

Dec. 24, 1940.

S. L. CLOTHIER ET AL

2,226,508

SCANNING METHOD AND APPARATUS

Filed March 20, 1939

4 Sheets-Sheet 1

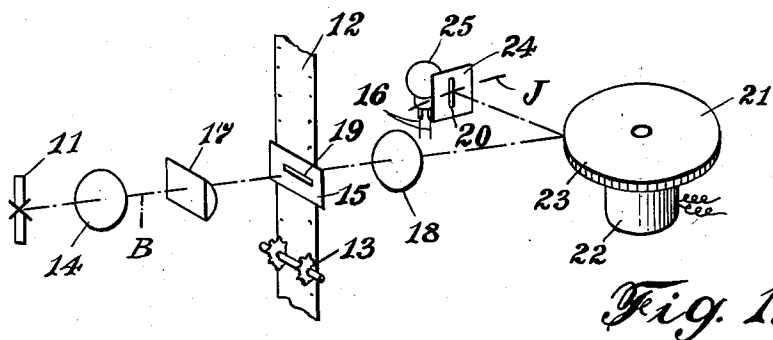


Fig. 1.

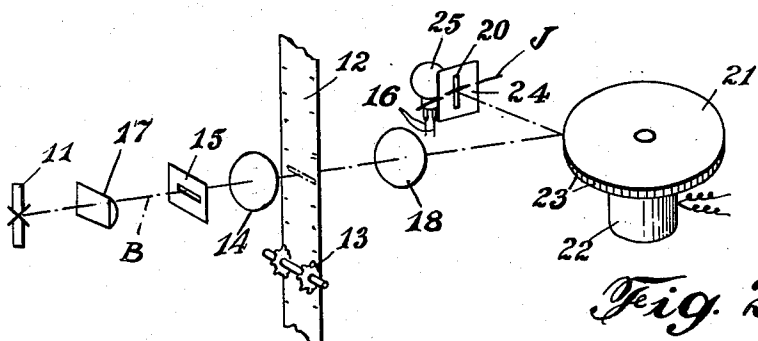


Fig. 2.

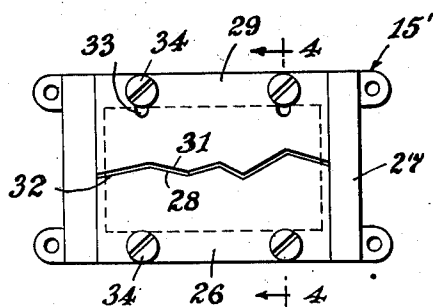


Fig. 3.

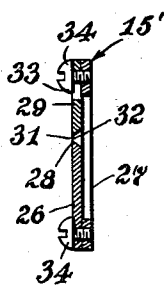


Fig. 4.

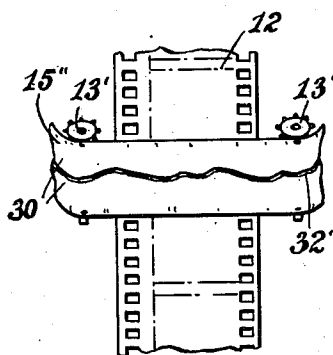


Fig. 5.

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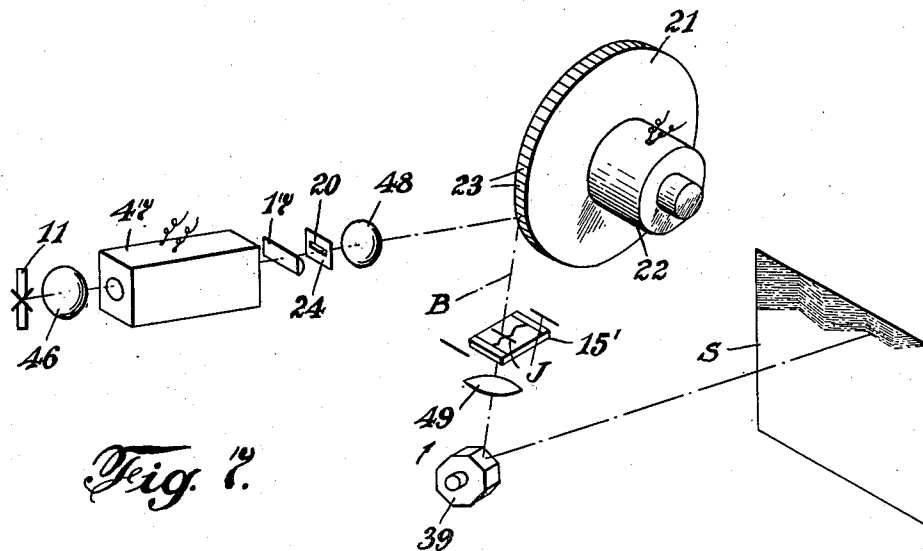
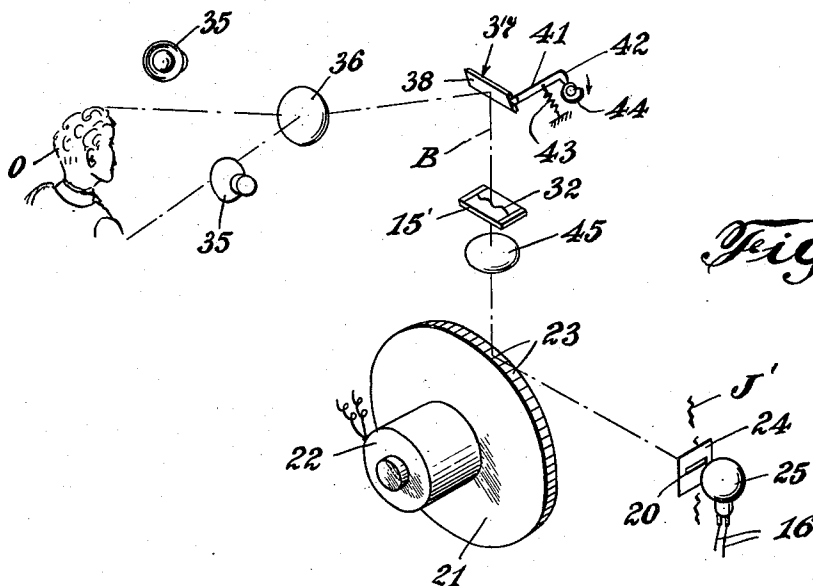
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4 Sheets-Sheet 2



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SCANNING METHOD AND APPARATUS

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4 Sheets-Sheet 3

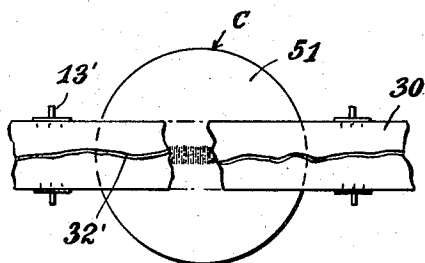
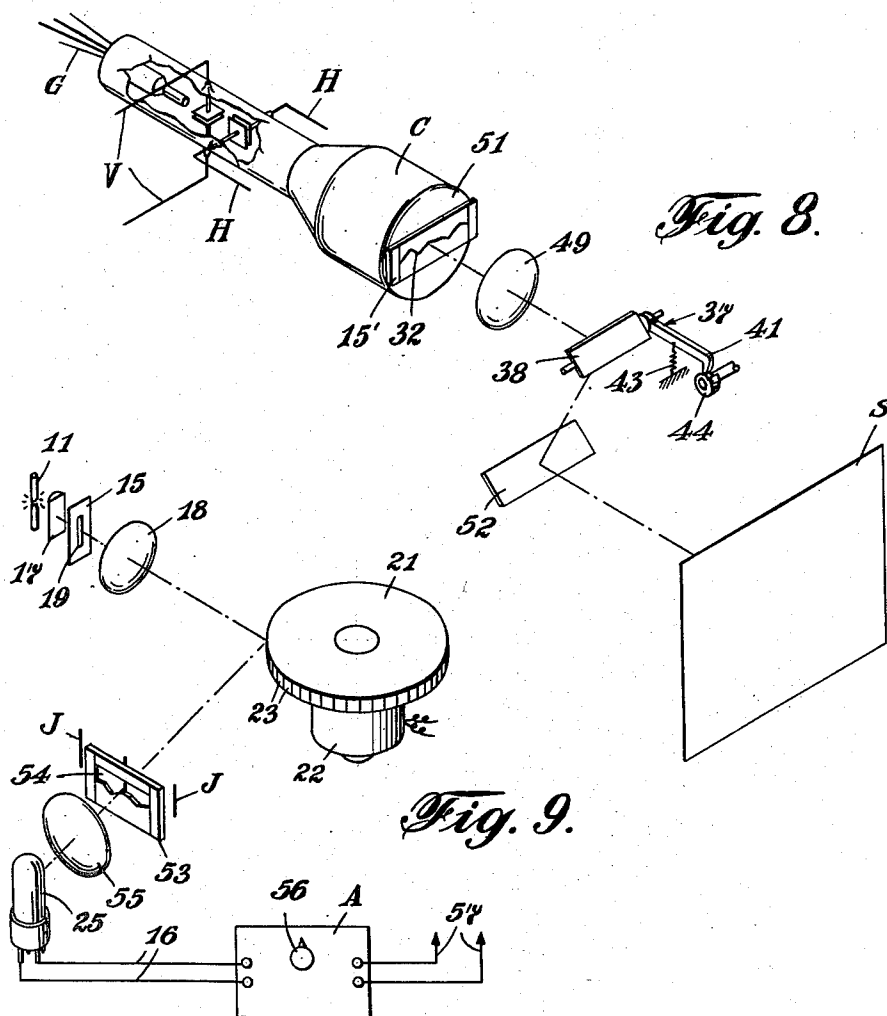


Fig. 10.

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SCANNING METHOD AND APPARATUS

2,226,508

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4 Sheets-Sheet 4

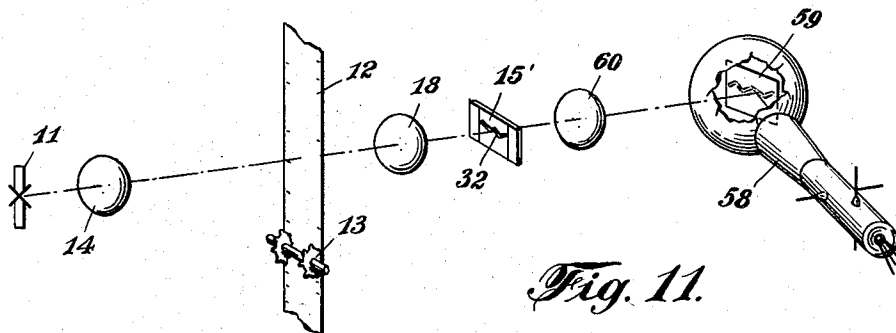


Fig. 11.

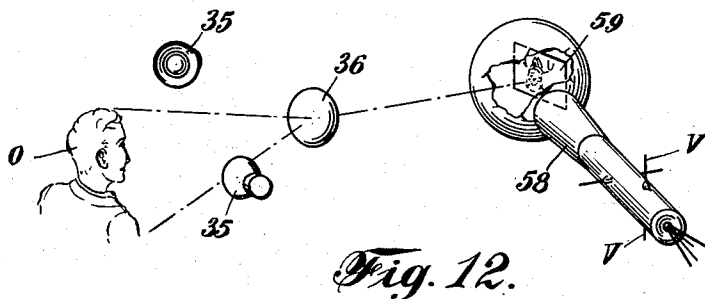


Fig. 12.

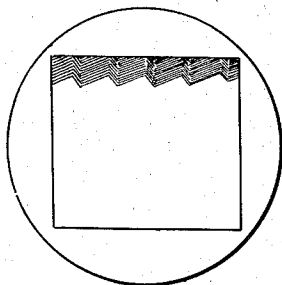


Fig. 13.

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UNITED STATES PATENT OFFICE

2,226,508

SCANNING METHOD AND APPARATUS

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Application March 20, 1939, Serial No. 263,016

10 Claims. (Cl. 178—6)

This invention relates to television transmitting and receiving systems employing either mechanical or electronic scanning means, and more particularly to novel methods and apparatus for obtaining unique scanning patterns in such systems for the purpose of providing secrecy.

It has been customary in the transmission and reception of television signals to interpose an aperture plate in the light path of the mechanical scanner in order to analyze the television image into a series of elemental areas. When it is desired to first divide the image into a series of elemental linear areas, the aperture plate ordinarily consists of an opaque mask provided with a straight elongated slot. Otherwise it has been customary to form the opening in the aperture plate as a relatively small square, representing an elemental area of the image being scanned. If electronic scanning methods are employed, the image customarily is scanned along a series of adjacent substantially parallel and straight lines.

The reception of radio signals from such television transmitting systems cannot ordinarily be restricted to any selected persons, but rather is available to any receiving station having standard equipment capable of being operated at the proper synchronous speed. Furthermore, scanning errors are often introduced when the aperture consists of a small square opening, as a result of any mechanical error in the moving scanners.

The principal objects of the present invention are: to provide methods and apparatus for obtaining selectively keyed television transmission and reception; to provide methods and apparatus for forming an elemental linear area resembling a broken curve of predetermined pattern; to provide means for forming an elemental linear area representing a finite line of substantially constant width generated by the motion of an elemental area along a path, the direction of which deviates from a fixed norm at predetermined varying degrees over predetermined intervals of the line scanning period; to provide means for attaining the foregoing objects in connection with mechanical and/or electronic systems of television transmission and reception; to provide in such systems methods and apparatus for constantly changing the shape of the elemental linear area while the scanning system is in operation; to provide an aperture plate of special configuration which restricts reception of the transmitted signals to such receiving systems as incorporate an aperture plate of similar design; to provide an aperture plate having a slot of irregular configuration the width of which may be altered to

suit various operating conditions; to provide means for scanning motion picture film while locating the aperture plate remote from the film; to provide a system for forming elemental linear areas of any desired shape; and to provide aperture plates of improved design which are so arranged as to compensate for mechanical errors introduced by undesirable motion in the rotating line scanner. These and other objects of the present invention will become apparent from the following description and from the accompanying drawings which disclose scanning systems embodying features of the present invention.

In the drawings:

Fig. 1 is a diagrammatic view of a scanning system operating according to the present invention and especially adapted for the television transmission of motion picture film;

Fig. 2 is a diagrammatic view of a film scanning system similar to that shown in Fig. 1;

Fig. 3 is an elevational view of an aperture plate constructed according to the present invention;

Fig. 4 is a cross-sectional view of the plate shown in Fig. 3 as taken on the line 4—4 of Fig. 3;

Fig. 5 is a diagrammatic view of an apparatus for resolving a motion picture film into a series of transverse linear areas of slowly varying configuration;

Fig. 6 is a diagrammatic view of one arrangement of a mechanical television scanning system incorporating features of the invention adapted to scan a directly-illuminated object;

Fig. 7 is a diagrammatic view of mechanical scanning means which may be employed for receiving the signals transmitted by such systems as are shown in Figs. 1, 2 and 6;

Fig. 8 is a diagrammatic view of one arrangement which may be employed to obtain selectively keyed television reception with a cathode ray tube;

Fig. 9 is a diagrammatic view of apparatus capable of producing electrical impulses of varying intensity for modulating the vertical deflection voltage of a cathode ray tube of the type shown in Fig. 8, according to a predetermined pattern;

Fig. 10 is a modified elevational view of the end of a cathode ray receiving tube of the type shown in Fig. 8, together with a slowly movable generally opaque belt provided with a linear transparent line of irregular configuration;

Figs. 11 and 12 are diagrammatic views illustrating electronic television transmitting apparatus incorporating principles of the present invention adapted for use respectively with motion

picture film and an illuminated animate object; and

Fig. 13 is an end view of a cathode ray tube illustrating the undulating scanning lines.

- 5 Fundamentally, the invention comprehends modifying the ordinary substantially straight elemental linear areas that are employed in analyzing a television image, by forming each linear area according to a unique predetermined
10 pattern. These modified linear areas extend across the image in much the same fashion as heretofore with the exception that the composite elemental areas are not aligned in a straight path but rather they form an irregular line, typified
15 by a broken curve, the contour of which curve follows a predetermined pattern. Various means may be employed to create the modified scanning line at the transmission apparatus, and to reproduce the same at the receiver. The principles of
20 the invention have been set forth in our copending application Serial Number 104,172, filed October 6, 1936, of which this application forms a continuation-in-part. In the parent application the invention has been described in connection
25 with television transmitters and receivers that employ mechanical scanning devices. As will be apparent from the following description, the invention is equally applicable to television systems employing electronic scanning devices, operating
30 alone or in conjunction with mechanical scanning means.

- The invention further comprehends illuminating a narrow transverse area of a strip of motion picture film in such a way that the illuminated
35 portion corresponds to an elemental linear area. Accordingly the shape of the illuminated portion is optically defined by focussing thereon an image of an illuminated elongated aperture. Since this aperture is located at an appreciable distance
40 from the film no dust particles are collected thereon from the film. It was formerly necessary to locate such plate as close as possible to the film to obtain a sharp image, but unless precautions were taken, the outline defined by the
45 aperture became obscured by the gradual accumulation of dust and other foreign particles, either within the slot or in the zone between the slot and the film.

- The advantages of the present invention will
50 become apparent when it is realized that all ordinary television systems scan in a regular and orderly fashion, for example by scanning the subject with successively adjoining straight lines. When the impulses from such television systems
55 are broadcast by radio they may be received, and the images reconstructed, by any one in possession of standard receiving apparatus. The ready availability of broadcast television signals naturally operates to defeat the aims of any commercial television news agencies or photograph-transmitting enterprises that are obligated to restrict
60 transmission to only duly authorized subscribers. By scanning along irregular paths in accordance with the teachings of the present invention, the signals when received by ordinary receiving equipment would result in the formation of images too
65 distorted and unintelligible to be of value. According to the present invention only such persons as are in possession of the key, or who are aware of the shape of the irregular linear area may properly receive the television signals. Unauthorized reception is further precluded by the inclusion of methods and apparatus for constantly or intermittently changing the shape of
70 the elemental linear area at transmitter and re-

ceiver while the scanning system is in operation.

Since many of the various elements comprising the system are repeatedly illustrated throughout the several views to perform similar functions, identical reference numbers will be used, wherever
5 convenient, to designate respectively similar parts.

In the arrangement shown in Fig. 1, a television transmitting apparatus embodying features of the invention comprises a source of high intensity
10 illumination 11 such as an electric arc or incandescent filament. A condensing lens 14 concentrates light rays emanating from the source 11 as a converging beam B upon a cylindrical converging lens 17 which further concentrates the
15 light as a brilliantly luminous line across an aperture plate 15 having an elongated straight slot 19. A motion picture film 12 moves continuously past the slotted aperture plate 15 as by means of a set of rotating sprockets 13 in such a manner
20 that the beam B passing through the slot 19, formed in the aperture plate 15, successively covers every portion of each film frame. Preferably the width of the slot 19 is equal to the width of the elemental linear area comprising a single line
25 scan.

The beam B which accordingly passes through the film 12 as a flat ribbon, also passes through a lens 18 and is then reflected from a scanner to
30 form a series of successive linear images J corresponding to elemental linear areas. The linear images are scanned along their length into separate series of consecutively located elemental areas, which successively actuate a photoelectric cell 25. Any convenient form of scanner may be employed for this purpose, but we prefer to employ a rotating drum 21 driven at a constant
35 speed as by means of a synchronous electric motor 22. The periphery of the drum 21 is provided with a series of scanning elements capable of forming a succession of images of the elemental linear areas. For purposes of illustration these scanning elements have been indicated in the drawings as a plurality of plane mirrors 23 which
40 are fitted about the periphery of the drum 21, all of which are identical in shape and size, and positioned at identical angles with respect to the axis of the drum 21. The photocell 25 is spaced an appreciable distance from the periphery of the drum 21 and is provided with a slotted aperture
45 plate 24 adjacent thereto upon which the projection lens 18, in conjunction with the mirrors 23, forms successive images J of the illuminated elemental linear area of the film 12, defined within the slot 19. Since the drum 21 is illustrated as rotating in a horizontal plane, and the slot 19 is horizontal, the images J move horizontally across the plate 24 in end-to-end relation. The plate 24 is positioned with its longitudinal slot 20 extending vertically so that as the images J pass the slot they are analyzed as a succession of elemental areas preferably of square configuration. The photocell 25 is arranged so that its active surface is exposed to substantially the entire length of the slot in the plate 24 so that any vertical shifting of the images J produced by vibration or other mechanical error in the scanning drum 21 produced no ill effect in the analysis of the images J, but merely raises or lowers them along the slot 20. This procedure eliminates distortion which would otherwise be present if the aperture plate 24 were provided with an opening of square configuration, as it is extremely difficult to maintain the images J in constant alignment with such a small opening. The photo-
75

photocell terminals 16 connect with an amplifier of any suitable design capable of amplifying the impulses prior to transmission.

As pointed out, the slot 19 in the plate 15 corresponds in size and shape with an elemental linear area of the film 12. The width or height of the slot 19 is determined by the number of line scans desired, and the size of each film frame. For example, with standard film having a frame height of three-fourths inch, the slot 19 preferably has a width of 0.0025 inch when 300 lines or elemental linear areas per frame are desired. The width of the slot 20 in the plate 24 is determined principally by the width of the images J and by the desired shape of the elemental areas. Assuming that the dimensions of the images J formed on the plate 24 by the lens 18 are increased six fold over the dimensions of the slot 19 and that elemental areas of square shape are desired, the slot 20 should have a width of 0.015 inch. If the elemental areas are to be of other rectangular shape, the width of the slot 20 may be correspondingly varied.

The television transmitting apparatus shown in Fig. 2 is very similar to that shown in Fig. 1 with the exception that the positions of the aperture plate 15 and the lenses have been substantially interchanged. With this arrangement, light from the source 11 is concentrated directly upon the plate 15 as by means of the cylindrical lens 17. A narrow band of light for illuminating an elemental linear area is focussed as an image of the aperture 15 upon the film 12 by means of the lens 14. As the film 12 is moved longitudinally by sprockets 13, images J of successive illuminated bands on the film are formed upon the surface of the plate 24 by the lens 18 and mirrors 23, which images excite the photocell 25 after passing through the slot 20 in the plate 24. By this arrangement a clearly defined linear area is optically formed on the film 12, which area remains sharply illuminated during operation, unaffected by dust particles that otherwise tend to collect within the slot 19 of the aperture plate 15 when it is positioned closely adjacent to the film as shown in Fig. 1. Furthermore, the linear area remains free of shadowy and indistinct outlines, such as are likely to be formed when the plate 15 is positioned adjacent to the film as shown in Fig. 1, though spaced substantially from the film to minimize the collection of dust and other foreign particles.

Signals transmitted by the apparatus shown in Figs. 1 and 2 may be received and transformed into visual images by a receiver of conventional design as the scanning is performed along consecutively positioned straight lines, in accord with standard practice. In order to restrict reception to authorized persons, or in effect to transmit signals secretly it has been found necessary only to change the shape of the straight elemental linear area to one of irregular configuration. This may be accomplished through the use of a modified aperture plate 15', shown in Figs. 3 and 4. The aperture plate 15' comprises essentially a mask of thin sheet material provided with an irregular slot, by which is meant a slot having a shape other than straight. For example, the slot may have the configuration of an undulating curve, such as a sinusoidal wave, though preferably it consists of a broken curve, formed for example, of a series of short, connected, straight lines disposed to form a saw-tooth shape or a configuration resembling the edge of a key designed for a tumbler lock.

Otherwise the shape of the slot may represent a combination of two or more of the foregoing shapes, the purpose being to form an elongated irregular opening which is difficult to reproduce. The aperture plate 15' shown in Figs. 3 and 4 preferably comprises a frame 27 to which is secured a pair of laminae or sheets 26 and 29, assembled in coplanar juxtaposed relation with adjacent bevelled edges 28 and 31 respectively defining an irregular slot 32 of substantially uniform width. The sheets may be mounted to the frame 27 in any convenient manner as by screws 34 which may project through elongated apertures 33 in at least one of the sheets 26 or 29 so that the width of the slot 32 may be adjusted. The sheets forming the laminae 26 and 29 may consist of any desired opaque material, for example, paper, cardboard or sheet metal. In the event that thin metal foil or the like is employed, use may be made of a transparent backing material such as glass, Celluloid, etc., for additional support.

The aperture plate 15' may be substituted in either of the transmitting systems indicated in Figs. 1 or 2 to replace the aperture plate 15 having a straight slot 19 with the exception that the beam cannot then be concentrated to a fine straight line at the mask but must be of such cross section as to fully illuminate the aperture opening. In either case the beam B after passing through the plate is in the form of a ribbon, the cross-section of which corresponds with the shape of the slot in the plate. Images formed on the aperture plate 24 do not consist of single straight lines but rather irregular lines simulating the shape of the slot 32. Each of the images reflected by the mirrors 23 successively passes longitudinally in a direction transversely of the slot 20 in the plate 24. When an aperture plate of the type shown in Fig. 3 is employed, the slot 20 must be long enough to accommodate the lateral displacement of the irregular linear images so that they are at no time screened from the photocell 25.

In order to more fully insure secrecy of the transmitted signals and to more completely guarantee their reception by only authorized persons, use may be made of an aperture plate or mask 15'' having a slot of continuously varying configuration as shown in Fig. 5. In order to accomplish this result the plate 15' may be provided with a slot 32 of relatively great length which may be oscillated slowly or otherwise moved in a predetermined manner with respect to the film 12 or other object being scanned. Preferably, however, the mask 15'' comprises an opaque belt 30 provided with a translucent or transparent linear area of irregular configuration 32'. The belt 30 may be composed of Celluloid or gelatin, the surface of which is rendered substantially opaque on opposite sides of the area 32' by photographic or other means. The irregular linear area 32', which is sufficiently clear to permit the passage of light, corresponds to the slot 32 in the aperture plate 15'. The belt 30 may be made to move longitudinally either continuously or intermittently at a relatively slow rate of speed across the film 12 by means of sprockets 13'. Since the elemental linear area designated by the clear portion 32' is of irregular shape, the contour thereof continuously changes with respect to the portion of the film 12 being scanned as the belt 30 moves. If the mask 15'' is substituted for the aperture plate 15 in either system shown in Figs. 1 or 2, an identical mask must

be employed at the receiving station, and must be moved in synchronism with the mask at the transmitting station. Obviously, the rate of motion of the mask must be sufficiently slow that it does not produce apparent distortion.

In Fig. 6 is disclosed apparatus for transmitting television signals according to the present invention, wherein an object is directly illuminated. One or more sources of high intensity illumination 35 are positioned so as to direct light upon an object O. Light reflected from the object O passes through a converging lens 36 which in turn concentrates the rays into a beam, directed upon a scanner 37. Any conventional form of mechanical scanner may be employed, as for example a rotating mirrored prism of the type indicated at 39 in Fig. 7, or an oscillating mirror 38 as indicated in Fig. 6. The mirror 38 is preferably a first-surface plane reflector pivoted at or near its midsection substantially in the plane of the reflecting surface. A lever arm 41, secured to the mirror 38, extends away from the pivotal mounting, being provided with a follower 42 at the extremity of the arm 41 for engagement with a rotatable cam 44 against whose surface the follower is continuously urged as by a spring 43. Rotation of the cam 44 causes the mirror 38 to oscillate through a small arc and to produce, in conjunction with the lens 36, a shifting image of the object O, preferably in the plane of the plate 15'.

Means is provided to divide or analyze the image thus formed into a series of elemental linear areas preferably of irregular configuration. Such means may comprise an aperture plate 15' or mask 15'' of the type disclosed in Figs. 3 or 5. The plate 15' shown in Fig. 6 is positioned substantially in the plane of the image of the object formed by the lens 36 and the mirror 38, and is arranged so that the slot 32, representing an elemental linear area, extends longitudinally in a direction generally parallel with the axis of the mirror 38. The beam B passing through the aperture plate 15' is projected through a lens 45 upon the mirrored periphery of a scanning drum or other similar means 21. Separate images J' of the slot 32, designating elemental linear areas, are formed at a distance from the periphery upon an aperture plate 24. The plate 24 is positioned adjacent to a photocell 25 with the slot 20 extending substantially at right angles to the images J'. As the drum 21 rotates, the images J', produced by reflection from the respective scanning elements 23 on the drum 21, pass successively in end-to-end relation transversely across the slot 20 and separately excite the photocell 25, the impulses from terminal wires 16 being amplified to form the television signals.

Fig. 7 discloses a receiving apparatus, embodying features of our invention, which is capable of transforming back into visual images, television signals developed by transmitters of the type indicated in Figs. 1, 2 and 6. Identical reference characters are used to designate parts corresponding in function and design with those already described. Use is made of a source of high intensity illumination 11, and a condensing lens 46 capable of directing rays from the light source 11 as a beam through a light modulating unit 47, of any conventional design, capable of acting upon the beam to vary its intensity in accordance with the electrical impulses received from the television transmitting station. The beam is concentrated upon an aperture plate 24 as by

means of a cylindrical lens 17. A scanning drum 21 provided with scanning elements 23 about its periphery and rotated by means of a motor 22 at a speed synchronized with a similar drum at the transmitting station is mounted in spaced relation to the plate 24. A lens 48, positioned between the plate 24 and the drum 21, cooperates with the scanning elements 23 to form in the plane of the plate 15', a series of images J of the illuminated slot 20.

An aperture plate 15' having a slot 32 of a configuration identical with that employed in the transmitting apparatus is located so that the images J are formed upon or adjacent to its surface, the length of each image J being sufficient to accommodate the lateral displacement of the irregular slot 32. The slot 32 is so positioned with respect to the drum 21, that the images are formed transversely on the slot 32 and move along the length of the slot. Successive portions of the slot 32 are accordingly illuminated by the movement of an image J along the slot, the intensity at any point being dependent upon the brightness of the modulated image at the instant it passes such point. Images of the slot 32 are formed upon a screen S by means of a projection lens 49 positioned between the plate 15' and the rotating mirrored prism 39.

The speed of rotation of the prism 39 is synchronized with the transmission apparatus so as to form the desired number of frames per second, each surface forming a complete frame or field during a single vertical sweep, as from the top to the bottom of the screen. In the case of the transmitters shown in Figs. 1 and 2 the prism 39 is rotated at a speed synchronized with the speed of the sprockets 13 so that the same number of frames are formed per second. In the case of the transmitter shown in Fig. 6 the prism 39 is synchronized with the scanner 37 so that the same number of frames are formed per second. As the prism 39 rotates, successive adjacently-disposed images of the illuminated irregular linear aperture 32 are formed upon the screen S to reconstruct the image of the object scanned. Whenever a mask of the type shown in Fig. 5 is employed in the transmitting equipment, an identical mask is required in the receiving apparatus mounted in the position indicated by the plate 15' in Fig. 7, and synchronized so as to move at the same speed as the belt 30 in the transmitting equipment.

With slight modification, the apparatus shown in Fig. 7 may be used as a direct pickup scanner for transmission, employing the "flying spot" method of scanning. For such use a constant intensity source of illumination is used and the light modulating unit 47 is omitted. The subject to be scanned is placed in the position occupied by the screen S of Fig. 7 and thus scanned by the moving spot of light. Light reflected from the subject is then used to activate photocells (not shown) according to the light and dark shaded elementary areas of the subject in the usual well known manner in which "flying spot" pickup is employed. In the present invention however the linear areas would of course follow the predetermined path deviating from a straight line according to the shape of the aperture employed in the plate 15'.

Fig. 8 discloses a method by which the invention may be adapted for use in conjunction with an electron beam scanning apparatus, for example a cathode ray tube. An aperture plate 15' of the type and design used at the transmitting

station is located directly adjacent to the screen end of a cathode ray tube C. Conventional horizontal deflection plates having external connections H, and vertical deflection plates having external connections V are provided in order to deflect the electron beam in horizontal and vertical paths respectively. The intensity of the electron beam is controlled in a conventional manner by means of voltage applied to the control grid connection G by the received signal impulses. An electrical wave of relatively high frequency, and preferably in the radio frequency range, is applied to the vertical deflection plates through connections V, the voltage applied being sufficient to deflect the beam enough to accommodate the lateral deviation of the angularly related segments forming the slot 32 in the plate 15'. Saw tooth voltage is applied to the horizontal deflection plates through the connections H to provide horizontal sweep of the electron stream in synchronism with the line scanning frequency. Accordingly as the respective voltages are applied to the connections G, H and V, and the tube is otherwise provided with the conventional operating potentials, the images of the successive scanning lines become visible through the slot 32, the respective portions representing varying degrees of luminosity in accordance with the intensity of the bombardment of the modulated electron stream on the portions of the fluorescent coating within the window 51 of the cathode ray tube C. The modulated irregular linear area visible thru the aperture slot of plate 15' is similar to that obtained on the plate 15' shown in Fig. 7, and the complete subject of transmission may then be reassembled as a visual image by the frame scanning means 39 illustrated in Fig. 7, located between the aperture plate 15' and the screen S, and a projection lens 49 capable of forming an image of the modulated linear area upon the screen S. If desired, means such as an oscillating scanner 37 of the type shown in Fig. 6 may be employed to sweep the irregular linear area vertically with respect to the screen S to form a complete image. The scanner 37, as previously described, comprises a plane reflecting mirror 38 oscillated by means of a cam 44 engaging an arm 41, the cam being designed preferably to impart uniform angular motion to the mirror 38 throughout the scanning operation of the cycle followed by a quick return motion between frame scanning periods. A fixed plane mirror 52 is positioned for convenience in reflecting the beam from the scanner 37 upon the screen S, although it is to be understood that by proper orientation of the parts the images may be formed on the screen S without the use of mirror 52. The operation of the receiving apparatus shown in Fig. 8 is believed to be obvious from the foregoing description but may be described briefly as follows. The electron beam within the tube C is deflected horizontally and vertically to form a fluorescent light source behind the slot 32, the beam being modulated by the transmitted television signals. Successive images of the slot 32 are formed upon the screen S by the lens 49 and scanner 37, each succeeding line image is placed adjacent to and directly beneath that of the previous line, the result being a complete image forming a copy of the subject of transmission.

In the arrangement shown in Fig. 8 only that portion of the luminous band on the window 51 which is visible thru the slot 32 is used in reproducing the subject of transmission. More efficient results may be obtained by eliminating the

aperture plate 15' and reproducing the modulated linear area according to the predetermined pattern by suitable electromagnetic or electrostatic deflection of the electron beam within the tube C. Accordingly, by applying a low voltage to the vertical deflection plates thru the connections V, and varying the voltage in accordance with the lateral displacement of the slot 32, while providing the usual horizontal deflection, the electron beam may be made to follow a course similar to the path designated by the slot 32. With such an arrangement the necessary sweep voltage is applied to the horizontal deflection plates at line scanning frequency to sweep the beam generally along the length of the elemental linear area, and the varying low voltage is applied to the vertical deflection plates through the connection V to provide the desired degree of deviation of each linear area from a fixed norm.

The voltage applied to the connections V may be generated and controlled in various ways, for example, by periodically varying a resistance or potentiometer in accordance with the transverse deviation of the segments forming the irregular linear area, or by imposing the voltage wave of a signal generator upon the vertical deflection plates. For example, with a line deflection frequency of 2700 cycles applied to the terminals H, a line-distorting wave of 13,500 cycles may be applied to the connections V, the wave being of sinusoidal, saw-tooth or other predetermined shape as shown in Fig. 13. The frequency, amplitude, and/or shape of the line-distorting wave may be varied, either continuously or intermittently, according to a predetermined pattern, at a rate sufficiently slow as not to produce apparent distortion of the picture. Another form of apparatus which may be employed to generate the desired wave form is disclosed in Fig. 9. Use is made of a source of light 11, concentrated upon a straight elongated slot 19 formed in an aperture plate 15 as by means of a cylindrical converging lens 17. A projection lens 18 is adapted to form an image of the illuminated slot 19 in the plane of a mask 53 having an opening 54 the length of which corresponds with the overall length of an irregular linear area. The height of the opening varies along its length in accordance with the shape of the irregular slot 32, or in other words, in accordance with the degree of deviation from a fixed norm. As shown in Fig. 9 the mask 53 preferably comprises a frame having an elongated opening therein, one side of which is preferably straight, the other side being made of irregular contour to correspond with the contour of the desired irregular linear area. Successive images J of the slot 19 are swept along the opening 54 as shown in Fig. 9 by means of a scanning drum 21 driven by a motor 22, the drum being provided about its periphery with mirror surfaces 23. A large condensing lens 55 concentrates the light which passes through the opening 54 upon a photocell 25. When the drum 21 is rotated the respective images J are successively swept along the opening 54, the degree of illumination falling upon the photocell 25 varying in accordance with the varying transverse amplitude of the opening 54. A large amplitude corresponds with a large width of the opening at any given point and permits the passage to the photocell of a relatively large amount of light as a result of the relatively great length of image J exposed, thus producing a corresponding relatively high deflection voltage after proper amplification. The responses of the photocell are conducted through wires 16 to

a suitable amplifier A of conventional design said amplifier preferably being provided with a conventional gain control 56. The amplified impulses leave the amplifier through wires 57, which wires may be attached to the connections V in Fig. 8 to control the vertical deflection of the electron stream, so as to reproduce, in conjunction with the horizontal deflection and other tube-control elements, a modulated beam forming a linear area on the window 51 which is similar in shape and illumination with a corresponding line at the transmitting apparatus. By this latter arrangement the irregular linear area represents a finite line of substantially constant thickness developed by the generation of an elemental area along a path, the direction of which deviates from a fixed norm, e. g., a straight line, by predetermined amounts during predetermined intervals of the line scanning period. If the voltage obtained from the connections 57 is superimposed upon the sweep voltage normally applied to the connections V to obtain frame scanning, a complete image of the subject of transmission is formed upon the window 51 of the cathode ray tube C, provided, of course, that the attending horizontal sweep voltage and modulating voltage are applied to the tube. In this manner the scanning mechanism 37 and the mask 15' may be dispensed with and the complete image may be viewed directly upon the window 51, or the image may be focussed upon the screen S as by means of the lens 49.

Fig. 10 discloses a cathode ray tube C provided with an opaque belt 30 of the type disclosed in Fig. 5. The belt 30 is moved longitudinally across the window 51 in predetermined fashion as by means of sprockets 13', the belt being substantially opaque with the exception of the irregular transparent linear area 32'. The belt 30 may be adapted for use with a system of the type disclosed in Fig. 8 wherein use is made of a linear area of continuously changing contour, both in the transmitter and receiver. Otherwise the mask 53 shown in Fig. 9 may be made to correspond with the contour of the line 32' of the belt 30, in which case the mask 53 might also be made movable so as to obtain the vertical deflection voltages to be applied to the connections V, to adapt the tube C for use with an irregular linear area of slowly changing configuration.

Fig. 11 discloses apparatus incorporating principles of the present invention for use with a conventional cathode ray transmitter tube. In this case the film apparatus is arranged in a manner similar to that disclosed in our copending patent application bearing Serial No. 195,938, filed March 15, 1938, except that a keyed aperture plate and electronic scanning is employed in this variation of the present invention. The apparatus disclosed in Fig. 11, which is specifically adapted for the television transmission of motion picture film, comprises a source of light 11 and a condensing lens 14, adapted to illuminate a portion of a motion picture film 12. Sprockets 13 are rotated in any suitable manner causing the film 12 to be moved longitudinally at a continuous rate of speed to provide scanning of the successive portions of the film. A projection lens 18 is adapted to form an image of the illuminated zone of the film 12 upon the aperture plate 15'. The image of the illuminated portion of the film is sufficiently large as to accommodate the transverse deviations of the irregular slot 32 formed in the aperture plate 15'. An image of the elemental linear area de-

fined within the slot 32 is formed upon the sensitive mosaic surface 59 of a cathode ray transmitting tube 58 by means of a converging lens 60. The respective elemental areas forming the irregular linear area focussed on the mosaic surface are successively scanned by means of sweep circuits operating substantially in the manner described in connection with the tube C of Fig. 8.

Fig. 12 illustrates a television transmitter incorporating electronic scanning wherein the subject of transmission comprises an animate object O or the like illuminated as by means of sources of illumination 35 as shown in Fig. 6. A converging lens 36 forms an image of the object O upon the sensitive mosaic surface 59 of a cathode ray transmitting tube 58. The horizontal and vertical deflection voltages applied to the tube 58 are conventional with the exception that the voltage across the wires 57 of the apparatus shown in Fig. 9 is superimposed upon the normal sweep voltage applied to the vertical deflection plates through connections V', thereby distorting the usual straight sweep of the electron scanning beam into one having the configuration of the desired irregular linear area. Obviously in any case where either the light beam or the electron beam is directed on the mosaic plate an oblique angle, proper keystone corrections are required.

It is obvious that various modifications will suggest themselves to those skilled in the art and that changes may be made in the apparatus and method herein disclosed without departing from the scope of the invention or sacrificing any of its advantages. For example, while we have herein described our invention as applied to television, it is obvious that it is equally desirable and applicable in facsimile and film recording work.

We claim:

1. In a television apparatus, in combination with means for scanning an object and analyzing an image of said object into a series of lines; an aperture plate adjacent to the image being scanned, said aperture plate being provided with a slot of irregular configuration.
2. In a television apparatus as claimed in claim 1 including means for adjusting the width of the slot in said aperture plate.
3. In a television apparatus as claimed in claim 1 including means for moving the aperture plate with respect to the image being scanned, the rate of movement of said aperture plate being sufficiently slow as not to cause apparent distortion.
4. In a television apparatus, in combination with means for scanning an image or object into a series of lines; aperture means comprising a substantially opaque belt provided with an irregular linear area capable of transmitting light, and means for moving said belt so as to form a linear aperture of continuously changing configuration with respect to the image being scanned, the rate of movement of said belt being sufficiently slow as not to cause apparent distortion.
5. In a motion picture film scanning apparatus, the combination with a beam of light for transmission through the film being scanned, and means for moving the film longitudinally; of an aperture plate provided with an elongated slot of irregular configuration and positioned adjacent to and transversely of the film being scanned so as to intercept the beam of light, means for resolving the beam passing through

the slot into a series of elemental areas, and a photoelectric cell positioned so as to have superimposed upon its active surface the successive elemental areas.

5 6. A television system inclusive of object scanning and analyzing means having means casting an irregular concentrated line of light, and means dividing said line into a number of elemental areas.

10 7. In television scanning apparatus, the combination which includes an aperture member provided with a slot of patterned irregular linear configuration and uniform thickness, and means producing an image of the slot for analyzing
15 the subject scanned into linear areas of the pattern selected.

8. A television system inclusive of object scanning and analyzing means having means casting a varying irregular concentrated line of light,

and means analyzing said line into a number of elemental areas.

9. In a method of scanning, the steps of analyzing an object for transmission along a series of scanning lines, each of which is identical and of
5 predetermined irregular asymmetric pattern for the purpose of obtaining secrecy; and of recomposing the received image in like manner.

10. A scanning system including means for analyzing an image of an object for transmission
10 along a series of scanning lines, each of which is identical and of predetermined irregular asymmetric configuration for the purpose of obtaining secrecy; and means for recomposing the image in like manner for viewing at a remote
15 point.

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