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H4F D12K1 D27E D27M2 D53C D54 D57 D60 D62M1
D65 D70G2 D70P D82S2 D83X(54) APPARATUS FOR EFFECTING LINE-BY-LINE
SCANNING OF A SERIES OF IMAGES IN MOTION

(71) We, AGFA-GEVAERT AKTIEN-
GESELLSCHAFT, a body corporate recog-
nised under German Law, of Leverkusen,
Germany, do hereby declare the invention, for
which we pray that a patent may be granted
to us, and the method by which it is to be
performed, to be particularly described in and
by the following statement:—

This invention relates to the line-by-line
scanning of a series of images and especially
to such scanning of cine films having an image
frequency of approximately 18 frames per
second, for the reproduction of these images
on a television receiver having a reproduction
frequency of approximately 50 frames per
second.

The present invention provides apparatus
for effecting line-by-line scanning of a series
of images of predetermined height to enable
the images to be reproduced on a television
receiver, which comprises means for trans-
porting a series of images continuously past
a scanning position, means for scanning re-
peatedly a series of three overlapping areas at
the scanning position, and a photo-electric
transducer arranged to receive light transmit-
ted by the images during scanning, the scan-
ning means being arranged to scan each area
in turn in the opposite direction to the direc-
tion of motion of the images, and the arrange-
ment being such that, in operation, the length
of each of the said scanned areas is equal to
two-thirds of the image height (the said length
and the said height each being measured in
the said direction of motion), that the second
and third of the said areas are each offset in
the said direction of motion by a distance
equal to half the said length in relation to the
immediately preceding area, and that said
series of three overlapping areas is scanned
once during the passage of each image through
the scanning position, the scanning means
comprising a cathode-ray tube for furnishing
a scanning light beam, saw-tooth voltage
generator means for producing a voltage for
controlling the deflection of the scanning beam
over the scanned areas, and means for pro-

ducing television frame sync pulses at a sub-
stantially constant frequency, the said saw-
tooth voltage generator means being arranged
to produce a voltage changing in one sense
over a range to cause deflection of the scan-
ning beam over one of the said overlapping
areas, and including means for shifting the
range in the opposite sense after each scan-
ning of each of the first two areas in said
series of three overlapping areas by an amount
equal to one half of the voltage difference over
the range, so as to produce the specified dis-
placement of the second and third areas in
such series, the arrangement being such that
the range is returned to its initial position
after each scanning of the third area in said
series of three overlapping areas, and the
transport means comprises a synchronous
motor having control means, and there is pro-
vided detector means for delivering a syn-
chronising signal to the control means on de-
tecting a perforation on the carrier, the control
means being arranged to regulate the motor
speed in accordance with a comparison be-
tween the frame synchronisation pulses of the
scanning means and the signals received from
the detector means.

Continuous advancement of an image car-
rier, most commonly a cine film, has the ad-
vantage of avoiding the undesirable strain on
film perforations, which can lead to damage,
that is characteristic of certain prior proposals
in this field, which call for intermittent trans-
port. Further, the specified triple scanning of
each image provides satisfactory image repro-
duction without unduly complicating the con-
struction of the apparatus.

In the most preferred case, the height of the
screen of the cathode-ray tube is such that the
height of a projection of the screen at the
scanning position is greater by one third than
the said predetermined image height. In that
case, during scanning of the said overlapping
areas, the scanning light point passes over an
area corresponding to half the screen area
which in turn corresponds at the scanning posi-
tion to two-thirds of the image height.

[Price 25p]

It will be appreciated that the lines followed by the scanning point, which lines constitute the scan, will all lie transverse to the direction of motion of the series of images.

5 The invention is primarily intended for use with television receivers having the conventional frame frequency of 50 per second and with film recorded at 18 frames per second. In the 50:18 case, even though the film has
10 to be played back through the scanner at only $16\frac{2}{3}$ frames per second (to permit the specified triple scan of each film image), the resultant slowing-down of the film when reproduced on the television screen (about 7%), is within
15 tolerable limits. Frame frequencies representing greater departures from 3:1 (receiver: film) may be utilised, but it will be appreciated that the greater the departure from 3:1, the greater will be the difference between the
20 time scale of the moving images as initially recorded and that of the reproduction on the television screen.

One form of apparatus constructed in accordance with the invention will now be described, by way of example, with reference
25 to the accompanying drawings, in which:

Figure 1 shows diagrammatically the overlapping scanned areas;

30 Figure 2 shows the scanning device schematically;

Figure 3 is a block wiring diagram of an apparatus for producing the voltage controlling the vertical deflection in a scanning tube according to Figure 2, and

35 Figure 4 shows the voltage curve for the vertical deflection of the light point in the scanning tube.

Figure 1 shows the series of three overlapping scanned areas which is scanned repeatedly. The first area of the series is shown with inclined lines extending upwardly towards the right; the second area is shown with horizontal lines; and the third area has inclined hatching lines extending downwardly
45 towards the right. During scanning, a film 1 is moved in the direction of the arrow 2 at a speed of one frame height in $3/50$ second, that is to say, $16\frac{2}{3}$ frames per second giving, in the case of film originally recorded at 18 frames per second, the 7% speed reduction already mentioned. The scanning of each of the overlapping areas is completed in $1/50$ second. The size of a film image corresponds to a rectangle 3 having the frame height 3a and 3b.
50

55 The scanning operation begins at the lower edge of the image 3 in the direction of the arrow 4 which points in the opposite direction to the arrow 2. As is customary in television reproduction, scanning is effected line-by-line, with adjacent lines being scanned one immediately after the other. Due to the movement of the film in the direction of the arrow 2 in the opposite direction to the scanning
60 direction, however, the trailing edge of the

image 3, on completion of scanning of the first overlapping area, has advanced by a distance equal to one-third of the image height 3a, so that the trailing edge is at a distance of two-thirds of the frame height 3a from the start of the scan.
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By means of appropriate control of the scanning tube, which will be described hereinafter, the next scanning cycle does not begin in the same position as the preceding one but on a line which is off-set in the direction of the film movement by one-third of the image height in relation to the first scanning line. From this point the second scanning cycle covers the whole image, but because of the movement of the film itself the scanning of the image is again completed when the trailing edge reaches a position which is off-set from its position at the start of the second scan by one-third of the image height in the direction of the film movement. Then the third scanning of the same film image begins in a position which is off-set from the start of the first scan by two-thirds of the image height in the direction of movement of the film and ends in the centre position shown in Figure 1. In this way, a scannable surface of only four-thirds of the frame height is required for the scanning of the film image in motion. This means that when using a normal television tube having 625 lines, 312.5 lines are inscribed during the scanning of each overlapping area, just what is necessary for one frame on the television screen of the reproduction apparatus. Due to the half line at the end of the scanning cycle, during the transition from one such frame (video) to the next there is also a shift in the scanning lines by one-half a line width, so that scanning is automatically effected by the line interlacing method. Because of the side ratio of 4:3 in the format of the cine film known as Super-8, optimum utilisation is produced for the rounded surface of the scanning tube of which the utilised area is in the form of a square
100 inscribed on the circle.

Referring now to Figure 2, in which the apparatus for scanning is shown schematically, the reference numeral 5 indicates an image scanning tube of normal construction having 625 lines. The screen 5a of this tube, over which the scanning light point moves, is projected by an objective 6 onto an image 7a on a cine film 7. The size of the projection of the illuminated screen 5a corresponds to exactly four-thirds of the size of the film image 7a.
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A photo-receiver 8 (comprising a secondary electron multiplier) is provided behind the film 7 in order to receive light transmitted by the images.
125

The film 7 is driven by a pair of rollers 9, 10 which are urged into frictional engagement with the film by, for example, a spring. In the arrangement shown in Figure 2, only the
130

roller 10 is connected to a drive motor (11), but both of the rollers may be driven if desired.

5 A perforation mark 7b is associated with each film image 7a. On the perforation edge there is provided an illumination device 12 which projects light onto a photo-resistor 14 through three scanning gaps 13a, b, c formed in a diaphragm 13. The gaps 13a, 13b, and 10 13c are spaced apart from one another at distances corresponding in each case to a third of the distance between two successive perforations 7b.

15 Figure 3 shows, in block form, the circuitry for producing the control voltage at the tube 5. The reference numeral 15 indicates a generator for a vertical sync pulse which is emitted with a high degree of accuracy each time a new scanning cycle is to be initiated, that is to say, each time the 312.5 lines of a 20 frame have been scanned. Such generators are generally known and usually contain as frequency standard a quartz resonator, although different constructions may be used. Also, 25 there is the further possibility of taking the vertical sync pulse from any required television programme emitted by a public transmitter.

The pulses from the generator 15 serve to control a saw-tooth generator 16 of known 30 construction which, during a scanning of each frame, emits a constantly changing signal which serves to effect the vertical deflection of the light point on the screen 5a of the tube 5 in Figure 2. When the extreme value is 35 reached, the voltage jumps back to the initial value within a short time, for example, within 10% of the time taken for the voltage to reach the extreme value. Saw-tooth generators of this type are frequently constructed as 40 astable multivibrators with a Miller integrator connected thereafter. Any of the known vibrators can be used at this point in the wiring diagram. In parallel with the generator 16, there are two further generators 17 and 45 18 which are each in the form of an astable multivibrator. The multivibrator 17 is triggered on by the vertical sync pulse generator and, after the first saw-tooth of the generator 16, emits a square-wave negative signal of 50 a voltage equal to half the maximum voltage of the generator 16. After the duration of the next saw-tooth the voltage returns to its initial value.

This drop in the signal at the vibrator 17 55 serves to trigger on the vibrator 18, which for the duration of the third saw-tooth in the generator 16 emits a negative signal having the magnitude of the maximum deflection voltage. The outputs of the three vibrators 16, 17, 18 60 are coupled by way of a summation amplifier 19 the output voltage of which is transmitted to the coil 5b of the tube 5.

65 Figure 3 also illustrates the control system of the motor 11. The motor is in the form of a synchronous motor and its speed of revolu-

tion can be regulated by way of the frequency of the alternating current fed into it, and the motor is connected to an alternating current generator 20. This compares the vertical sync pulse of the generator 15 according to phase 70 with the signal emitted by the photo-resistor 14, which emits three pulses during the passing of one cine frame 7a, one such pulse being emitted each time one of the gaps 13a—c registers with a perforation 7b. If the motor 75 11 runs too slowly compared with the timer 15, the frequency of the current to the motor is increased, and *vice versa*.

In Figure 4, the output voltage from the summation amplifier 19 is shown as a function of time. The vertical deflection voltage 80 starting from the deflection-less zero position rises for the duration of the scanning of the first frame of 1/50th sec. to the maximum value U_{max} . and then, in response to the 85 negative signal from the vibrator 17, drops to a value of half the maximum negative voltage, $-U_{max}/2$. From this point it rises during the scanning of the second frame to half the positive maximum value $U_{max}/2$ 90 and then drops to the extreme negative value, $-U_{max}$, due to the simultaneous cessation of the signal from the vibrator 17 and the commencement of the signal from the vibrator 18. From that point the rise of the voltage 95 for the scanning of the third frame begins. The drop of the saw-tooth and the end of the signal from the vibrator 18 compensate one another, so that the voltage rise is continued 100 constantly after a short transition phase, in order to scan for the first time the next cine frame 7a.

The method of operation of the apparatus described is as follows:

The cine film 7 is moved past the SEV 8 105 at a constant speed of one frame per 3/50th second by the rollers 9, 10. The speed of the motor 11 is regulated in the manner described with reference to Figure 3, in accordance with 110 the signal from the photo-resistor 14. Synchronously with the movement of the perforations 7b in front of the mask 13, the screen 5a is illuminated point-by-point in the series of overlapping areas explained with reference 115 to Figure 1. By means of the objective lens 6, the scanning spot is projected onto the film images 7a and the SEV 8 emits a corresponding brightness signal for each point scanned 120 on the image. For each cine frame 7a there are three scanings, which are reproduced on the television screen one after the other, on a 625 line tube, being off-set by one line in each case according to the line interlacing method. It is presupposed that the SEV can register 125 the brightness values on the film within an area which is 1/3rd higher than that of the cine frame 7a. Any necessary amplification can be effected by an amplifier 21 connected to the SEV 8, and the amplified signal can then

1. Be delivered to a television receiver of known construction.

WHAT WE CLAIM IS:—

1. Apparatus for effecting line-by-line scanning of a series of images of predetermined height to enable the images to be reproduced on a television receiver, which comprises means for transporting a carrier bearing a series of images continuously past a scanning position, means for scanning repeatedly a series of three overlapping areas at the scanning position, and a photo-electric transducer arranged to receive light transmitted by the images, during scanning, the scanning means being arranged to scan each area in turn in the opposite direction to the direction of motion of the images, and the arrangement being such that, in operation, the length of each of the said scanned areas is equal to two-thirds of the image height (the said length and the said height each being measured in the said direction of motion), that the second and third of the said areas are each offset in the said direction of motion by a distance equal to half the said length in relation to the immediately preceding area, and that said series of three overlapping areas is scanned once during the passage of each image through the scanning position, the scanning means comprising a cathode-ray tube for furnishing a scanning light beam, saw-tooth voltage generator means for producing a voltage for controlling the deflection of the scanning beam over the scanned areas, and means for producing television frame sync pulses at a substantially constant frequency, the said saw-tooth voltage generator means being arranged to produce a voltage changing in one sense over a range to cause deflection of the scanning beam over one of the said overlapping areas, and including means for shifting the range in the opposite sense after each scanning of each of the first two areas in said series of three overlapping areas by an amount equal to one half of the voltage difference over the range, so as to produce the specified displacement of the second and third areas in such series, the arrangement being such that the range is returned to its initial position after each scanning of the third area in said series of three overlapping areas, and the transport means comprises a synchronous motor having control means, and there is provided detector means for delivering a synchronising signal to the control means on detecting a perforation on the carrier, the control means being arranged to regulate the motor speed in accordance with the comparison between the frame synchronisation pulses of the scanning means and the signals received from the detector means.

2. Apparatus as claimed in claim 1, wherein the means for shifting the said range comprises two pulse generators, which are arranged to emit voltages in the said opposite sense for the duration of scanning of the said second and third areas, respectively, the magnitude of the voltage emitted by the first pulse generator being equal to one half of the voltage difference over the said range, and the magnitude of the voltage emitted by the second pulse generator being equal to the said voltage difference.

3. Apparatus as claimed in claim 1 or claim 2, wherein the television frame sync pulse generator includes a quartz resonator.

4. Apparatus as claimed in claim 2 or claim 3 as appended thereto, wherein each of the pulse generators comprises an astable multivibrator.

5. Apparatus as claimed in any one of claims 1 to 4, wherein the detector means comprises means for causing narrow light beams to be incident on the image carrier at three positions spaced apart in the direction of motion of the images, the distance between adjacent positions being equal to one-third of the image height, at least one photoelectric transducer being arranged to receive light from said narrow beams passing through the perforations.

6. Apparatus as claimed in any one of claims 1 to 5, wherein the transport means includes a pair of co-operating rollers arranged to impart movement to the image carrier.

7. Apparatus for effecting line-by-line scanning of a series of images, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

8. A method for line-by-line scanning of a series of images on a carrier, to enable the images to be reproduced on a television receiver having a frame scan rate of approximately three times the image frequency at which said series was recorded, wherein the series of images is transported continuously past a scanning position, each image is scanned at said scanning position three times in the opposite direction to its direction of motion, the scanning area is shifted after each of the first two scans by one-third of the image height in the direction of motion and has a length equal to two-thirds said image height, and is returned to the initial position for the first scanning of the next image, and wherein transport of the series of images is synchronised with the scanning utilising synchronising signals produced by detection of perforations on said carrier.

9. A method as claimed in claim 8, wherein the series of images is transported at $16\frac{2}{3}$ frames per second and said frame mean rate is 50 per second.

10. Apparatus as claimed in any one of



1 be delivered to a television receiver of known construction.

WHAT WE CLAIM IS:—

5 1. Apparatus for effecting line-by-line scanning of a series of images of predetermined height to enable the images to be reproduced on a television receiver, which comprises means for transporting a carrier bearing a series of images continuously past a scanning position, means for scanning repeatedly a series of three overlapping areas at the scanning position, and a photo-electric transducer arranged to receive light transmitted by the images, during scanning, the scanning means being arranged to scan each area in turn in the opposite direction to the direction of motion of the images, and the arrangement being such that, in operation, the length of each of the said scanned areas is equal to two-thirds of the image height (the said length and the said height each being measured in the said direction of motion), that the second and third of the said areas are each offset in the said direction of motion by a distance equal to half the said length in relation to the immediately preceding area, and that said series of three overlapping areas is scanned once during the passage of each image through the scanning position, the scanning means comprising a cathode-ray tube for furnishing a scanning light beam, saw-tooth voltage generator means for producing a voltage for controlling the deflection of the scanning beam over the scanned areas, and means for producing television frame sync pulses at a substantially constant frequency, the said saw-tooth voltage generator means being arranged to produce a voltage changing in one sense over a range to cause deflection of the scanning beam over one of the said overlapping areas, and including means for shifting the range in the opposite sense after each scanning of each of the first two areas in said series of three overlapping areas by an amount equal to one half of the voltage difference over the range, so as to produce the specified displacement of the second and third areas in such series, the arrangement being such that the range is returned to its initial position after each scanning of the third area in said series of three overlapping areas, and the transport means comprises a synchronous motor having control means, and there is provided detector means for delivering a synchronising signal to the control means on detecting a perforation on the carrier, the control means being arranged to regulate the motor speed in accordance with the comparison between the frame synchronisation pulses of the scanning means and the signals received from the detector means.

2. Apparatus as claimed in claim 1, wherein the means for shifting the said range comprises two pulse generators, which are arranged to emit voltages in the said opposite sense for the duration of scanning of the said second and third areas, respectively, the magnitude of the voltage emitted by the first pulse generator being equal to one half of the voltage difference over the said range, and the magnitude of the voltage emitted by the second pulse generator being equal to the said voltage difference.

3. Apparatus as claimed in claim 1 or claim 2, wherein the television frame sync pulse generator includes a quartz resonator.

4. Apparatus as claimed in claim 2 or claim 3 as appended thereto, wherein each of the pulse generators comprises an astable multivibrator.

5. Apparatus as claimed in any one of claims 1 to 4, wherein the detector means comprises means for causing narrow light beams to be incident on the image carrier at three positions spaced apart in the direction of motion of the images, the distance between adjacent positions being equal to one-third of the image height, at least one photoelectric transducer being arranged to receive light from said narrow beams passing through the perforations.

6. Apparatus as claimed in any one of claims 1 to 5, wherein the transport means includes a pair of co-operating rollers arranged to impart movement to the image carrier.

7. Apparatus for effecting line-by-line scanning of a series of images, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

8. A method for line-by-line scanning of a series of images on a carrier, to enable the images to be reproduced on a television receiver having a frame scan rate of approximately three times the image frequency at which said series was recorded, wherein the series of images is transported continuously past a scanning position, each image is scanned at said scanning position three times in the opposite direction to its direction of motion, the scanning area is shifted after each of the first two scans by one-third of the image height in the direction of motion and has a length equal to two-thirds said image height, and is returned to the initial position for the first scanning of the next image, and wherein transport of the series of images is synchronised with the scanning utilising synchronising signals produced by detection of perforations on said carrier.

9. A method as claimed in claim 8, wherein the series of images is transported at $16\frac{2}{3}$ frames per second and said frame mean rate is 50 per second.

10. Apparatus as claimed in any one of

claims 1 to 6, wherein the height of the
screen of the cathode-ray tube is such that the
height of a projection of the screen at the
scanning position is greater by one third than
5 the said predetermined image height.

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