July 14, 1942. W. REICHEL 2,289,457

COLOR TELEVISION

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Fig. 1

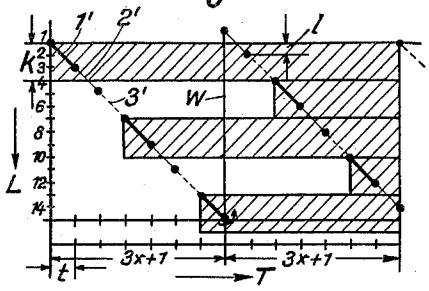


Fig. 2

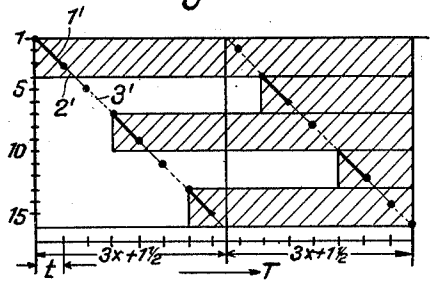


Fig. 3

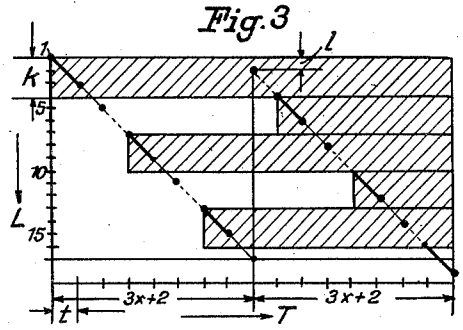
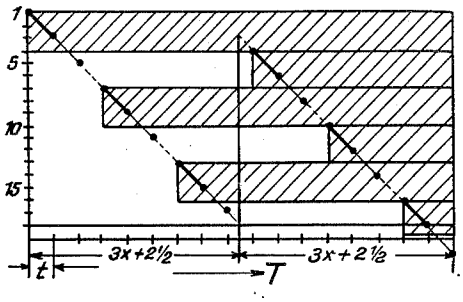


Fig. 4



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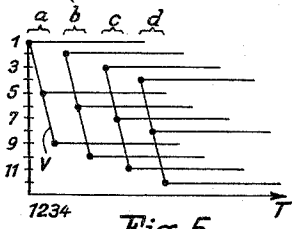


Fig. 5

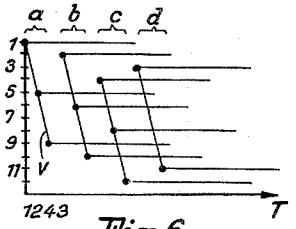


Fig. 6

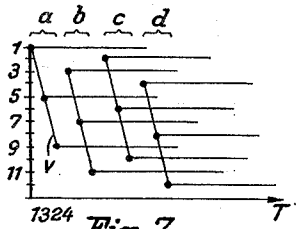


Fig. 7

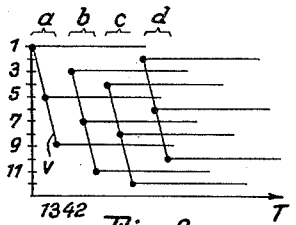


Fig. 8

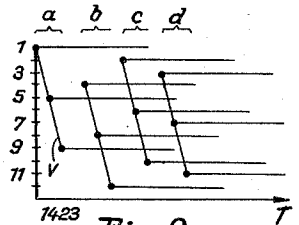


Fig. 9

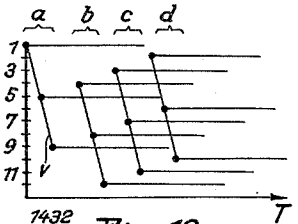


Fig. 10.

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Fig. 11

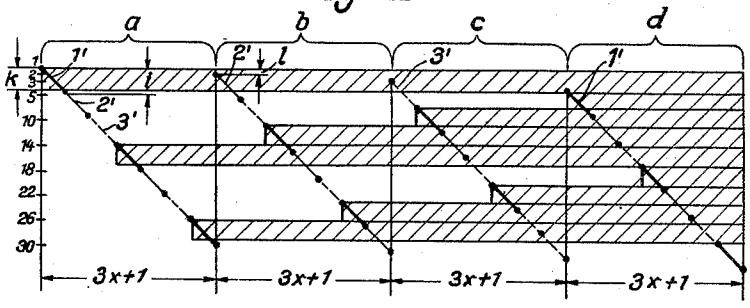
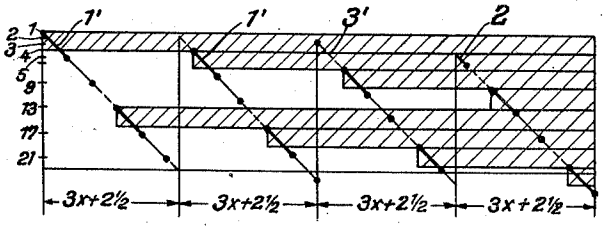


Fig. 12



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Fig. 13

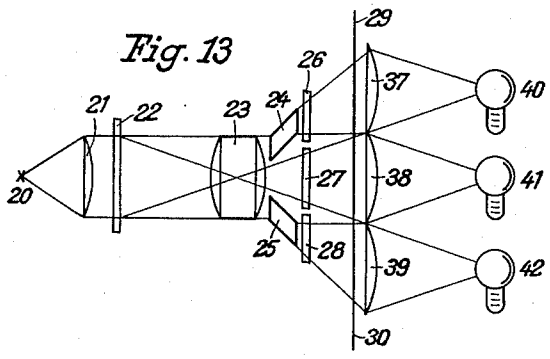


Fig. 14

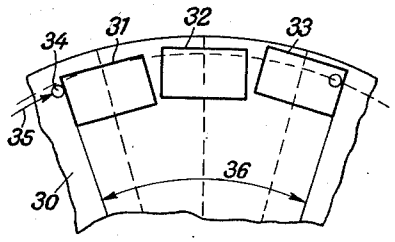
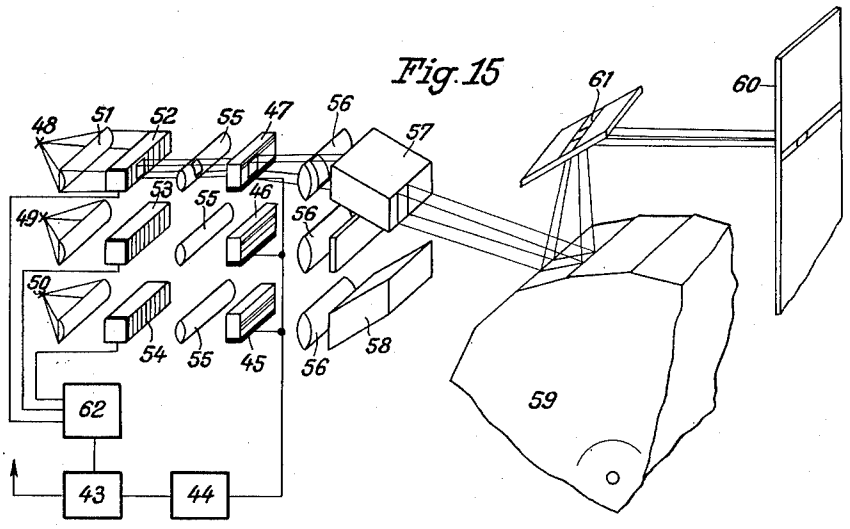


Fig. 15



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UNITED STATES PATENT OFFICE

2,289,457

COLOR TELEVISION

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Application May 13, 1940, Serial No. 334,882
In Germany May 19, 1939

18 Claims. (Cl. 178—5.2)

My invention relates to methods and means for transmitting television images in natural colors and it refers particularly to systems in which a number of color components are transmitted in regular succession.

It is an object of the invention to scan the image in such a manner that an interlaced scanning pattern is produced in order to reduce flicker and at the same time to change the colors in such regular order that a correct mixture of the color components is obtained. It is a further object to produce pictures which are free from color flicker, colored edges and moving color zones. A further object is to bring the number and situation of the color changes in relation to the number and situation of the lines and of the field of lines.

It has been suggested heretofore to effect the change of color simultaneously with the change of lines, i. e. during the line retrace period. It has however been found that in such a method an incorrect blending of the color components will be produced unless precautionary steps are taken. If for instance the usual interlaced scanning scheme with an interlace ratio of 2:1 is used and if the colors are changed simply from line to line in the order as the lines are written, wandering zones of color will be observed disturbing the image to an objectionable degree.

In order to overcome these and other difficulties a method of scanning is used according to the invention in which the lines belonging to a single color component are arranged to form a correct interlaced scanning pattern. The picture is scanned, transmitted and/or reproduced in a number of interlaced fields of lines, each field containing lines of all three color components. The lines have such a width and situation that if only the lines of one single color are considered the image is completely scanned by this color component at the end of the last field of each picture. According to the invention each point of the picture is covered once and only once during each picture period by all three color components so that the correct mixture of the colors is obtained. If in a 2:1 interlace the horizontal lines start at the top of the frame and the first line of the second field is situated below the first line of the first field, the first line of the second field must have the same color as the third line of the first field. If the first line of the second field is situated above the first line of the first field it must have the same color as the second line of the first field. In other words, the lines of the second field of each one of the colors must be situated symmetrically between the lines of the first field having the same color. The invention applies also to scanning methods having a higher interlace ratio, as for example 4:1. In this case the last mentioned condition must prevail between two successive fields or between alternative fields of lines.

Other effects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawings, Figs. 1, 2, 3 and 4 are each a diagrammatical representation of the sequence and position of the lines of various colors for a 2:1 interlaced scanning pattern and various numbers of lines per picture,

Figs. 5, 6, 7, 8, 9 and 10 are each a diagrammatical representation of the different orders of the fields in a 4:1 interlaced scanning pattern,

Figs. 11 and 12 are each a diagrammatical representation of the sequence of lines in a 4:1 interlaced scanning pattern,

Fig. 13 is a plan view of a scanning arrangement,

Fig. 14 is a side view of a section of a scanning disc and

Fig.15 is a perspective view of a receiving arrangement.

In the diagrams of Figs. 1, 2, 3, 4, 11 and 12 each line of a picture is represented by a line drawn from the upper left corner towards the lower right corner. The arrow L indicates the situation and the direction of numbering of the lines and the arrow T the direction of time. In the scale on the left-hand side one partition indicates the line distance l measured for example between the centres of neighboring lines. The partitions t indicate the duration of a single line. The lines indicated by heavy lines have the color 1', for example blue, the thinner lines have the color 2', for example yellow, and the dotted lines have the color 3', for example red. The dots at the beginning of the lines indicate the starting point of the lines with regard to their situation and time. The lines are numbered from top to bottom according to their local situation irrespective of the fact whether they belong to the first or second field of lines. The line retraces are omitted in these representations so that lines succeeding one another form an unbroken series. The vertical line w indicates the change-over from one field of lines to the next one. This change takes place either during the line retrace

or in the middle of a line depending upon whether there is an even or odd number of lines per picture.

Fig. 1 shows the diagram of a picture with 14 lines and 2:1 interlace resulting in 7 lines per field. In order to produce the interlace the first line of the second field starts higher by the height of one line than the first line of the first field. The change from the first field to the next one takes place at the end of line 13, and the change from the second field to the next picture at the end of line 12. The entire area of the picture shall be covered by each single color component once during the picture period $T=14t$. This is achieved according to the invention by making the width k of the lines equal to three times the distance l between neighboring lines. The width of the first line is indicated in the diagram by the hatched zone, the upper left corner of which coincides with the starting point of line 1. This hatched zone does not represent the line itself because the line ends at the starting point of line 2, but it shall only indicate that this horizontal region of the frame has been covered by color 1' and must not be scanned again during the same picture period by the same color. The figure indicates that at the end of two fields the entire frame has been scanned completely by the color component 1'. It has been found that for each total number of lines per image the situation and the color of the first line of the second field must be chosen according to certain rules, if a complete and correct scanning shall be obtained.

Figs. 1–4 show the conditions for four different numbers of lines. The total number is either odd or even. The figures do not show the case in which a field of line contains $3x$ lines, x being a whole number, because in this case a periodic change of the color makes difficulties. In Figs. 1 and 3 the total number of lines per picture is even while in Figs. 2 and 4 the total number is odd. In all these cases the line of the second field situated directly below the first line of the first field, i. e. line 2 of the figures, must have the color 3'. The height of the field retrace w can be measured directly in the figures.

The method of the invention can also be used in case of a multiple interlaced scanning pattern, for example, with a ratio of 3:1 or 4:1. In the case of a 4:1 interlace the width k of the lines is also made equal to three times the distance l between lines having consecutive numbers (Fig. 11). As the line scanned immediately after line 1 has the local number 5 it can be seen that between the first line having color 1' and the line scanned immediately thereafter with color 2' there remains a free space of one line distance l so that the width k of a line is equal to ¾ of the distance between consecutive lines of a field of lines. Also in the multiple interlace the condition must be fulfilled that each color component considered by itself and independent of the other colors must be scanned in a correct interlace so that at the end of four fields the entire area of the picture is scanned once and only once by each color component.

The 4:1 interlace differs from the usually employed 2:1 interlace by the fact that 6 different orders are possible for the situation of the first lines of each field. These different orders are represented in Figs. 5–10. In these figures a different manner of representation is chosen. The scale at the left side of each figure indicates again the local order of the total number of lines per picture. The arrow T indicates time. The lines are represented by horizontal strokes and the beginning of each line is marked by a dot. The horizontal length of the lines does however not indicate the duration of the line but it is made longer for the sake of clearness. The lines belonging to the first field are lines 1, 5 and 9, the first field being indicated by letter a. The second field is lettered b, the third field c and the fourth field d. The lines belonging to one and the same field are connected by a line v in order to make the grouping clearer. The figures show that the field b may begin with any one of lines 2, 3 or 4 and that six different orders for the first lines of the four fields are possible. These "orders" are indicated by a number defining the sequence of the first lines of each field. This order number is applied to each figure in the lower left corner. Fig. 5 shows a 4:1 interlace with the order 1 2 3 4, Fig. 6 the order 1 2 4 3, Fig. 7 the order 1 3 2 4 and so on. Of special importance is the continuously advancing interlace of Fig. 5 with the order 1 2 3 4 and the order of Figs. 7 and 9. The last mentioned two orders allow the reception of the 4:1 interlace with a 2:1 interlace receiver without producing disturbing effects in the image representation.

Taking into consideration the different orders of the 4:1 interlace in connection with the change of colors certain rules must be followed according to the invention for producing a correct scanning. Fig. 11 shows a 4:1 interlace of the order 1 2 3 4; the first line 1 of the first field a and the first line 4 of the fourth field d have the color 1'. The first line 2 of the second field b has the color 2' and the first line 3 of the third field c has the color 3'. According to the invention the number of the color of the first line of each field must be equal to the order number of the interlace, i. e. the field beginning with line 2 must also have color 2', the field beginning with line 3 must have color 3' and the field beginning with line 4 must have color 1' again. If the further condition is followed that the number of lines in each field shall not differ by more than one line from one another, the invention can only be carried into effect if certain total line numbers per picture are used.

Figs. 11 and 12 show two examples of a 4:1 interlace with color changes at the end of each line. In Fig. 11 each field a, b, c and d contains $3x+1$ lines. The complete image contains therefore $12x+4$ lines. In case the first field contains $3x+1$ lines the order of Figs. 5 or 6 must be employed. If the first field contains $3x$ lines the order of Figs. 9 or 10 must be used. If the first field contains $3x+2$ lines the order of Figs. 7 and 8 must be employed. Which one of the two orders has to be used in each case depends on the number of lines in the second field.

Similar conditions exist if the field contains besides the complete lines also parts of lines. Fig. 12 shows for example the case of $3x+2\frac{1}{2}$ lines in the first field. In this case the order of Figs. 7 or 8 must be used.

For carrying out the method of the invention an embodiment for a transmitting and a receiving arrangement is described in connection with Figs. 13, 14 and 15 in which the transmitter contains a device for mechanically scanning the image by means of a Nipkow disc, and the receiver a light control by means of supersonic cells and an image reproducing device making use of a mirror drum. The invention is however not limited to these embodiments given only by

way of example but it can be carried out with other known means for scanning and reproducing an image as for example cathode ray pick-up tubes of the storage type, dissector tubes, Braun tubes etc.

The arrangement of Figs. 13 and 14 contains a source of light **20**, a condenser **21** and a color film **22**, the picture of which shall be transmitted. An image of the film **22** is produced by means of an objective **23** in the plane **29** of a scanning device, for example a Nipkow disc **30**. Behind the objective **23** the light current is split up into three parts by means of two plane-parallel prisms **24** and **25**. Each of the separate paths of light includes a color filter **26**, **27** and **28** allowing the passage of only one color component of the multicolored film picture **22**. In this manner three adjacent images **31**, **32** and **33** of the film are reproduced in plane **29**, each image having a different color. The three images are not exactly aligned, but they are staggered in their height by the distance between two lines. It is furthermore preferable that the two outer images are turned to a small degree with respect to the central image so that the central axes of the images **31** and **33** have a common point of cross section in the centre point of the Nipkow disc. If a scanning aperture **34** of the disc is moved in the direction **35** across the three images, the three lines **1**, **3**, **5** of Fig. 1 are scanned one after the other, the width of the opening corresponding to the width k of the line. The openings of the Nipkow disc have a peripheral spacing given by the angle **36**. The openings are arranged in such a manner that at first the field containing the lines **1**, **3**, **5** etc. and after half a revolution of the Nipkow disc the second field containing the lines **2**, **4** and **6** will be scanned. Instead of the Nipkow disc with two spirals of holes filling out each 180° a Nipkow disc containing a multiple spiral can be used in connection with a suitable shutter disc. The light passing through the openings of the Nipkow disc passes also through collecting lenses **37**, **38** and **39** and is focussed upon one of the photocells **40**, **41** and **42** provided for each of the color components. The impulses representing the color components are amplified separately and brought to the required value, and are then mixed and transmitted together with the synchronizing impulses. It is preferable to distinguish the line impulse at the end of each third line from the other line impulses either by different amplitude, duration, steepness or the like. It may be sufficient if the transmission standard is so chosen that the field having color **1'** in a transmission with an odd number of lines according to Fig. 2 is co-ordinated with the field impulse co-inciding with a line impulse while the field impulse not coinciding with a line impulse is produced during the second color. This is an advantage of the method operating with $3x+1\frac{1}{2}$ lines per field.

In the receiver shown in Fig. 15, the image signals together with the synchronizing signals are amplified in the amplifier **43** and separated from one another. The image signals which may be further amplified in the amplifier **44** are applied to three light valves consisting of three supersonic cells **45**, **46**, **47**. These cells are situated in the path of a light ray bundle having an image point shaped cross section. These light rays are produced by sources of light **48**, **49** and **50** by way of condensers **51**, supersonic cells **52**, **53**, **54** and cylindrical lenses **55**. Each source of light produces an illuminated line in the plane of the cells **52**, **53**, **54**. Each of these cells receives line impulses from the amplifier **43** which may be amplified and suitably shaped in the device **62**, so that only every third line impulse is applied to one of these cells. A transparent region travels along the cell with the velocity of the image point as it is known in the art from the so called wave slot devices. The cells allow the passage of light only through a moving spot defining the size of an image point. The moving light ray is modulated in its brightness by the cells **45**, **46** and **47** in which zones of different brightness are moving upwardly as excited by the image signal. The light passing through the cells **45**, **46** and **47** passes through the objectives **56** and through prisms **57**, **58**. The objectives produce an image of the moving aperture of cells **45**, **46**, **47** upon a screen **60** over a mirror drum **59** and a stationary mirror **61**. The composition of the image along the line is produced by means of the supersonic cells and the composition of the lines by means of the rotating mirror drum **59**. As the length and shape of the lines is determined by the form of the supersonic cells and as the properties of optical reproduction of the three cells may be equalized to a large degree the color lines on the projection screen **60** will be situated exactly as prescribed by the scanning pattern. The mirror drum **59** has such a number of mirrors and such a number of revolutions that during the scanning of each line the movement in the vertical direction is equal to twice the distance l so that the interlaced pattern is produced.

In place of the three separate light paths and three supersonic cells **45**, **46**, **47** an arrangement can be used in which only a single wave slot cell and a single supersonic cell is used. In this case however, a three color filter must be provided, for example, in the form of a rotating disc having colored sectors. This color disc is arranged preferably at the narrowest point of the light path and is moved with such a velocity that for the duration of each line a sector of certain color is situated in the path of light. At the end of each line the next sector comes into operation. It is also possible with such a device to effect the color change not at the end of each line but at the end of a small group of lines.

The invention is not limited to the described embodiment. It can be used in connection with dissector tubes, iconoscopes or other forms of electronic image pick-up devices and in connection with receiving arrangements in which a storage of the light effects is used. The method is suited for the transmission of color films as well as of natural scenes. On the receiving side a reproduction can take place with projection receivers for a large audience or with small scale receivers. The method has the further advantage that it is possible to receive the multicolored transmissions also with single color receivers which are cheaper and more simple in construction.

What I claim is:

1. The method of transmitting television images with three different color components over a single transmission channel, including the steps of scanning the image in lines having a width equal to three times the distance between adjacent lines, changing the color after the completion of each line, transmitting each complete picture in a number of fields of lines, and starting each successive field with a line of different color in such manner that the lines having one of said three colors in one field are inter-

laced with the lines of the same color in the remaining field or fields.

2. The method of transmitting television images with three different color components over a single transmission channel, including the steps of scanning the image in lines having a width equal to three times the distance between adjacent lines, changing the color after the completion of each line, transmitting each complete picture in a number of fields of lines, and starting each successive field with a line of different color in such manner that the lines having one of said three colors in one field are interlaced with the lines of the same color in the remaining field or fields in such a manner that the lines of each single color component fill out the entire area of each complete picture.

3. The method of transmitting television images with three different colors over a single transmission channel including the steps of scanning the frames in lines having a width equal to three times the distance between the centres of adjacent lines, changing the color at the end of a small number of lines including one in sequential regular order, scanning each frame in a number of interlaced fields, and starting the second field of each frame with a line of such color that the line of this color is correctly interlaced with the lines of the same color of the first field of the frame.

4. Method of transmitting colored television images including the steps of scanning the frames in a number of interlaced fields, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, situating the first complete line of the second field inwardly of the first line of the first field, changing the color at the end of each line, and starting the first line of the second field with the color of the third line of the first field.

5. Method of transmitting colored television images including the steps of scanning the frames in a number of interlaced fields, situating the first complete line of the second field inwardly of the first line of the first field, changing the color at the end of each line, starting the first line of the second field with the color of the third line of the first field, and making the width of the lines equal to three times the distance between the centers of the first lines of each field.

6. Method of transmitting colored television images including the steps of scanning the frames in a number of interlaced fields, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, situating the complete first line of the second field outwardly of the first line of the first field, changing the color at the end of each line, and starting the first line of the second field with the color of the second line of the first field.

7. Method of transmitting colored television images including the steps of scanning the frames in a number of interlaced fields, situating the complete first line of the second field outwardly of the first line of the first field, changing the color at the end of each line, starting the first line of the second field with the color of the second line of the first field, and making the width of the lines equal to three times the distance between the centres of the first lines of each field.

8. Method of transmitting television images with three color components including the steps of scanning each image frame in four interlaced fields, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, changing the color at the end of each line, and starting each field with a color dependent upon the position of the first line in such a manner that the number of the first line of each field corresponds to the number of the color, the lines being numbered in their local order and line 4 having the color 1.

9. Method of transmitting television images with three color components including the steps of scanning each image frame in four interlaced fields, changing the color at the end of each line, starting each field with a color dependent upon the position of the first line in such a manner that the number of the first line of each field corresponds to the number of the color, the lines being numbered in their local order and line 4 having the color 1, and making the width of each line equal to three times the distance between the centres of neighboring lines.

10. Method of scanning television images for a three color transmission including the steps of dividing each complete image into four fields of lines interlaced with one another, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, each line having one of three colors numbered one, two and three, and so situating the first complete line of each field that the number of the line in the local order of the lines is equal to the color number, line number four corresponding the color number one.

11. Method of scanning television images for a three color transmission including the steps of using an interlaced scanning pattern with a ratio of 4:1, comprising four fields of lines interlaced with each other, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, arranging the first lines of the four fields in numerical order, and scanning the complete image with a number of lines equal to $12x+4$, x being a whole unbroken number.

12. Method of scanning television images for a three color transmission in which an interlaced scanning pattern with a ratio of 4:1 is used, comprising four fields of lines interlaced with each other, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, arranging the first lines of the four scanning fields in numerical order, changing the color after each line in regular succession, using a line width of three times the distance of the centre of the lines, and scanning the complete image with a number of lines equal to $12x+4$, x being a whole unbroken number.

13. Method of scanning television images for a three color transmission including the steps of dividing each complete image into four fields of lines interlaced with one another, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, each line having one of three colors numbered one, two and three, arranging the first lines of the four fields in the local order 1 4 2 3, and scanning the complete image with a number of

lines equal to $12x+10$, x being a whole unbroken number.

14. Method of scanning television images for three color transmission with an interlaced scanning pattern of the ratio 4:1 comprising four fields of lines interlaced with each other, each of said fields comprising a plurality of parallel lines, each having a width equal to several times the distance between the centers of adjacent lines, the first field of the image comprising 34 lines, including the steps of changing the color at the end of each line, and arranging the first complete line of the second field so that it is the fourth line of the complete picture if the lines are numbered in their local order.

15. Method of scanning television images for three color transmission with an interlaced scanning pattern of the ratio 4:1 comprising four fields of lines interlaced with each other, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, the first field of the image comprising $3x+1$ lines, including the steps of changing the color at the end of each line, and arranging the first complete line of the second field so that it is the second line of the complete picture if the lines are numbered according to their local order.

16. Method of scanning television images for a three color transmission with an interlaced scanning pattern of the ratio 4:1 comprising four fields of lines interlaced with each other, each of said fields comprising a plurality of parallel lines each having a width equal to several times the distance between the centers of adjacent lines, the first field of the image comprising $3x+2$ lines, including the steps of changing the color at the end of each line, and arranging the first complete line of the second field so that it is the third line of the complete picture if the lines are numbered in their local order.

17. In a television system for the transmission of colored images containing three color components, means for scanning the frames in a number of interlaced fields of lines, means for making the width of each line substantially equal to three times the distance of the centres of neighboring lines, means for changing the color at the end of a small number of lines including one in a regular succession, and means for placing the first complete line of the second field of each frame in such a position that the line of this color is correctly interlaced with the lines of the same color of the first field.

18. In a television system for transmitting images in natural colors, means for forming an optical image of the object to be televised, means for splitting said optical image into three images, means in the path of each of said images for excluding all but one color component, means for scanning alternatingly a line of each of said images so that each line is proceeded and followed by a line of different color, means for scanning the complete image in a number of interlaced fields of lines, means for adjusting the width of each line so that it is substantially equal to three times the distance between two neighboring lines of different fields, and means for positioning the second field in such a manner that all lines having one and the same color cover the complete frame in a correct interlace pattern.

WILHELM REICHEL.

CERTIFICATE OF CORRECTION.

Patent No. 2,289,457. July 14, 1942.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, first column, line 11, claim 14, for "34 lines" read --3x lines--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 8th day of September, A. D. 1942.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)