invention is to produce a vertical deflection signal for a flying spot scanning device in response to the rate of movement of the film being scanned.

It is also an object of the present invention to controllably deflect a scanning beam to the frames of the stationary or continuously moving motion picture film in response to the rate of movement of the film.

A preferred embodiment of the present invention includes means for scanning, in a raster pattern, the frames of motion picture film in a scanning station to produce an image signal therefrom. Means are provided to move the motion picture film through the scanning station at the nominal rate at which the images are recorded on the frames of the film. Sensing means responsive to the actual rate of movement of the film, detect and generate a train of pulses in accordance with the raster deflection rate and also detect and generate a further train of pulses representative of the television field rate. The pulse trains are combined to produce a complex vertical deflecton wave form signal that controls deflection of the scanning means in the direction of movement of the film. More particularly, pulse trains are combined in an integrating circuit to produce the complete vertical deflection sawtooth wave form signal.

In one preferred embodiment of the invention, the respective pulse trains are generated by photoresponsive devices sensitive to light modulated by indicia on a disc mounted for rotation with the sprocket wheel of the film drive. In another preferred embodiment of the invention, the respective pulse trains are detected by a series of photoresponsive devices sensitive to light modulated by the sprocket holes in the motion picture film.

Means are also provided to produce a vertical deflection wave form signal sufficient to register the raster pattern on a stationary film frame.

Other objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the detailed description of the preferred embodiment of the invention presented below, reference is made to the accompanying drawings, in which:

FIG. 1 is a schematic illustration of one embodiment of a film scanning system in accordance with the invention;

FIG. 2 is a view showing wave forms for scanning a continuously moving film in accordance with the embodiment of FIG. 1;

FIG. 3 is a schematic illustration of an alternative disc for use in FIG. 1;

FIG. 4 is a schematic illustration of a sensor mask for use in conjunction with the disc of FIG. 3;

FIG. 5 is a schematic illustration in partial perspective of another embodiment of a film scanning system in accordance with the invention;

FIG. 6 is a view showing wave forms for scanning a 30 in moving film in accordance with the embodiment of FIG. 5; by a electric

FIG. 7 is a schematic representation of an alternative vertical deflection circuit that may be used in FIG. 1; and

FIG. 8 is a schematic illustration in partial perspective of an alternative array of photosensors for use in FIG. 5 in conjunction with FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and first to FIG. 1, as one preferred embodiment of the invention, there is shown a flying spot scanning system for converting images on a motion picture film into video signals suitable for television transmission or direct application to a television receiver. The motion picture film is scanned at the 60 field per second video scanning rate that is commonly employed in the United States, while the film is moving at the frame rate at which it was exposed and would normally be projected. In order to scan each film frame by an integral number of television fields in an interlaced pattern of line scans, it is necessary to synchronize the vertical deflection of the scanning beam of the flying spot scanning device with the film frame rate. In the embodiment shown in FIG. **1**, this synchronization is accomplished with the timing disc and vertical deflection circuit described hereafter.

The scanning system includes a cathode ray tube **10** having a cathode **12** that emits an electron beam **14**, the concentration of which is controlled by an intensity control circuit **16**. A horizontal deflection yoke operates in the well known manner under the influence of a horizontal deflection circuit **18** to direct the beam **14** horizontally across the screen of a cathode ray tube **10** at a scanning frequency of 15,750 Hz. A vertical deflection yoke operates to deflect the electron beam **14** vertically in response to a complex vertical deflection wave form signal generated by vertical deflection circuit **20**.

The screen of the cathode ray tube **10** preferably is composed of a wide band spectral emission fluorescent material such as zinc oxide (P_{24}) phosphor which, when excited by the electron beam **14**, will produce a light spot on the screen. Under the control of the horizontal and vertical deflection signals, the electron beam **14** is swept across the screen in a raster pattern of discrete spaced apart line scans to generate a scanning light beam **22**.

The light beam **22** is condensed by a lens **24** and thereafter focused by lens **26** onto an image bearing medium **28** located with respect to a scanning station **30**. Scanning station **30** may consist of, in the preferred embodiment of the invention, an opaque film gate having an aperture therein. The aperture of the film gate has a dimension in the direction of elongation of the film **28** which is related to the rate of movement of the film and the height of the film frames. In order to accommodate the maximum vertical deflection of the scanning light beam that can be expected, the dimension is equal to twice the dimension of a film frame.

The image bearing media may take the form, for example, of Super 8 color motion picture film which has been exposed in a motion picture camera and processed using known techniques. As is well known in the art, such film is manufactured with sprocket holes along one side to enable the film to be advanced a predetermined rate in the camera and exposed to record images thereon in spaced discrete frames. The standard film exposure frame rate of the prior art is nominally 18 or 24 frames per second.

The motion picture film **28** is advanced through the scanning area **30** in a downward direction by sprocket wheel **32** that is mechanically coupled in a manner well known in the art as indicated by a dotted line in FIG. **1**, to an electric motor **34** and driven in the clockwise direction. Preferably the electric motor **34** is synchronized to the 60 Hz. alternating current source and rotates in the clockwise direction at a constant rate that may be adjusted to accommodate the film being scanned. The motion picture film **28** is also engaged by a capstan **38** and a tensioning wheel **40** which cooperate to keep the film taut within the scanning station. The electic motor **34** is also coupled as indicated by dotted lines to rotate takeup reel **42** in the clockwise direction to wind the film **28** from the supply reel **44** onto the takeup reel **42**.

The scanning light beam **22** passes through the frame within the scanning station **30** in the raster pattern described and is modulated by the color image thereon. The modulated light beam is focused by a lens **46** and is intercepted by dichroic mirrors **48** and **50** which are effective to separate and pass the blue, red, and green color components of the modulated light to respective photoresponsive devices **52, 54** and **56**. The dichroic mirror **48** is effective to reflect the blue color component to the surface of the photoresponsive device **52** and pass the green and red color components to the surface of dichroic mirror **50**. Dichroic mirror **50** is effective to transmit the green color component to photoreponsive device **56** and reflect the red color component to photoresponsive device **54**. The photoresponsive devices **52, 54** and **56** translate the intensity of their respective color components into electrical signals which are applied to the video color signal processor **58** of the television transmitter or receiver.

The film **28** may also have a sound track which may be detected by an audio reproduction transducer **60** and translated into an audio signal for the audio signal processor **62** of the television transmitter or receiver.

The system hereinbefore described with respect to FIG. **1** is known in the prior art of telecine reproduction. In the past, practioners of the art have either employed optical image deflecting apparatus interposed between the flying spot scanner and the scanning station, or inflexible vertical deflection apparatus for producing a vertical deflection signal which compensates for movement of the film frames. These prior art approaches have required the employment of highly accurate film moving mechanisms to insure that the scanning raster is properly registered with each moving film frame. In neither approach, have the prior art practioners provided a vertical deflection apparatus wherein the television field rate and the raster deflection rate are detected from the movement of the motion picture film and synchronized thereby. In accordance with the present invention, vertical deflection circuitry is provided that combines detected pulse trains representative of the television field rate and the raster deflection rate to produce a vertical deflection signal having a complex sawtooth wave form.

The detection apparatus of FIG. **1** consists of a disc **64** mounted to rotate with the sprocket wheel **32** (displaced for convenience of illustration) and having thereon, in two concentric tracks **66** and **68**, indicia spaced apart at the frequency of the television field rate and the raster deflection rate, respectively. Photoresponsive devices **70** and **72** are disposed to detect and translate light transmitted from a suitable light source and mask (not shown) through transparent indicia, or reflected by opaque indicia, into respective television field rate frequency and raster deflection rate pulse trains, respectively.

As stated hereinbefore, the television field rate frequency is the rate at which the scanning raster pattern is repeated and is 60 per second in the United States.

In order to translate the information appearing in each motion picture film frame into signals suitable for television reproduction of the image frame, it is necessary, as stated hereinbefore, to scan each film frame by an integral number of television fields in an interlaced pattern of line scans. To accomplish this objective in accordance with the preferred embodiments of the present invention, apparatus is provided to determine, in accordance with the rate of movement of the film, the proper number of television fields to scan each image frame. Referring to FIG. 2a there are shown the relative periods of 24 frames per second, motion picture film and the 60 field per second, television scanning rate. The common denominator of the 1/60 second period and the 1/24 second period is 1/12 second and, as illustrated, five field scans occur in a time of two film frames ($5 \times 1/60 = 2 \times 1/24 = 1/12$). An examination of the disc **64** reveals that in the interval including two successive sprocket teeth indicated at **74**, there appear two raster deflection and five field rate pulses.

The raster deflection that will properly scan the moving film consists of alternate frames of the film being scanned twice in 1/30 second and three times in 1/20 second for a total of five field scans in two film frames. The detected raster deflection rate pulses shown in FIG. 2c are therefore spaced apart at alternate 1/20 and 1/30 second periods and are in phase with the field rate pulses.

The vertical deflection circuitry **20** includes two monostable multivibrators **76** and **78** to which are applied, at their respective input terminals, the detected field rate pulse train of FIG. 2a, as derived from the photoresponsive device **70**, and the detected raster deflection rate pulse train in FIG. 2c, as derived from the photoresponsive device **72**. An integrator circuit including operational amplifier **80** and condenser **82** is connected at the output terminals of the monostable multivibrator circuits and is effective to produce a vertical deflection signal having the complex sawtooth wave form necessary to register the scanning raster pattern upon the moving motion picture film frames.

The representative block diagrams of the multivibrator circuits **76** and **78** have trigger T inputs and Y and $\overline{Y}$ outputs in accordance with symbology employed by Millman and Taub in the textbook, Pulse, Digital and Switching Wave Forms published by McGraw-Hill Book Co., and in which suitable practical circuits may be found to employ in the practice of the present invention. The symbols Y and $\overline{Y}$ simply means that an output signal on Y is the complement of an output signal on $\overline{Y}$.

The monostable multivibrator circuit **76** and **78** are responsive to the positive going transitions of the detected pulse trains to produce the pulse trains of FIGS. 2b and 2d, each pulse having a constant duration t1 equal to the retrace time between field scans of the cathode ray beam **14**. The signals depicted by the wave forms of FIGS. 2b and 2d are transmitted by diodes **84**, **86**, **88** and **90** and variable resistors R1, R2, R3 and R4 to the summing input terminal **100** of operational amplifier **80**, capacitor **82**, connected between the summing input terminal **100** and the output terminal **102** of the operational amplifier, is effective, in cooperation with the operational amplifier, to operate as a Miller integrator to integrate the summed pulse trains.

The integrator circuit operates in the well known manner, as described, for example, at pages **458** and **462** in the book entitled Reference Data for Radio Engineers, Fourth Edition, published by International Telephone and Telegraph Co., to integrate a square wave input signal into a triangular wave output signal by means of a series RC circuit.

The sawtooth wave forms of FIGS. 2e, 2f and 2g represent respectively, the response of the integrator circuit to the field rate pulse wave form of FIG. 2b, the raster deflection rate pulse wave form of FIG. 2d, and the combination of the wave forms of FIGS. 2b and 2d. The wave form of FIG. 2g represents the mathematical summation of the wave forms of FIGS. 2e and 2f and constitutes the requisite wave form of the vertical deflection signal necessary to scan continuously moving film at 24 frames per second.

The wave form of FIG. 2e must have a maximum amplitude equal to the voltage necessary to deflect vertically the scanning raster pattern of the flying spot scanning device **10** upon a stationary film frame. The slope of the wave form of FIG. 2e is governed by the relative values of resistors R4 and R3 and capacitor **82**. The time constant of resistor R4 and capacitor **82** is adjusted to be equal to the retrace time t1. The occurrence of each pulse of the wave form of FIG. 2b charges the capacitor **82** to the maximum amplitude potential through diode **90** and resistor R4. The positive potential at the input terminal **100** is inverted by operational amplifier **80**, and the output signal at the output terminal **102** decreases during the interval of time t1 to a reference potential depicted as O in FIG. 2e. Thereafter, in the interval t2 the capacitor **82** is discharged to the reference potential O of FIG. 2b through resistor R3 and diode **88**. The operational amplifier **80** inverts the discharge signal of the capacitor **82** and the output signal at the output terminal **102** increases in voltage at a linear rate as shown in FIG. 2e. The linear rate and the maximum amplitude of the wave form of FIG. 2e is determined by adjusting the resistance R3 to be equal to the product of R4 $\times$ t2/t1. Therefore, in the absence of any raster deflection pulse signal, the integrator circuit would operate to produce a signal having the wave form of FIG. 2e.

In like manner, the time constant of resistor R1 and capacitor **82** is adjusted by varying the resistance of resistor R1 to be equal to the retrace time t1. However, the resistor R2 must be adjusted to be equal to the product of R1 +60 (field rate frequency-K)/(frame rate of movement-M). In the same manner as described above, the resistors R2 and R1, the diodes **84** and **86**, and the capacitor **82** cooperate to produce from the raster deflection signal having the wave form of FIG. 2d an output signal at terminal **102** having the wave form of FIG. 2f. At each occurrence of the raster deflection signal, the wave form of FIG. 2f undergoes a transition having a maximum value equal to the maximum amplitude of the wave form of FIG. 2e.

The resulting complex sawtooth wave form of FIG. 2g represents the mathematical summation by the integrator of the wave forms of FIGS. 2e and 2f. The slope of the resultant wave form of FIG. 2g automatically adjusted to compress the scanning raster pattern of each television field by an amount equal to 24/60's of the vertical dimension of a film frame. The movement of the film in the downward direction cooperates with the compressed scanning raster pattern to expand the pattern to scan the entire image frame during each television field.

In the event that a stationary film frame is selected for viewing by the operator, a single frame control **33**, which may take the form of a mechanical clutch, is interposed between the motor **34**, the sprocket wheel **32**, the capstan **40**, and the takeup reel **42**, to withdraw the sprocket wheel and halt the movement of the film. Furthermore, a switch **35** is provided in the output conductor of multivibrator **78** that is operated in conjunction with the control **33** to open the conductive path between the $\bar{Y}$ terminal of multivibrator **78** and the diodes **84** and **86**. The resultant vertical deflection signal would have the wave form of FIG. 2e.

In like manner a disc **64** may be prepared for any integral frame scanning rate, and the resistors **R1 - R4** may be adjusted in the manner described to produce a vertical deflection signal having the requisite complex sawtooth wave form to scan the motion picture film moving at that frame rate. The number N of equally spaced indicia on the field rate frequency track of the scanning disc is governed by the constant 60 field per second frequency K, the variable frame rate of movement M, and the number of sprocket teeth P, in the following relationship:

$$K/M = N/P;$$

and

$$N = P \times K/M.$$

The number of indicia on the raster deflection track is always equal to the number of sprocket teeth since one film frame corresponds to each sprocket hole in the film. The spacing of the raster deflection indicia is governed by the requirement that the scanning raster of the flying spot scanning device **10** must be deflected in a repetitive pattern at the field rate frequency to scan each film frame an integral number of times. Therefore, the raster deflection indicia are in phase with the field rate indicia and spaced apart by integral multiples of the field rate indicia. For all the film frame rates between 20 and 30 frames per second, the raster deflection indicia are spaced apart by either two or three field rate indicia. For all the frame rates between 10 and 20 frames per second, the raster deflection indicia are spaced apart by either three or four field rate indicia, and at the 20 frame per second rate, the raster deflection indicia are in phase with, and spaced apart by three field rate indicia.

Referring now to FIG. **3** there is shown an alternate disc **104** suitable for use with both 24 frame per motion picture film and 18 frame per second motion picture film. As shown, the sprocket wheel has six sprocket teeth thereon. Therefore, the number of indicia in track **106** at 24 frames per second is equal to: $(60 \times 6)/24 = 15$. The number of raster deflection indicia in row **110** at 24 frames per second is equal to 6, and they are spaced apart by two and three successive field rate indicia.

The number of field rate indicia in row **108** for 18 frames per second is equal to: $(60 \times 6)/18 = 20$. The number of raster deflection indicia in row **112**, at 18 frames per second, is equal to 6, and they are spaced apart in a pattern of three, three and four field rate indicia. Therefore, three successive image frames are scanned by three, three and four television fields, respectively.

Two pairs of photosensors, **114** and **116**, are arranged to detect light emitted by a source (not shown) that passes through or is reflected by the field rate indicia of tracks **106** and **108** and the raster deflection indicia of tracks **110** and **112**, respectively. The pair of photosensors **114** is electrically connected in parallel to a voltage source +V and the input terminal T of multivibrator **76**. In like manner, the pair of photosensors **116** is electrically connected in parallel to the voltage source +V and the input terminal T of multivibrator **78**.

The mask **117** of FIG. **4** is provided in order to allow, in accordance with the rate of film movement, the modulated light to strike one photosensor of each pair of photosensors **114**, **116**. Although not illustrated, the light mask is intended to be supported between, and in close proximity to, the photosensor pairs **114** and **116** and the disc **104**. The mask **104** is intended to be movable, in the direction of the arrows, to mark one or the other photosensor of each pair in accordance with the proper rate of movement of the film.

Obviously, any number of tracks of raster deflection and field rate indicia, with associated marks and photocells, could be provided on such a disc.

In FIGS. **5** and **6**, there is shown an alternative apparatus for generating the raster deflection television field rate pulse signals from the movement of the sprocket holes of the motion picture film. At 20 frames per second, or any other rate of movement that is an integral submultiple of the 60 per second television field rate, a plurality of photosensors equal in number to the aforementioned integer are arranged equally spaced apart in the dimension between the leading edges of two sprocket holes. As depicted in FIG. **5**, at 20 frames per second, three photosensors **118a**, **118b** and **118c** are arranged on a suitable substrate **120** equally spaced apart in the distance between two successive sprocket holes **122**. Light source **124** and mask **126** cooperate with each sprocket hole **122** as it advances in the direction of movement of the film, indicated by the arrow, to direct light successively upon the photosensors **118a**, **118b** and **118c**. The detection of the light by the photosensors produces the pulse signals depicted by the wave forms of FIGS. **6a**, **6b** and **6c**.

The pulse signals of wave forms **6a**, **6b** and **6c** are added by OR gate **128** and applied to the input terminal T of the monostable multivibrator **76** of FIG. **1**. The output signal of multivibrator **76** is shown by wave form **6d** and has a frequency equal to the 60 per second television field rate.

The pulse signal of wave form **6a** is also applied to the input terminal T of the multivibrator **78** of FIG. **1**. The output signal of multivibrator **78** is shown by wave form **6e** and has a frequency equal to both the 20 frames per second rate of movement and the raster deflection rate.

In accordance with the practice set forth hereinbefore, resistors R1 and R4 are adjusted to reflect the period t1; resistor R3 is adjusted to reflect the period t2; and resistor R2 is adjusted to reflect the period equal to:

$$(K)/(M)60/20 \times t2$$

or

$$3t2.$$

The resulting sawtooth wave forms A, B and C are depicted in superimposition in FIG. **6f**. The raster deflection signal having the wave form C is the sum of the detected raster deflection sawtooth wave form signal B and the detected television field rate sawtooth wave form signal A.

Referring now to FIG. **7** there is shown an alternative embodiment of the vertical deflection circuit **20** of FIG. **1**. In FIG. **2**, monostable multivibrators are responsive to the positive transitions of the detected pulse signals to produce further pulse signals having a duration t1 equal to the vertical retract time of the flying spot scanning device. The circuit of FIG. **7**, however, employs bistable multivibrators **76'** and **78'** having set S and reset R input terminals. The positive transitions of a signal applied to either input terminal will determine the bistable state of the multivibrators **76'** and **78'**. The use of bistable multivibrators therefor necessitates the employment of a pair of photosensors in place of each single photosensor of FIGS. **1**, **3** and **5**. The photosensors of a pair furthermore must be spaced apart by a dimension, with respect to the frame rate of movement of the film, that will provide a time period between the respective pair of impulses generated thereby equal to the vertical retrace time t1 of the flying spot scanning device.

Referring to FIG. **8**, there is shown an array of photosensor pairs **130**, **132**, and **134** arranged on a substrate **120'** in the manner described with reference to the embodiment of FIG. **5**. The photosensor pair **130**, for example, replaces photosensor **118a** of FIG. **5** and consists of a leading (in the direction of film movement depicted in FIG. **5**) and a lagging photosensor. The leading and lagging photosensors of each pair are spaced apart by a distance that, when traversed by a sprocket hole or indicia **122** of the film **28** at 20 frames per second, results in the production of a pair of impulses spaced apart in time by the retrace time period t1. The leading impulses generated by the leading photosensors of each pair are added by OR gate **136** to the set S input terminal of bistable multivibrator **76'**. The lagging impulses generated by the lagging photosensors of each pair are added by OR gate **138** to the reset R input terminal of the bistable multivibrator **76'**. The leading and lagging impulses generated by the lagging and leading photosensors of the photosensor pair **130** are applied to the reset R and set S input terminals of bistable multivibrator **78'**. The resulting wave forms and operation of the circuit of FIG. 7 is identical to those described with respect to FIGS. **5** and **6**.

With respect to FIG. **1**, the photosensors **70** and **72** would have to be replace by pairs **70'** and **72'** of photosensors each pair being physically arranged in parallel along its associated track on the disc **64**. The output signals of the leading (in the direction of rotation of the disc) photosensor of each pair would be applied to the set S inputs of multivibrator **76'** and **78'**. The output signals of the lagging photosensor of each pair would be applied to the reset R inputs of the respective multivibrators **76'** and **78'**.

From the description of the preferred embodiment set forth above, it is apparent that the invention can be practiced in many alternative ways. It is apparent that the invention may be practiced in substantially the same manner as disclosed in the preferred embodiments at the European 50 per second, television field rate or any other standard field rate.

Also, it is apparent that the rate of movement of the motion picture film or other image bearing media may be detected from indicia, instead of the sprocket holes, recorded on the media.

Furthermore, it is apparent that the indicia on the rotating disk may be opaque or transparent to light and may consist of slits in an opaque disk.

As may be seen, a novel system has been disclosed for transforming the images and sound track of an ordinary, inexpensive motion picture film into respective video and audio signals for television transmission or direct connection to the antenna terminals of the conventional television receiver. The system if compatible with professional and amateur motion picture films, both black and white and color, and with and without sound tracks.

In summary, it will be readily apparent that by virtue of the novel arrangements disclosed whereby the vertical deflection circuit is directly controlled by the detected film frame rate and raster deflection rate, the deflection of the scanning beam is readily effected in exacy synchronism with the film movement. The vertical deflection disclosed is adaptable to a wide range of film frame rates and compensates for minor fluctuations in the spacing between film frames or the frame rate itself since the television field rate is detected from the actual rate of movement of the film.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. In apparatus for deriving an image signal from an information bearing medium having a plurality of successive image frames disposed thereon, the combination comprising:

a. means for defining a scanning station;

b. means for moving the information bearing medium at a nominal image frame rate relative to said scanning station;

c. means for scanning repetitively at a first rate the image frames moving relative to said scanning station in a raster pattern comprising a plurality of spaced line scans and for providing an image signal of the scanned image frames;

d. first means for detecting the first rate from the movement of the information bearing medium relative to said scanning station and for producing a first signal indicative of the first rate;

e. second means for detecting the raster deflection rate of said scanning means from the movement of the information bearing medium relative to said scanning station and for producing a second signal indicative of the raster deflection rate;

f. third means responsive to said first and second signals for producing a third signal indicative of the raster deflection rate of said second signal and the first rate of said first signal; and

g. means responsive to said third signal for positioning the scanning raster pattern in synchronism with the moving image frames in accordance with said raster deflection rate and repeating the scanning raster pattern at said first rate.

2. The apparatus of claim **1** wherein said information bearing medium consists of motion picture film.

3. The apparatus of claim **1** wherein said information bearing medium consists of motion picture film having sprocket holes associated with each image bearing frame thereon and wherein said first and second detecting means comprise:

a. means for directing radiation in a path intercepted by said sprocket holes; and

b. photoresponsive means positioned with respect to said sprocket holes to detect the radiation modulated by said sprocket holes.

4. The apparatus of claim **3** wherein said photoresponsive means comprises a plurality of photosensors equally spaced one from the other in a dimension equal to the dimension between adjacent sprocket holes of the motion picture film.

5. The apparatus of claim **4** wherein the number of said photosensors is the integral quotient of said first rate divided by the motion picture film frame rate of movement, and the raster deflection rate is equal to said rate of movement.

6. The apparatus of claim **1** wherein said information bearing medium consists of a motion picture film, said moving means comprises a rotating sprocket wheel adapted to engage the sprocket holes on the motion picture film, and said first and second detecting means comprise:

a. a disc adapted to rotate with said sprocket wheel and having repetitive indicia disposed in concentric tracks on said disc;
b. means for directing radiation in a path intercepted by said indicia on said disc; and
c. photoresponsive means positioned with respect to said concentric tracks of said indicia to detect the radiation modulated by said indicia.

7. The apparatus of claim 6 wherein said sprocket wheel includes a number of projections adapted to engage the sprocket holes of the motion picture film, the frame rate of movement is equal to the number M, said first rate is required a constant number K, and said indicia are disposed in first and second concentric tracks on the surface of said disc, the indicia in said first track being equally spaced apart and of a number N equal to the [produce] *product* of P × K/M, and the number of indicia disposed in said second track are equal to the number P and are disposed in phase with selected indicia of said first track.

8. The apparatus of claim 6 wherein said disc is opaque to said radiation and said indicia comprise slits in said disc through which said radiation is transmitted, and said photoresponsive means are disposed to intercept said radiation transmitted through said slits.

9. In apparatus for deriving an image signal from a motion picture film having a plurality of successive image frames disposed thereon, the combination comprising:

a. means for defining a scanning station;
b. means for moving the motion picture film at a nominal image frame rate relative to said scanning station;
c. means for scanning repetitively at a television field rate frequency the image frames moving relative to said scanning station in a television raster pattern comprising a plurality of spaced line scans and for providing an image signal of the scanned image frames;
d. first means for detecting said television field rate from the movement of the motion picture film relative to said scanning station and for producing a first signal indicative of said television field rate;
e. second means for detecting the [waste] *raster* deflection rate of said scanning means from the movement of said motion picture film relative to said scanning station and for producing a second signal indicative of said raster deflection rate;
f. third means responsive to the first and second signals for producing a third signal having a complex sawtooth wave form and a frequency equal to said television field rate; and
g. fourth means responsive to the third signal for generating said raster pattern at said television field rate and positioning said raster pattern in synchronism with the movement of each image frame relative to said scanning station.

10. The apparatus of claim 9 wherein said third means comprises:

a. an integrating circuit having a summing input terminal and an output terminal;
b. a first pair of unidirectionally conducting elements connected between said summing input terminal and said first means for applying said first signal to said summing input terminal; and
c. a second pair of unidirectionally conductive, elements connected between said summing input terminal and said second means for applying said second signal to said summing input terminal.

11. The apparatus of claim 9 wherein said motion picture film has a sprocket hole associated with each image bearing frame thereon and wherein said first and second detecting means comprise:

a. means for directing radiation in a path intercepted by said sprocket holes; and
b. photoresponsive means positioned with respect to said sprocket holes to detect the radiation modulated by said sprocket holes.

12. The apparatus of claim 11 wherein said photoresponsive means comprises a plurality of photosensors equally spaced one from the other in a dimension equal to the dimension between adjacent sprocket holes of said motion picture film.

13. The apparatus of claim 12 wherein the number of said photosensors is the integral quotient of the television field rate divided by the motion picture film frame rate of movement, and the raster deflection rate is equal to said rate of movement.

14. The apparatus of claim 9 wherein said motion picture film has a sprocket hole associated with each image bearing frame, said moving means comprises a rotating sprocket wheel adapted to engage the sprocket holes in the motion picture film, and said first and second detecting means comprise:

a. a disc adapted to rotate with said sprocket wheel and bearing repetitive indicia disposed in concentric tracks on said disc;
b. means for directing radiation in a path intercepted by the indicia on said disc; and
c. photoresponsive means positioned with respect to said concentric tracks of indicia to detect the radiation modulated by said indicia.

15. The apparatus of claim 14 wherein said sprocket wheel includes a number P of projections adapted to engage the sprocket holes of the motion picture film, said frame rate of movement is equal to the number M, said given rate is a constant number K, and said indicia are disposed in first and second concentric tracks on the surface of said disc, the indicia in said first track being equally spaced apart and of a number N equal to the [produce] *product* of P × K/M, and the number of indicia disposed in said second track are equal to the number P and are disposed in phase with selected indicia of said first track.

16. The apparatus of claim 14 wherein said disc is opaque to said radiation and said indicia comprise slits in said disc through which said radiation is transmitted, and said photoresponsive means are disposed to intercept said radiation transmitted by said slits.

17. In apparatus for selectively deriving an image signal from the image frames of a moving or stationary image bearing medium the combination comprising:

a. means for defining a scanning station;
b. means operative in a first mode for moving the image bearing medium at a nominal image frame rate relative to said scanning station and operative in a second mode for locating a single image frame in a stationary relationship with respect to said scanning station;
c. means for scanning repetitively in a raster pattern at a field rate frequency and for providing an image

signal of the image frames moving relative to said scanning station in said first mode of operation and the single image frame disposed in a stationary relationship with respect to said scanning station in said second mode of operation, the raster pattern comprising a plurality of spaced line scans;

d. first means responsive to the operation of said moving means in said first and second mode for detecting said field rate and for producing a first signal indicative of said field rate;

e. second means responsive to the operation of said moving means in said first mode for detecting the raster deflection rate of said scanning means and for producing a second signal indicative of said raster deflection rate;

f. said first means and said second means comprising

1. a disc adapted to rotate with the operation of said moving means in said first and second mode and bearing repetitive indicia disposed in concentric first and second tracks on said disc,
2. means for directing radiation in a path intercepted by the indicia on said disc, and
3. photoresponsive means positioned with respect to said first and second concentric tracks of indicia to detect the radiation modulated by said indicia and produce said first and second signals, respectively;

g. means responsive to said first and second signals for producing a third signal having a complex sawtooth wave form and a frequency N equal to said field rate when said moving means is operative in said first mode;

h. means responsive to said third signal for generating said raster pattern at said field rate and for positioning said raster pattern in synchronism with the movement of each image frame relative to said scanning station when said moving means is operative in said first mode; and

i. means responsive to said first signal for generating said raster pattern at said field rate and positioning said raster pattern upon said stationary image frame when said moving means is operative in said second mode.

18. In apparatus for selectively deriving an image signal from the image frames of a moving or stationary image bearing medium the combination comprising:

a. means for defining a scanning station;

b. means operative in a first mode for moving the image frames of said image bearing medium at a nominal rate relative to said scanning station and operative in a second mode for locating a single image frame in stationary relationship with respect to said scanning station;

c. a disc coupled with said moving means to rotate at a rate related to the rate of movement of the motion picture film, said disc bearing repetitive indicia disposed in first and second concentric tracks on said disc;

d. first means responsive to the operation of said moving means in said first and second mode for detecting said field rate and for producing a first signal indicative of said field rate;

e. first means responsive to the operation of said moving means in said first mode ad said second mode for detecting said field rate from said first track of indicia on said disc and for producing a first signal indicative of said field rate;

f. second means responsive to the operation of said moving means in said first mode for detecting the raster deflection rate of said scanning means from said second track of indicia on said rotating disc and for producing a second signal indicative of said raster deflection rate;

g. means responsive to said first signal for generating said raster pattern at the television field rate and, in said second mode of operation of said moving means, for positioning said raster pattern upon said single stationary image frame disposed with respect to said scanning station;

h. means responsive to said first and second signal, when said moving means is operative in said first mode, for producing a third signal having a complex sawtooth wave form and a frequency equal to said television field rate; and

i. means responsive to said third signal for generating said raster pattern at said television field rate and positioning said raster pattern in synchronism with the movement of each image frame moving relative to said scanning station in said first mode of operation.

19. Apparatus for deriving from film electrical signals suitable to the provision of a visual display comprising in combination:

flying spot scanner means including a flying spot scanner tube with associated means for effecting horizontal and vertical electron beam scanning of the scanner tube, an adjacent film scanning zone, and an image detection and processing means;

transport means associated with said flying spot scanner means for moving a film of film frames through said scanning zone at a continuous and predetermined rate of film frame movement, said film and scanner means effecting development of image information signals;

vertical scan modification means coupled to said transport means for developing vertical scan signals and vertical scan modifying signals, said modifying signals having a magnitude continuously varying at a rate substantially equal to the rate of film frame movement through said film scanning zone and having a frequency at a submultiple of the frequency of vertical electron beam scanning of the scanner tube; and

signal combining network means coupling said means for effecting horizontal and vertical electron beam scanning and said vertical scan modification means to said scanner tube means, said means effecting development of a combined vertical deflection signal derived from said vertical scan and vertical scan modifying signals whereby a raster is vertically scanned at a given frequency and continuously moved vertically at a submultiple of said given frequency and at a rate substantially equal to said film frame movement rate.

20. The combination of claim 19 wherein said vertical electron beam scanning signals and said vertical scan modification signals are in a ratio of about 3:1.

21. The combination of claim 19 wherein said vertical electron beam scanning signals have a frequency of about 60 Hz. and said vertical scan modification signals have a frequency of about 20 Hz.

22. A color image display system comprising in combination:

a color television receiver having a color image display device;

a flying spot scanner means having a flying spot scanner tube, horizontal and vertical electron beam scanning *voltage sources, an adjacent film scanning zone, and an image detection and processing means for providing color image signals and applying said signals to said receiver;*

transport means associated with said flying spot scanner means for moving a film of film frames through said film scanning zone at a continuous and predetermined film frame rate;

vertical scan modification means coupled to said transport means for effecting development of vertical scan and vertical scan modifying signals at a submultiple frequency of said vertical scan signal frequency; and

signal combining means coupled to said flying spot scanner means and to said vertical scan modification means to effect vertical scanning of said flying spot scanner tube and continuous vertical alteration of said vertical scanning of said flying spot scanner tube at a rate substantially equal to said predetermined film frame rate.

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