

Aug. 23, 1949.

P. M. G. TOULON

2,479,880

DISCONTINUOUS INTERLACED SCANNING SYSTEM

Filed July 3, 1937

2 Sheets-Sheet 1

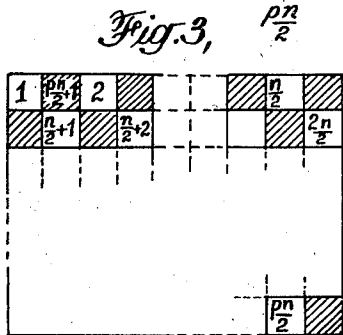
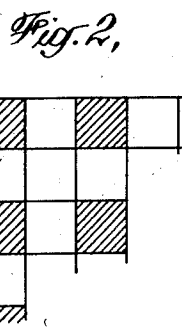
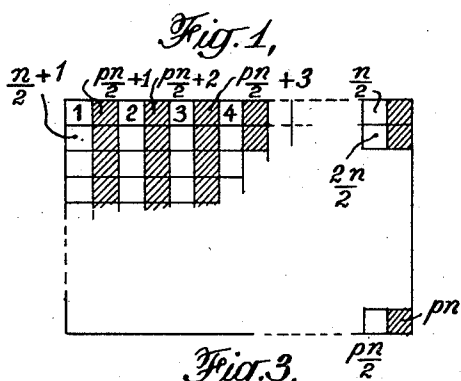
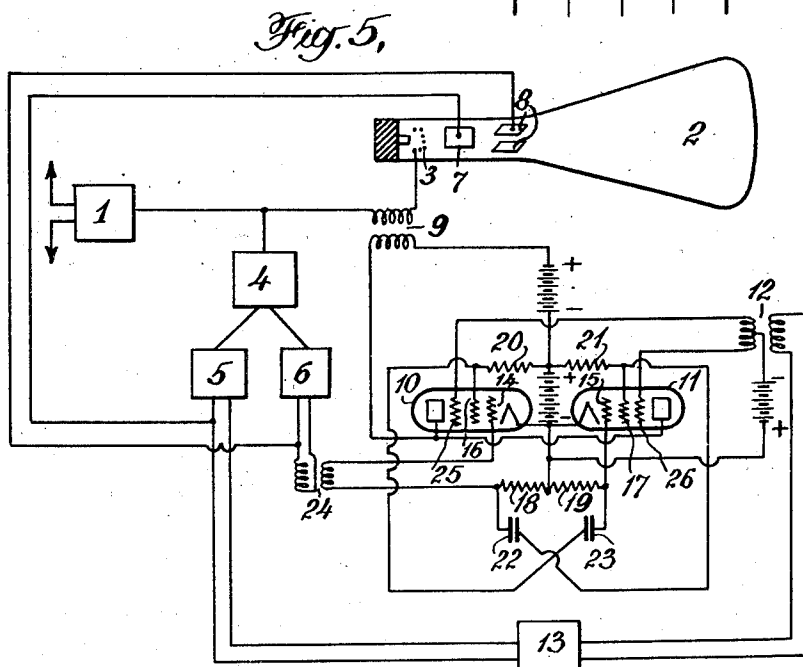


Fig. 4,

3	12	7	16	3	12
6	1	14	9	6	1
15	8	11	4	15	8
10	5	2	13	10	5
3	12	7	16	3	12
6	1	14	9	6	1



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2 Sheets-Sheet 2

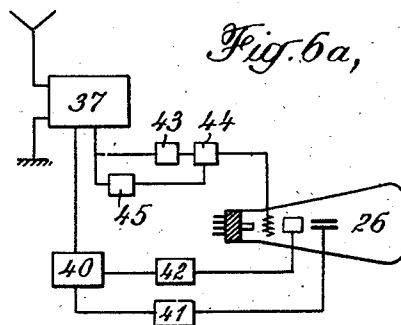
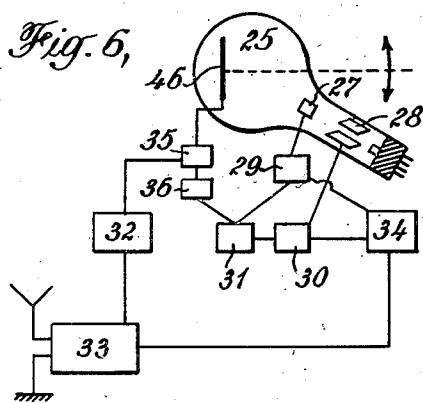


Fig. 7 a

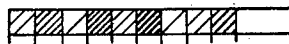


Fig. 7 b



Fig. 7 c

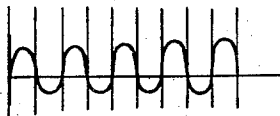


Fig. 7 d



Fig. 7 e



Fig. 7 f

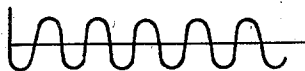


Fig. 7 h



Fig. 7 i



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UNITED STATES PATENT OFFICE

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DISCONTINUOUS INTERLACED SCANNING
SYSTEM

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In France July 4, 1936Section 3, Public Law 690, August 8, 1946
Patent expires July 4, 1956

2 Claims. (Cl. 178—7.7)

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This invention refers to television apparatus in which the exploration either in transmission or reception is effected by means of a movable cathode beam. It especially refers to transmission apparatus in which the exploration is effected by the displacement or shutting off of the electronic image.

One of the present problems which television technique is trying to solve is the reduction of flickering and the increase in sharpness. It has already been suggested to effect the exploration by interlaced scanning. The application, which has now become conventional, of this method of exploration has for its sole purpose the reduction of flickering. It consists in doubling the number of images transmitted per second by exploring the first image along the odd lines, the second image along the even lines, and so on. For a given transmission pass band, the improvement realized applies only to flickering. As a matter of fact, the number of lines explored per image is one-half compared with ordinary exploration. To the eye of the observer it appears that the total number of lines has not changed and therefore the definition or sharpness of the image is not increased, only the flickering being reduced. It is naturally possible, with a like width of pass band and furthermore by employing the interlaced-line system of transmission, not to double the number of images transmitted per second, and thus to maintain the number of the lines explored for each image, as in the case of normal transmission. As the lines of an image interpose themselves between those of the preceding image, the observer receives the impression that it is an image the number of lines of which is double. The sharpness is therefore increased, but the flickering remains the same.

Thus it can be seen that it is possible to double the sharpness without increasing the flickering or else it is possible to reduce the flickering by one-half, without affecting the sharpness, by means of interlaced scanning. However, if it is desired to still further improve the quality of the image, it is possible by this method, for a given pass-band width, only to improve either one of the factors of sharpness or flickering to the detriment of the other factor.

It is an object of this invention to provide an exploration method by which it is possible to exceed these limits considerably, namely to improve the sharpness by more than 50% without changing the flickering, or to reduce the flickering by more than 50% without detriment to the sharpness, or even to considerably improve these two

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factors simultaneously, all of this being accomplished without increasing the transmission pass band. The invention furthermore makes it possible to considerably improve the definition of the points of the image in the direction of the sweep.

In accordance with the invention, the cathodic beam or its electric circuit or electric circuits connected therewith are acted upon in such a manner that the exploration no longer is made in a continuous manner, but by separate points.

In the descriptions of the exploration systems used up to the present time in television, the terms or words "sweeping" and "exploration" or "scanning" have been confused and often taken one for the other, because the order of exploration and the order of sweeping were the same. In the new method which is the subject matter of the invention, each one of these terms must be understood to have a very precise, special meaning. In the following description the term "sweeping" designates a geometric action, for instance the displacement of the electronic beam along a line and from one line to another of the image. The term "exploration" or "scanning" designates a physical action, for instance the transformation of a point of the image into an electric impulse, or vice versa. Thus, when sweeping a line, it is possible to explore only a part of its points.

In accordance with the invention, the points explored during the sweeping may be at a certain distance from each other, either on the same line or on different lines, at equal or different distances.

A further object of the invention is to provide means which make it possible to assure this exploration in such a manner that all the points of the image are explored once during a certain time interval.

When applied to receiving, the action in accordance with the invention consists of a complete modulation of the intensity, namely the cathodic beam is caused to appear and to disappear periodically on the swept line. In case of application to an electronic transmitter, for instance an iconoscope, it is possible either to modulate the electronic beam or to act upon the line of transmission of the vision impulses.

Preferably the action exercised in accordance with the invention is periodical, that is, the different points of each line are explored by skipping an always equal number of points which are to be explored subsequently during the subsequent sweepings. In the case of a sweeping with constant speed, the appearance and disappear-

ance of the electronic beam are obtained preferably by acting on the potential of an electrode of the cathodic beam tube by means of an auxiliary current source. If Wenhelt cylinders are used as control electrodes, the auxiliary voltage is superimposed upon the modulation voltage. The auxiliary current is preferably alternating, in such a manner that the cathodic beam is periodically interrupted at the corresponding frequencies and as the sweeping occurs at constant speed, the points explored are located at successive equal distances from one another. Preferably the frequency of this auxiliary current is synchronized with the image frequency of the transmitter, in such a manner that all the points of the surface are explored always in the same order. This frequency may furthermore show a certain fixed ratio with the frequency of the lines; in other words, in a line there is always found the same number of points explored at each sweeping. The ratio between these two frequencies need not necessarily be an integer.

The order of the sweeping may be such that the points explored on each line are placed one below the other.

The analysis thus realized corresponds to an interlaced line exploration or interlaced scanning in a direction perpendicular to the sweeping, that is, perpendicular to the motion of the beam.

Each one of the lines of the image may be swept several times in succession by exploring different elements of this line each time, which elements complement each other. In this way all the points of the line are explored before passing to the following line; it is also possible to explore one part of the elements of the line swept, then pass to the next line, exploring again certain points and in this way sweep the entire surface; after this sweeping is over, a return may be made to the first line in order to explore a certain number of points which have been missing, and so on, exploring in this way all the points of the image during several successive sweepings of the entire surface.

Irrespective of the form of the invention used, the fact that the exploration is done in a discontinuous manner, namely, that some points, arranged at a certain distance from each other, are successively explored and the intermediate points explored subsequently, makes it possible to considerably increase the definition in the direction of the sweeping. This was not possible with the systems used up to the present time in which the exploration was always continuous. Furthermore, the manners of exploration in accordance with the invention make it possible to decrease very considerably the flickering without any detriment to the sharpness or vice versa, or else to reduce the width of the pass band which corresponds to the vision currents. The progress thus realized is much more considerable than with the most perfected sweeping methods used at the present time, as for example interlaced lines.

The invention will be better understood by reference to the accompanying drawings, in which several illustrative embodiments of the invention are shown, as follows:

Figs. 1, 2 and 3 show diagrammatically the tracings of the special manners of exploration in accordance with the invention;

Fig. 4 shows the partial tracing of another improved variant of exploration;

Fig. 5 shows an assembly making possible, among other things, the realization of the exploration in accordance with Fig. 1;

Fig. 6 shows diagrammatically the general arrangement of a complete transmitting assembly using the principle of the invention;

Fig. 6a shows the receiving assembly corresponding to the transmitting assembly of Fig. 6; and

Fig. 7 indicates as a function of time the currents which circulate in the different parts of the assembly of Fig. 6 and thus makes clear the operation of the embodiment of Fig. 6.

Fig. 1 shows the tracing of a special manner of exploration in which, as the electronic beam moves horizontally, the explored points of each line are located with respect to the points of the neighboring horizontal line in such a manner as to form continuous vertical strips.

In the examples which follow, n designates the number of contiguous points which constitute the horizontal line and p the number of contiguous lines arranged one above the other in the vertical direction and which constitute the image. It is assumed that the sweeping of each line is effected from left to right and that the sweeping of the successive lines of the image is done in a downward direction. It is also assumed that the electronic beam starts to strike point 1, which belongs to the electronic image in the case of a transmitter of the iconoscope type or belongs to a fluorescent screen in the case of a Braun tube receiving apparatus.

As the exploration is periodically interrupted, the regular sweeping makes possible the exploration of point 2, located in the third compartment of the line, then points 3, 4 and so on, arranged respectively in the 5th and 7th compartments up to the point $n/2$ which is located in next to the last compartment of the line. The second line is then swept. The exploration then starts at the point

$$\frac{n}{2} + 1$$

located in the first compartment of the second line, and so on. It terminates at the point $2n/2$ located in the next to the last compartment of the second line. The sweeping is continued up to the exploration of the point located in the next to the last compartment of the last line, which is $pn/2$. Thereupon the beam starts again sweeping a second time the first line and exploring the missing points of this line in the following order:

$$\frac{pn}{2} + 1, \frac{pn}{2} + 2, \frac{pn}{2} + 3$$

and so on, which are placed as shown in the figure in the second, fourth, sixth compartments and so on, respectively of the first line. These points are interposed between those of the exploration realized during the first sweeping. The exploration continues in this way until the last point of the last line of the image, which is point pn , is swept.

The compartments of the second sweeping are shaded. It can be seen immediately that the analysis is made along vertical strips, that is, in strips which are perpendicular to the direction of the sweeping and which are interlaced. The advantage of this exploration lies in the fact that the points of a horizontal line are much more clearly defined because the contour of each one of them is given an even greater precision, which is not the case with the present method in which the horizontal exploration is continuous.

If it is desired to decrease the flickering effect, it is possible to skip one line over two during the

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vertical sweeping of the successive lines. Fig. 2 shows the result of this exploration on a fraction of the image, giving the impression of tile-work.

Fig. 3 shows an exploration arranged like a checker board. As in the case of Fig. 1, the first line is explored in the following order: 1, 2, 3, 4 . . . $n/2$. Then the second line is explored in the following order:

$$\frac{n}{2}+1, \frac{n}{2}+2, \frac{2n}{2}$$

the points explored along the second line being staggered to the extent of one compartment with respect to those explored in the first line. The first sweeping of the image is terminated at point $pn/2$ and the sweeping starts again with the exploration of the point $pn/2+1$ located in the second compartment of the first line, and so on. The sweeping continues by always skipping one compartment. The compartments explored during the second sweeping are shaded and from Fig. 3 of the drawings it is clear that the two explorations interlace like a checker board. From the point of view of the reduction of flickering, this manner of exploration offers the advantage that the points explored during the course of each sweeping are not in alignment either in vertical or in horizontal direction.

In order to realize the improved exploration in accordance with Fig. 4, it is assumed that the entire image is sub-divided into several groups each comprising several compartments and the exploration is effected in such a manner that from one point of a group the sweeping passes successively to a corresponding point of another group and that the sweeping thus explores successively a point located in each group during a complete sweeping of the image. The sweeping thereupon starts again with the first group and selects one compartment which is located as far as possible away from the compartments previously explored.

Fig. 4 shows a fraction of the image on which there can be seen surrounded by heavy black lines a group containing 16 compartments. During the course of the first sweeping of the surface all the points 1 of each group are explored. During the course of the second sweeping all the points 2 of each group are explored, and so on. The complete exploration of an image is terminated after the 16th sweeping. As all the successive points appear irregularly on the screen and at points which are very far from each other, this process strongly increases either the definition or the persistence of the luminosity of the screen.

Fig. 5 shows an assembly making it possible to realize an exploration like the one described in Fig. 1. The principle of this assembly consists in operating the Wehnelt cylinder of the receiving Braun tube by an alternating voltage supplied by a heterodyne and in reversing the phase of the coupling between the heterodyne and the Wehnelt cylinder at the end of each sweeping. In this example the television receiving apparatus comprises a radio receiving set 1 and a Braun tube 2, the Wehnelt cylinder 3 of which receives the modulation coming from set 1. The system 4 selects the line and image synchronization signals; the latter release two relaxation devices respectively; the relaxation device 5 (lines) operates the horizontal deflecting electrodes 7 of the Braun tube while the relaxation device 6 (images) operates the vertical deflecting electrodes 8 of the Braun tube 2. In accordance with the invention there is superimposed over the modu-

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lation voltage which operates the Wehnelt cylinder an alternating voltage supplied by the transformer 9 which itself receives it from a group of amplifier tubes 10 and 11. The latter receive it from a heterodyne 13 with constant frequency through a transformer 12. The arrangement of the tubes 10 and 11 assures a connection between the transformer 12 and the transformer 9 the phase of which connection is periodically inverted at the end of each "image" sweeping.

This result is obtained for instance as shown in Fig. 5 by utilizing tubes 10 and 11 with 5 grids (virtual cathode tubes with two modulation grids) connected as a multivibrator and serving at the same time for amplification.

In order to realize this multivibrator the grid 14 of the tube 10 is connected to the first anode grid 17 of the tube 11 through the condenser 22 and the grid 15 is connected with the grid 16 by means of the condenser 23.

To the grids 14 and 15 respectively there are connected resistances 18 and 19 and to the anode grids 16 and 17 respectively are connected resistances 20 and 21.

It is known that such a coupling between grids and anodes of two tubes gives a series of very sudden inversions of currents separated by long intervals during which the variation of the intensity of the current is very slow. In other words, everything occurs as if the virtual cathode formed beyond the anode grids 16 or 17 of one or the other of the two tubes ceased periodically to transmit; in other words, when one of the tubes operates, the other is out of operation and vice versa. The periodicity of these inversions of the multivibrator is made to correspond to the image frequency, for instance by means of the transformer 24 arranged in series with the grid 14 of the tube 10. The primary of the transformer 24 is traversed by the discharge current of the image thyratron which constitutes the relaxation device 6.

The tubes 10 and 11 operate alternately and transmit the modulation from the heterodyne 13 to the transformer 9, periodically inverting the phase; for this the second control grids 25 and 26 are connected with two opposite ends of the secondary of the transformer 12 and thus receive modulations in phase opposition. On the other hand the plates of the tubes 10 and 11 feed in parallel the primary of the transformer 9. Thus during the first complete sweeping the heterodyne 13 therefore extinguishes periodically the cathodic beam by acting on the Wehnelt cylinder through the circuit comprising the transformer 12, the tube 10 and the transformer 9. During the following sweeping of the image the heterodyne continues to extinguish the beam periodically but in view of the fact that the connection occurs each time through the circuit which comprises the tube 11, the phase of this extinction is staggered or displaced to the extent of half a cycle of the alternating voltage of the heterodyne 13 and the points explored during the second sweeping are staggered to the extent of one compartment.

The frequency of the heterodyne 13 may be any frequency whatsoever provided it is sufficiently high and remains quite constant with respect to time. It is, however, advantageous in order to obtain a good relative position of the points explored during successive sweepings, to control this frequency in connection with the frequency of the sweepings of the lines in such

a manner that the "centering" of each exploration is again well defined at the beginning of the sweeping of each line. This result may be obtained, for instance, by inducting on the control grid circuit of the heterodyne 13 a voltage taken from the circuit of the line relaxation device 5. For instance, the discharge current of the thyratron constituting this relaxation device may be utilized in order to obtain the current impulse which is necessary to assure the stabilization of the heterodyne 13. If the assembly of Fig. 5 is used with present methods of transmission with interlaced lines, a checker board exploration is realized in accordance with that of Fig. 2 and in this way a greater precision of the points is assured and the flickering is reduced to a further extent.

Instead of acting on the electronic beam by the variation of its intensity as indicated above, a deflecting action or a shutting off action may be applied to the beam. These last mentioned variants may be realized by using a Braun tube of special construction, for instance by introducing in front of the fluorescent screen a grid through which the beam passes and which either absorbs the beam or concentrates it and thereupon deflects it. Thus there are produced on the screen points at a distance from each other.

By applying an outside electrostatic or electromagnetic field perpendicular to the electronic trajectory and by, for instance, varying the field periodically, it is possible to displace on the screen the distant points thus obtained in such a manner as to realize one of the explorations in accordance with the invention. Instead of acting on the electronic beam in order to displace the luminous points, it is possible on the contrary to leave them stationary and to displace before the screen an optical system; for instance a grid which comprises a great number of small parallel cylindrical lenses mounted in front of the screen may be used, and the lenses displaced periodically by means, for instance, of an electromagnet which imparts a vibratory motion to this grid.

It must be clearly understood that all the assemblies described can also be used for transmission. If, for instance, an iconoscope tube is used, it is possible to realize the exploration in accordance with the invention by acting on the cathode beam which sweeps the surface in a mosaic like manner. It is also possible to act on the vision electric circuit outside of the tube; especially, this circuit may be interrupted periodically and the interruptions staggered during the successive sweepings.

In accordance with one variant of the invention, the staggering between the points explored during consecutive sweepings is realized by a suitable choice between the frequency of the heterodyne of the receiving station and the frequency of the "line" synchronization signals. If necessary, special "end of lines" synchronization signals or signals which are suitably staggered in time may be used for this purpose.

In particular it is necessary that the heterodyne execute an odd number of alternations in the interval between two "end of lines" synchronization signals. The periodical extinction of the beam, realized by the heterodyne, then produces automatically a "checker board" exploration in accordance with that shown in Fig. 3, this being done without having recourse at the place of reception to any "phase" inversion artifice at the end of each line, as was necessary in the example described in connection with Fig. 5. If

the number of lines of the image swept is odd, the second sweeping automatically realizes the exploration of the complementary points of the checker board. The flickering is thus greatly reduced and the sharpness is increased.

The new exploration in accordance with the invention makes it possible to realize transmissions of images destined for television, the sharpness and definition of which are considerably increased when the pass band utilized for the transmission is the same width. This result is very important if the difficulties which occur in connection with increasing the transmission pass-band width are considered.

Figs. 6 and 6a show complete basic diagrams of a transmission system based on the new process which is the subject matter of the invention.

Fig. 6 shows the transmitter and Fig. 6a the receiving station. Fig. 7 makes it possible to understand why an improvement of the definition of the image is obtained although the band width for the transmission is not extended.

In Figs. 6 and 6a, 25 represents an iconoscope tube on which there is formed the image 46 to be transmitted and 26 is the Braun tube on which this image is received. As customary, the sweeping of the cathode beam of the iconoscope is accomplished by means of deflecting electrodes 27 and 28 connected respectively with the two relaxation devices 29 and 30 for the lines and images, these two relaxation devices being fed by a common multivibrator 31. The modulation supplied by the sweeping of the elements of the photoelectric surface of the iconoscope is transmitted to the amplifier 32 which modulates the radio transmitting set 33. This station receives at the same time, the "line" and "image" synchronization signals suitably arranged after extraction starting from the relaxation devices 29 and 30 through the intermediary of the amplifier 34. In accordance with this example of the invention, the image current of the iconoscope is periodically interrupted by means of a member 35 operated by a heterodyne 36. The latter is controlled by an oscillatory member with fixed frequency, for instance, the multivibrator 31, so as to retain a certain relation of frequency with same. In other words, the number of points explored along each line swept is suitably fixed. The amplifier 32 reduces the amplitude of the cuts made on the modulation transmitted, as will be explained below. The radio receiving set 37 in Fig. 6a receives at the same time the modulation and image signals. The sorting device 40 separates the "line" and "image" synchronization signals. These signals are transmitted to the relaxation devices 41 and 42, respectively, acting on the deflecting plates of the Braun tube 26. On the other hand, the modulation received by the set 37 controls the Wehnelt cylinder due to the amplifier 43.

In accordance with the invention, a member 44 periodically interrupts the cathode beam. This member 44 is operated by the heterodyne 45, the frequency of which is stabilized due to the modulation supplied by the heterodyne 36 of the iconoscope a slight residue of which is superimposed upon the useful vision modulation during the course of the transmission. This stabilization is obtained, for instance, by placing at the output of the receiving set 37 an oscillatory circuit tuned to the frequency of the heterodyne 36.

In Fig. 7a there is shown the brightness of the successive points of a line of the image to be transmitted. In Fig. 7b there is shown the cor-

responding vision current generated by a standard iconoscope and not possessing the improvement of the invention. The heterodyne 36 supplies a voltage represented as a function of time by the curve in Fig. 7c. This heterodyne acts on the vision current through a suitable interrupting member 35. The thus interrupted vision current is represented by the curve of Fig. 7d. As can be noted, the curve corresponds to the exploration of odd points.

The amplifier 32 is especially arranged to prolong the duration of signals and comprises one or more coupling elements between its stages having a certain time constant. The latter may be obtained with the aid of several parallel capacitors in the plate circuit of one of the tubes and of series resistors joining the capacitors, which arrangement also functions as a low-pass filter. The curve of Fig. 7e represents the retarding effect produced systematically on these signals due to the amplifier 32. In the place of a complete interruption of the current between each point explored, only a very slight reduction of the current is obtained. However, this slight variation suffices to assure the synchronism of the heterodyne 45 at the receiving station with the heterodyne 36. When examining the curve of Fig. 7e, it is easily understood that the necessary pass-band width is clearly less than that for the curve of Fig. 7d.

The curve of Fig. 7f represents the voltage supplied by the heterodyne 36 during the next sweeping of the same line, during which sweeping only the even points of this line are explored. The curve of Fig. 7h represents the vision current during this sweeping and the curve of Fig. 7i shows the current which leaves the amplifier 32 and which is to serve for the modulation of the Hertzian wave.

The receiving set receives alternately the vision currents of Figs. 7e and 7i during successive sweepings. Due to the heterodyne 45 acting on the interrupter 44, there is reestablished at the receiving set the voltage curves of Figs. 7d and 7h on the Wehnelt cylinder and thus the checker board exploration of Fig. 3, for instance, is realized.

The present invention covers also any other manner of transmission in which the exploration is realized in accordance with the invention either at the place of transmitting or the place or receiving or both together.

Although several manners of realization of the invention have been shown and described, it is pointed out that the invention is not limited to these particular forms which have been given simply by way of example and without any re-

strictive character and that, therefore, all the variants having the same principle and the same purpose as the arrangements indicated above would fall within the scope of the invention like those mentioned above.

Having thus described my invention, what I claim is:

1. In an electron beam scanning system, an explored surface defined by a plurality of groups of elemental areas, each group defining substantially a square area, means for generating on electron scanning beam, means for horizontally and vertically deflecting said beam in synchronism with a line and field frequency respectively, means for periodically interrupting said beam, and means for so synchronizing said deflecting means and said interrupting means that at least one elemental area in each of said groups is scanned during each field and that different elemental areas in each of said groups are scanned during successive ones of said fields.

2. An electron beam scanning system, comprising an explored surface defined by a plurality of groups of at least four substantially equal elemental areas extending substantially equidistantly along two coordinates, means for generating an electron scanning beam, means for deflecting said beam along said coordinates in synchronism with a line and a field sequence, means for periodically interrupting said beam, and means for so synchronizing said means for deflecting and said means for interrupting that a corresponding elemental area in each of said groups is scanned during each field, and that different elemental areas in each group are scanned during successive ones of said fields.

PIERRE MARIE GABRIEL TOULON.

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