June 20, 1939. S. L. CLOTHIER ET AL 2,163,538

TELEVISION APPARATUS

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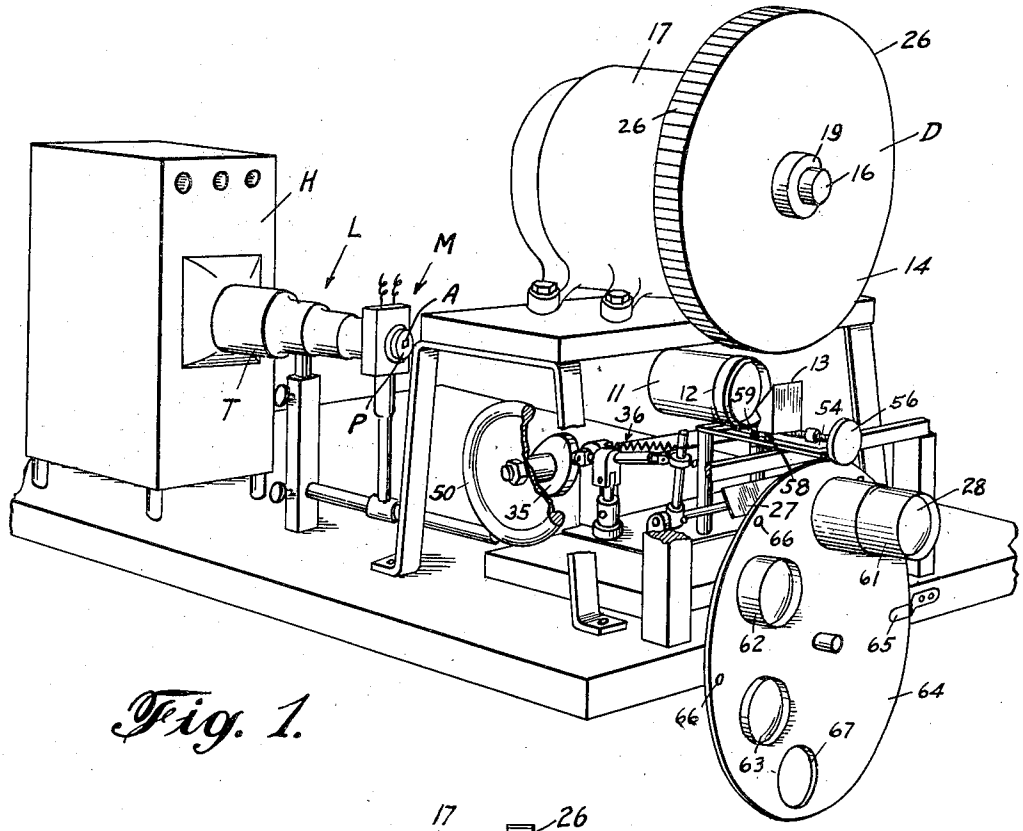


Fig. 1.

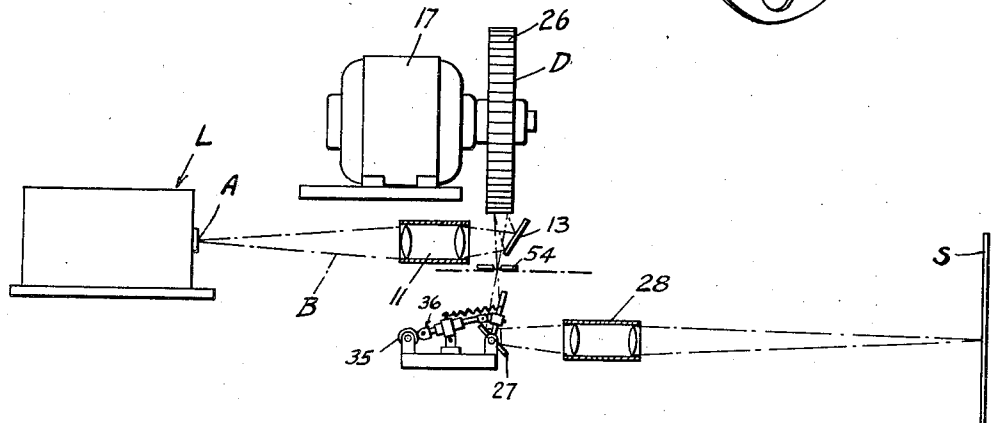


Fig. 2.

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Fig. 3

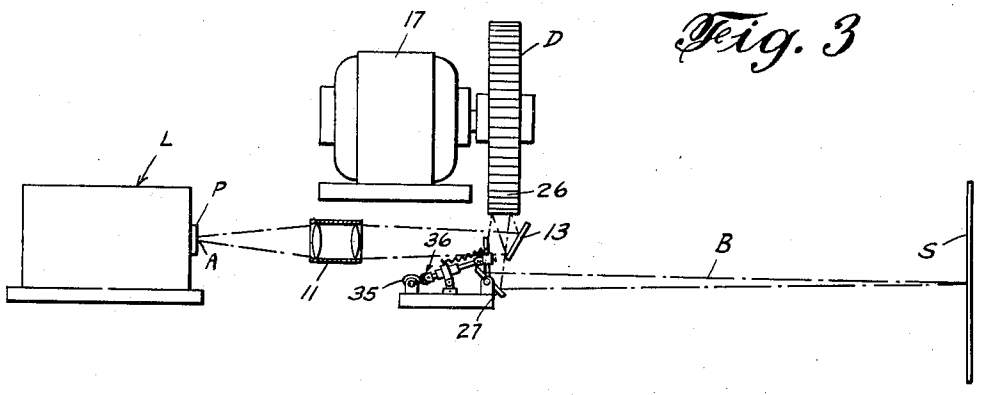


Fig. 4

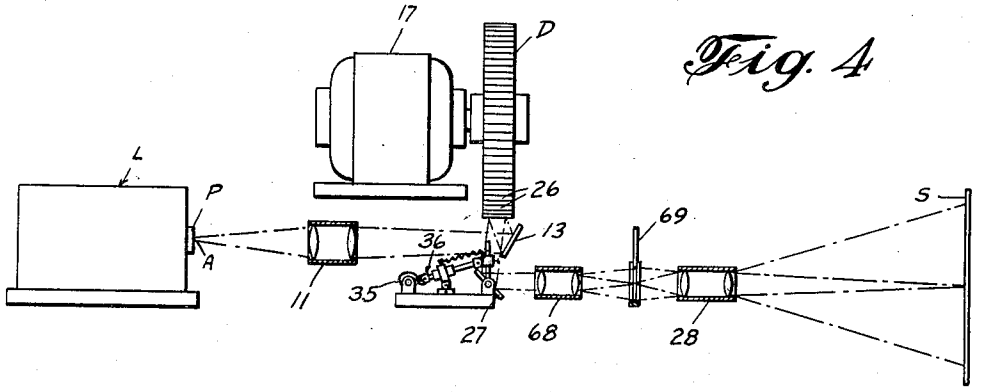
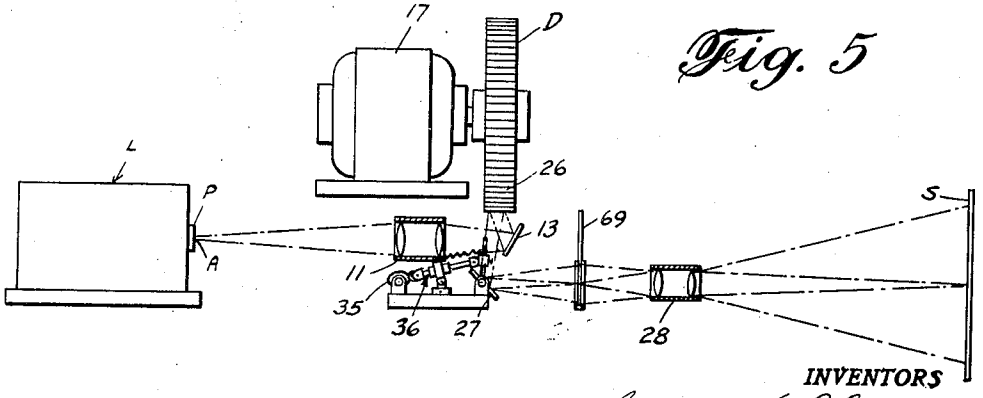


Fig. 5



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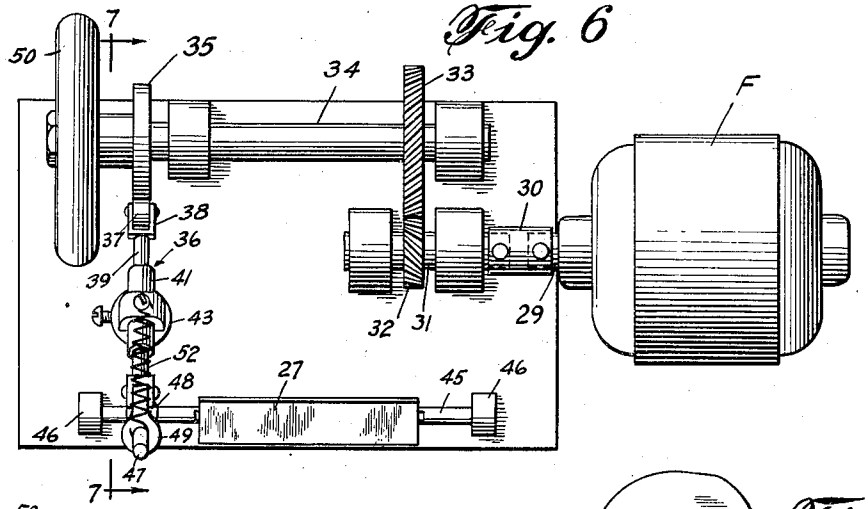
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Fig. 6



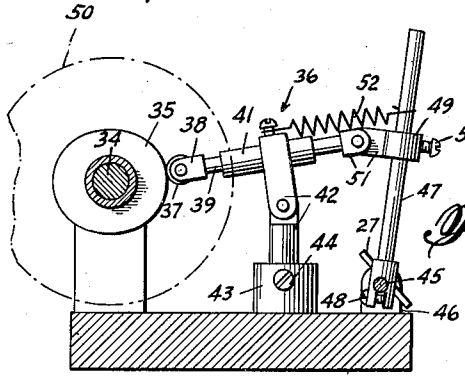


Fig. 7

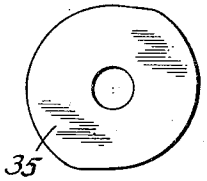


Fig. 9

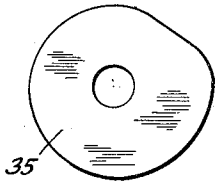


Fig. 10

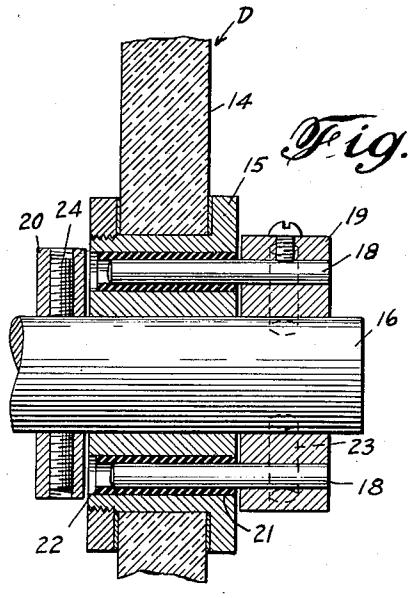


Fig. 8

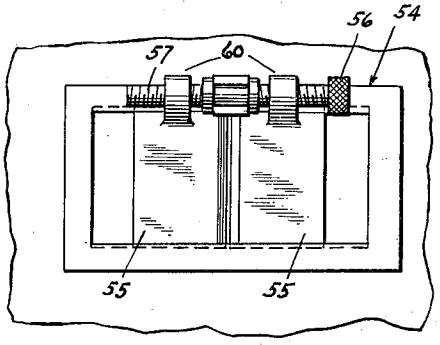


Fig. 11

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UNITED STATES PATENT OFFICE

2,163,538

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Application July 17, 1937, Serial No. 154,218

4 Claims. (Cl. 178—7.6)

This invention relates to television and more particularly to mechanical scanning methods and apparatus.

Cathode ray tubes have been employed in electron-beam scanning apparatus but such use has been attended by certain limitations with respect to the small size of tube available and the relatively great expense thereof, which limitations have generally precluded the use of a cathode ray tube where a screen of any appreciable size is required. In order to make use of a larger screen, resort has been made to rotating scanning mechanisms for intercepting the modulated light beam in order that the desired image may be formed to any desired size commensurate with proper light intensity and suitable definition. At the relatively high speeds of rotation employed to obtain adequate resolution of the image, a certain degree of optical distortion is ordinarily produced by undesirable dynamic forces present in and acting upon the moving parts. For example, where the mirrored drum consists of peripherally mounted plates, rapid rotation of the drum may cause deflection of the plates from their normal position as a result of centrifugal force. Furthermore, the armature of the synchronous motor which drives the mirrored drum, though apparently rotating at a constant speed is subject to electromagnetic pulsations producing variations in torque of sufficient magnitude to set up fluctuations in the speed of rotation of the drum. These and other effects incidental to the operation of a mechanical scanner may introduce a serious source of distortion in the finally-formed image.

In the present invention, through the use of apparatus incorporating novel design principles, many of the factors which detracted from the formation of a satisfactory image have been eliminated. In the present apparatus provisions have been made which count for high optical efficiency and which eliminate those detrimental characteristics introduced by undesirable fluctuations in the movement of the parts.

Accordingly the principal objects of the present invention are to provide an improved television scanning apparatus incorporating novel design features; to provide in such apparatus means for minimizing undesirable variations in the motion of the parts; to provide improved means for projecting the image upon a screen to one of several pre-determined sizes; and to provide an improved cam-operated mechanism for actuating the frame scanner. These and other objects of the invention will become readily apparent from the following specification in conjunction with the appended drawings.

In the drawings:

Fig. 1 is a perspective view of a preferred form of television scanning apparatus incorporating features of the present invention;

Figs. 2, 3, 4 and 5 are schematic views illustrating various optical systems which may be employed with an apparatus of the type disclosed in Fig. 1;

Fig. 6 is a plan view of the frame scanning mechanism;

Fig. 7 is a cross-sectional view of the frame scanning mechanism taken on the line 7—7 of Fig. 6;

Fig. 8 is a cross-sectional view through the scanning disc illustrating the hub construction;

Fig. 9 and Fig. 10 illustrate two forms of plate-type cams which may be employed with the frame scanning mechanism shown in Figs. 6 and 7;

Fig. 11 is a plan view of the slotted aperture plate.

The same reference numerals are used to identify similar parts throughout the several views.

Referring again to the drawings, the invention comprises a source of modulated light L which may be of any conventional form. As shown in Fig. 1, the modulated light source comprises a housing H for enclosing a suitable light source as for example an electric arc. The light emerges as a beam from the housing H through a tube T containing conventional condensing lenses or other means capable of focussing light from the source into a luminous spot of concentrated light preferably covering a square opening or aperture A. A light modulator M is positioned at the extremity of the tube T and is operative to modulate the light, by varying its intensity in response to the television signals received from the transmitting station. The light modulator M may be of any conventional design for example, of a type incorporating a Kerr cell in conjunction with a pair of properly oriented calcite blocks or Nicol prisms.

The modulated light beam B issues from an aperture A formed in a plate P at the end of the tube T and passes through an objective lens or lens system 11 which is capable of forming an image of the aperture A. The lens system 11 is held by means of a collar 12 and may be moved axially in order to vary the position of the image plane within predetermined limits in a manner to be more fully described. After passing through the system 11 the beam B is deflected by a normally stationary but angularly positioned plane

mirror 13 which causes the beam B to be directed upon the periphery of a scanning disc or drum D. In order to provide maximum rigidity and the greatest freedom from vibration and distortion, the disc or drum D is preferably made of a single piece of uniform quality plate glass 14. The hub 15 is firmly secured within a central aperture of the glass plate 14, as shown in Fig. 8, preferably as an initial operation in the fabrication of the disc D. The hub 15 is carefully bored so as to form a smooth sliding fit upon the shaft 16 of a motor 17. An outer collar 19 and an inner collar 20 are firmly secured on opposite sides of the disc D to the shaft 16, as by means of setscrews 23 and 24 and prevent the disc D from shifting axially on the shaft 16. The rotative movement is transmitted to the disc D by means of one or more pins 18 extending axially from the outer collar 19 through registering apertures 21 formed in the hub 15. The apertures 21 are sufficiently larger than the pins 18 to provide space for a sleeve 22 of resilient cushioning material, for example, soft rubber. It has been found that through the use of such a resilient sleeve between the pins and the disc D that a considerable amount of torque variation produced by the uneven motion of the armature and otherwise transmitted to the disc D is filtered out and eliminated. Although the cushioning motion occasioned by the flexing of the resilient sleeves 22 is relatively slight, it is nevertheless sufficient to overcome what has heretofore proven to be a considerable source of distortion in the television image.

The outer periphery of the scanning disc D is preferably provided with from 45 to 180 plane reflecting surfaces 26 which are formed by accurately grinding and polishing the glass plate 14. These surfaces 26 intercept equal arcs on the periphery of the disc D and are all positioned at the same angle with, and preferably perpendicular to one face of the plate 14. The number of surfaces employed and the speed of the motor 17 are determined by the frequency of the impulses received from the transmitting station. The surfaces after being properly polished are preferably coated with a reflecting material as by depositing metallic silver about the periphery of the disc D. The coating after being firmly deposited is polished to mirror brilliance so as to be capable of faithfully reflecting the beam B. When the disc D rotates, the beam B is reflected upon a frame-scanning mirror 27 as a succession of shifting light impulses which after passing through a projection lens 28 are focussed upon a screen S as a laterally extending line of light. The successive light impulses may be spread over a predetermined area of the screen S as a series of adjoining lines by oscillating the mirror 27.

The apparatus employed for actuating the frame scanning mechanism is more clearly shown in Figs. 6 and 7 and comprises a frame-scanning motor F, having a motor shaft 29. A flexible coupling 30 links shaft 29 with a pinion shaft 31, having a pinion 32 secured thereto for operative engagement with a gear 33 mounted on a cam shaft 34. A plate cam 35 is rigidly secured to the shaft 34 for rotation therewith. Cam follower mechanism 36 extends between the cam 35 and the frame scanning mirror 27 and operates to impart oscillatory motion from the cam to the mirror. The mechanism 36 preferably comprises a hardened steel ball-bearing roller 37 journalled within a yoke 38. The roller 37 is preferably as wide as the cam 35 to provide larger contact area, and to minimize wear. A follower rod 39 preferably of circular cross-section extends from the yoke 38 through a guide 41 which permits the roller 37 and the follower rod 39 to slidely freely in an axial direction as the cam rotates. A pivoted guide support 42 is adjustably held within a base member 43 and may be maintained at any desired position as by means of a screw 44.

The frame scanning mirror is firmly secured to a spindle 45, and the spindle is mounted for oscillatory movement within a pair of spaced bearing blocks 46. A lever 47 is secured to the spindle 45 as by means of a clamp 48 in such a manner that movement of the lever 47 imparts a pivotal motion to the mirror 27 about the spindle 45 as a fulcrum. The movement of the roller 37, imparted by the cam 35, is conveyed to the lever 47 by means of an adjustable collar 49 and an articulated joint 51 securing the collar 49 to the follower rod 39. A tension spring 52 engages the lever 47 and urges the roller 37 continually against the cam 35. A cam for example of the type shown in Fig. 9, when rotating with the cam shaft 34 causes the rod 39 to oscillate longitudinally, describing simple harmonic motion or any similar predetermined form of oscillation as incorporated in and governed by the shape of the cam employed. Although the amplitude of the oscillation is governed somewhat by the rise in the cam, the degree of angular oscillation or sweep imparted to the mirror 27 may also be regulated by adjusting the sliding collar 49 on the lever 47. The required sweep of the mirror 27 is determined by the distance of the mirror 27 from the plane of the image formed by the lens system 11, and by the size of the image which is to be formed on the screen S. The position of the collar 49 upon the lever 47 for a given set of operating conditions may be determined mathematically or experimentally and when once adjusted may be fixed by means of a set screw 53. The guide support 42 may be raised or lowered as desired so that the rod 39 extends substantially radially from the cam 35, the pivoted joint in the support 42 compensating for the change in the angular position of the guide 41 in response to the vertical adjustment.

The configuration of the cam 35 is determined by the needs of various operating conditions. In the form of cam indicated in Fig. 7 two complete cycles of oscillation are imparted to the mirror 27 during each revolution of the cam. Modified cams, of somewhat different shape, are shown in Figs. 9 and 10 respectively. The cam indicated in Figs. 9 and 10 are intended to provide a scanning motion of the mirror 27 by imparting uniform or substantially uniform angular velocity in one direction during a single frame scan followed by a quick motion in the opposite direction to return the mirror to the initial position, which return motion is best effected in the time interval between successive frames. In the form of cam indicated in Fig. 9, one complete frame-scanning cycle is effected during each half rotation of the cam, while with the form of cam shown in Fig. 10 this same cycle of operation is effected during an entire rotation of the cam.

With a cam of the type indicated in Fig. 7, in order to obtain 30 separate pictures per second, the cam must rotate at 450 revolutions per minute. Even at this relatively slow speed, however, it is absolutely essential that the cam rotate evenly at the intended rate without any fluctuations in speed, and further that chattering between the cam and the follower be avoided. The latter difficulty may be quite completely eliminated

through the use of a properly designed spring 52, but when excessive pressure is exerted against the roller 37 urging it against the cam surface, the pressure may exert an undesirable influence upon the rate of rotation of the cam. Tests have indicated that this condition ordinarily prevails, and the varying pressure imparted by the rising and falling cam follower exerts retarding and accelerating influences upon the cam 35 causing the cam to undergo undesirable speed fluctuations. When gears are employed between the camshaft and the driving motor this variation in speed may be represented by lost motion in the gearing. Another factor contributing to variation in the speed of the cam 35 is the fluctuations imparted to the shaft 31 by the varying torque of the armature of the motor F, although the flexible coupling 30 materially aids in smoothing out these variations. In any case, all of these factors affect the smooth operation of the cam and detract from the fidelity of the reproduced image. However, it has been found that a flywheel 50 secured upon the shaft 34 in close relation to the cam 35 operates to smooth out such fluctuations and to materially improve the quality of the reproduced image. The flywheel 50 may be keyed or otherwise rigidly secured to the shaft 34 to prevent any relative rotative movement between the two parts.

Although the aperture A preferably comprises a relatively small square opening upon which the light beam is concentrated as a luminous spot, as an alternative arrangement the opening may comprise a narrow vertical slot. If the aperture A comprises a slot, use is made of an additional slotted aperture plate 54 preferably positioned adjacent to the plane of the aperture image, indicated by dot and dash lines in Fig. 2. The plate 54 is positioned with the slot extending perpendicular to the image of the elongated aperture A. When employed with the optical arrangement indicated in Fig. 2, the slot of the plate 54 extends parallel with the axis of the spindle 45 and normal to the axis of the drum D so that the successive images of the elongated aperture in the plate P traverse the slot in the plate 54 at right angles. By this use of perpendicularly arranged slotted apertures compensation is made for undesirable motion of the drum D, for example such motion as might be caused by slight axial motion either of the disc D or of the shaft of the motor 17. Suitable means may be provided if desired to alter the width of the slot in the plate 54. A typical means for obtaining this result is shown in Fig. 11, and comprises a pair of sliding portions 55, the beveled edges of which form the slot. The sliding portions 55 are operable as by means of a thumbscrew 56 and lead screw 57 having right and left hand threads for engagement with lugs 60. The screw 57 is rotated in order to obtain the proper slot width, or to widely separate the portions 55 as will be described.

As shown in Figs. 1 and 2, the plane mirror 13 is mounted closely adjacent to the condensing lens 11 and to the disc D so that the beam B issuing from the lens 11 may be reflected upwardly upon the periphery of the disc D from which successive images of the aperture in the plate P are formed in the plane of the plate 54. Manipulation of the lens 11 and adjustment of the position of the mirror 13 may be necessary in order to obtain optimum operating conditions. The mirror 13 which is preferably of the first-surface type is mounted for vertical and angular adjustment. For simplicity's sake, the mirror adjusting means is illustrated in Fig. 1 as consisting of four threaded posts 58 secured in any convenient manner to the plate 54. Adjustment nuts 59, threaded on the posts 58, are employed to fix the mirror in the adjusted position.

The plane in which the image of the aperture A (or optionally the vertical slot) is formed may vary somewhat. However, the image plane preferably should not be located upon or substantially upon a tangent plane of the drum D or upon the oscillating mirror 27 as under these conditions the scanning effect becomes negligible. Under any one set of operating conditions the images of the aperture A preferably are formed in a fixed and predetermined plane. Accordingly, lenses 61, 62 and 63 of different focal lengths may be operatively mounted upon a turret 64, any one of which may be swung into operating position to project the complete image upon the screen S to any one of several desired sizes. Suitable indexing means as for example a spring 65 may be employed to cooperate with suitably positioned notches or apertures 66 formed in the turret 64, as shown in Fig. 1. In this manner the spring 65 may be lifted momentarily and substitution of the projection lens effected by partial rotation of the turret 64. The turret may also be provided with an opening 67 to permit passage of the beam B when no turret lens is required.

The diagram shown in Fig. 2 is illustrative of one preferred optical arrangement which may be employed with apparatus as shown in Fig. 1. The mirror 13 and the lens system 11 are adjusted until an image of the aperture A is formed between the disc D and the oscillating mirror 27, in the plane indicated by dot and dash lines. If an elongated aperture A is employed, a slotted plate 54 is interposed in the path of the beam substantially coincident with the image plane, and with the slot extending perpendicularly to the image of the aperture A. The slot width is then adjusted by turning the thumbscrew 56, until the emergent beam is of approximately square cross-section. The necessary adjustment is made upon the frame scanning mirror until the desired scanning motion is produced, and the projection lens moved to the proper focus, or the turret 64 is rotated until an image of the desired size is formed upon the screen S.

Modified optical arrangements are shown in Figs. 3, 4 and 5. In Fig. 3, the image of the square aperture A is formed directly upon the screen S by a lens 11, having the proper focal length. If a turret 64 is employed, it is indexed until the opening 67 is aligned with the beam B. The lens 11 is then moved while the disc D and mirror 27 are stationary until the aperture is properly focussed on the screen. If this, or the following arrangements are employed with apparatus as shown in Fig. 1, the sliding portions 55 of the aperture plate 54 are separated to permit the passage of the beam B, and use is made of a square aperture A.

In the arrangement shown in Fig. 4, the lens 11 projects a substantially parallel beam against the disc D and oscillating mirror 27, after which a supplementary lens 68 forms an image of the aperture A in space between the mirror 27 and the screen S when the disc D and mirror 27 are stationary. If a sliding ground glass or other translucent sheet 69 is positioned in the plane of the image in space, it serves as a monitoring screen upon which a complete picture is formed, aiding the operator in the adjustment of the various lenses and mirrors, and serving as an indicator

of normal operation. This ground glass may be left in position permanently if desired as it appears to have but little influence upon the completed picture on the screen S. A projection lens 28 forms a real and enlarged image of the aperture image upon the screen S when the scanners are stationary, or an enlarged completed picture when the apparatus is in operation.

The arrangement shown in Fig. 5 is similar to that shown in Fig. 2, with the exception that the lens 11 is adjusted to form an image of the aperture A in space between the screen S and the mirror 27 rather than between the disc D and the mirror 27. With this and the previously described arrangement, a monitoring screen 69 may be employed to form a small-size complete picture to aid the operator in the adjustment of the parts. A projection lens 28 forms the large picture upon the screen S.

The mirror 27 in common with the mirror 13 and the surfaces 26, is preferably of the first-surface type. While various types of cams have been illustrated to show the manner in which the mirror 27 may be made to follow in predetermined motion, it is to be understood that the mirror 27 may comprise the oscillating reflector of an electromagnetic oscillograph apparatus the operation of which is well known. In this manner it is possible by operating such an oscillograph with the desired wave form to produce a corresponding motion in the frame scanner. The motors F and 17 are preferably mounted resiliently upon the supporting structure.

Various other modifications may be made without departing from the spirit and scope of the invention as we contemplate any form of construction properly within the scope of the appended claims.

We claim:

1. A mechanical television scanning apparatus comprising a light source; means for concentrating light from said source into a beam; a plate having an aperture in the path of said beam, means for modulating said beam of light; scanning means for scanning said beam in mutually perpendicular directions; a screen; means for focussing said beam to form an image of said aperture in space between one of said scanners and said screen; and a monitoring device comprising a translucent sheet arranged for positioning in the path of said beam in the plane of said image; and means between the image and the screen for projecting an enlarged image of said image upon said screen.

2. A mechanical television scanning apparatus comprising a light source; means for concentrating light from said source into a beam; a plate having an aperture in the path of said beam; means for modulating said beam of light; a first scanner comprising a rotatable disc provided with scanning elements adjacent to its periphery for successively scanning said beam; a second scanner for scanning said beam in a direction perpendicular to that of said first scanner; a screen; means focussed on said aperture for forming during operation of said scanners a relatively small complete television image between said second scanner and said screen; a translucent sheet positioned in the plane of said small complete television image; and means between said image and said screen for forming an enlarged image and projecting the same upon said screen.

3. A mechanical television scanning apparatus comprising a light source; means for projecting light from said source as a luminous spot; means for varying the intensity of said luminous spot in accordance with the television impulses; scanning means for acting successively upon said spot in mutually perpendicular directions; a screen; means for forming an image of said spot between said scanning means and said screen; a translucent sheet located in the plane of said image, and means between said translucent sheet and said screen for projecting an enlarged image of said image upon said screen.

4. A mechanical television scanning apparatus comprising a light source; means for concentrating light from said source as a beam; a plate having an aperture therein interposed in the path of said beam; means for modulating said beam in accordance with the television impulses; scanning means operative in mutually perpendicular directions; means focussed on said aperture for projecting a substantially parallel beam upon said scanning means; a screen for receiving said beam; means in the path of said beam for forming an image of said aperture in space between said scanners and said screen; a translucent sheet arranged for positioning in the plane of said image in space; and means between said image and said screen for projecting an enlarged image of said aperture image upon said screen.

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