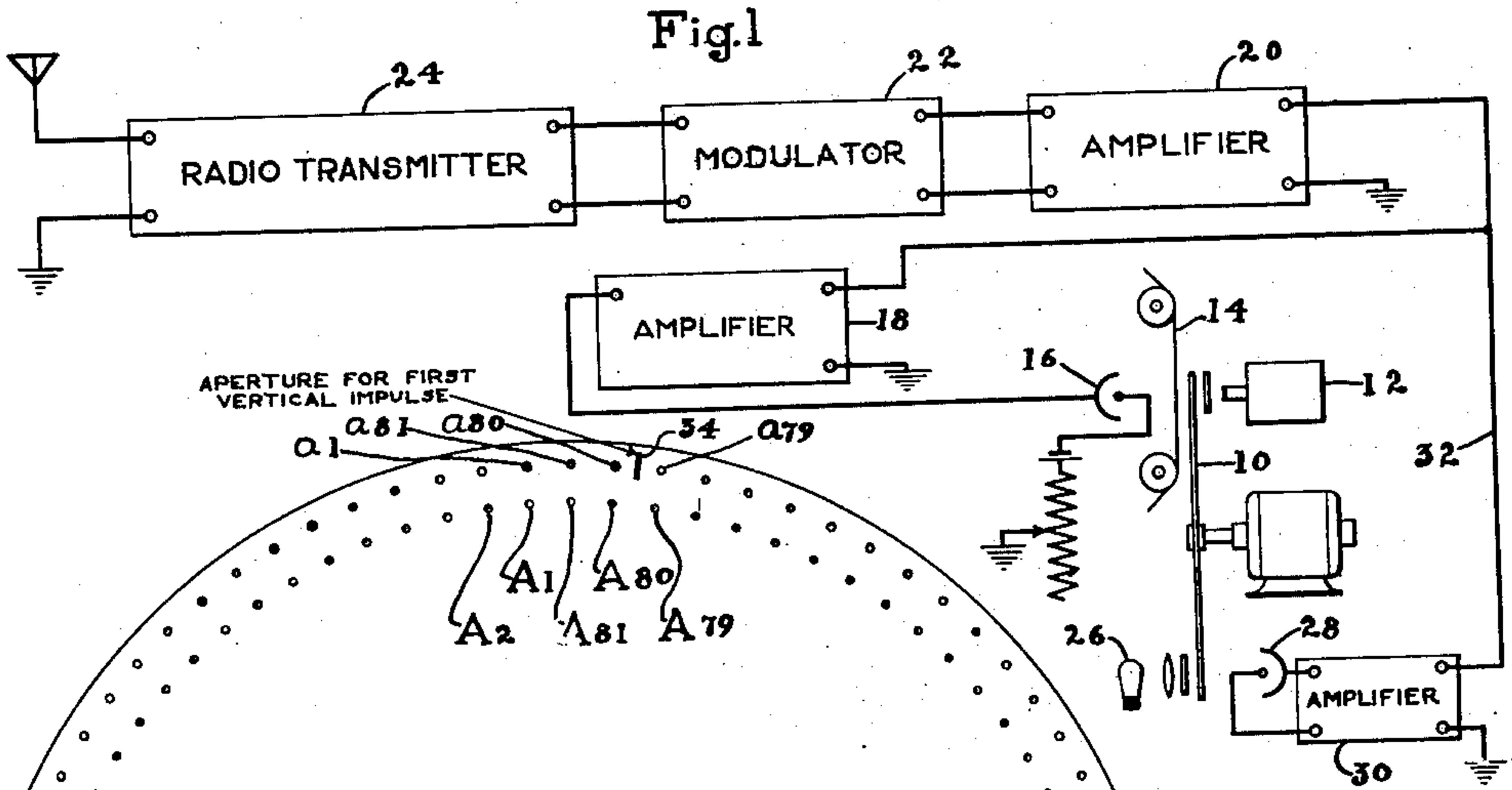
March 28, 1939. R. C. BALLARD 2,152,234

TELEVISION SYSTEM

Filed July 19, 1932 2 Sheets-Sheet 1

Fig. 1



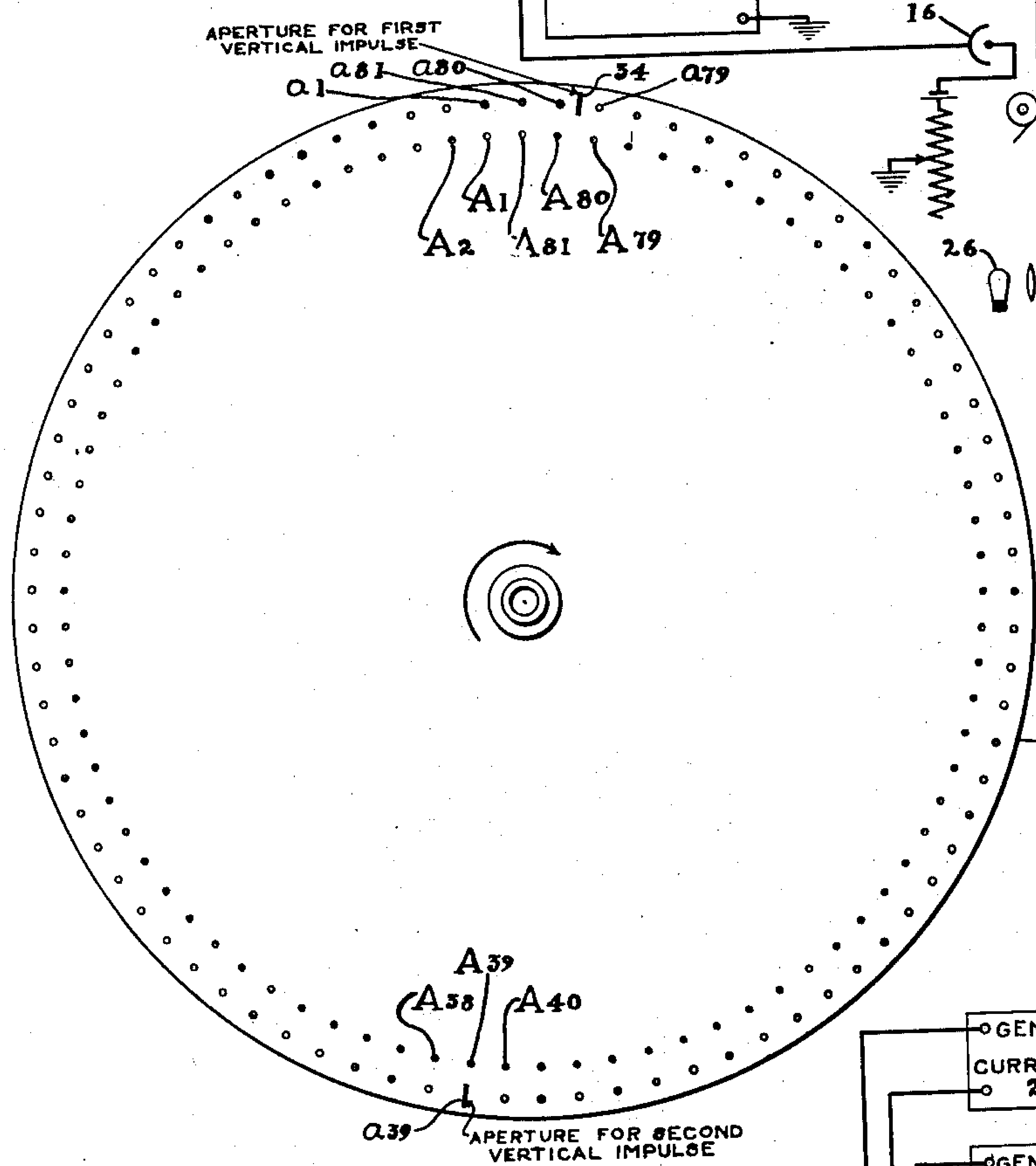


Fig. 2

Fig. 3

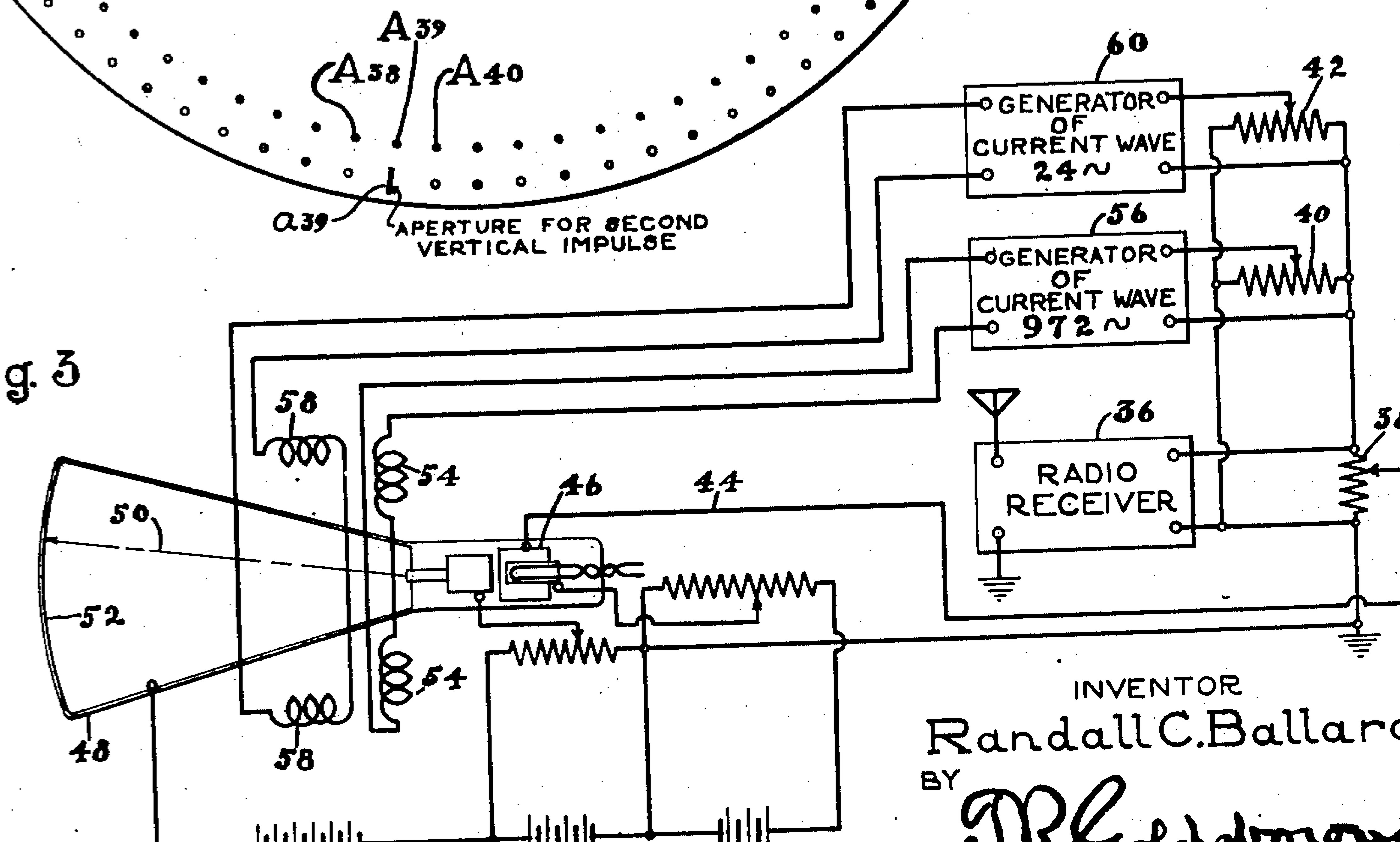


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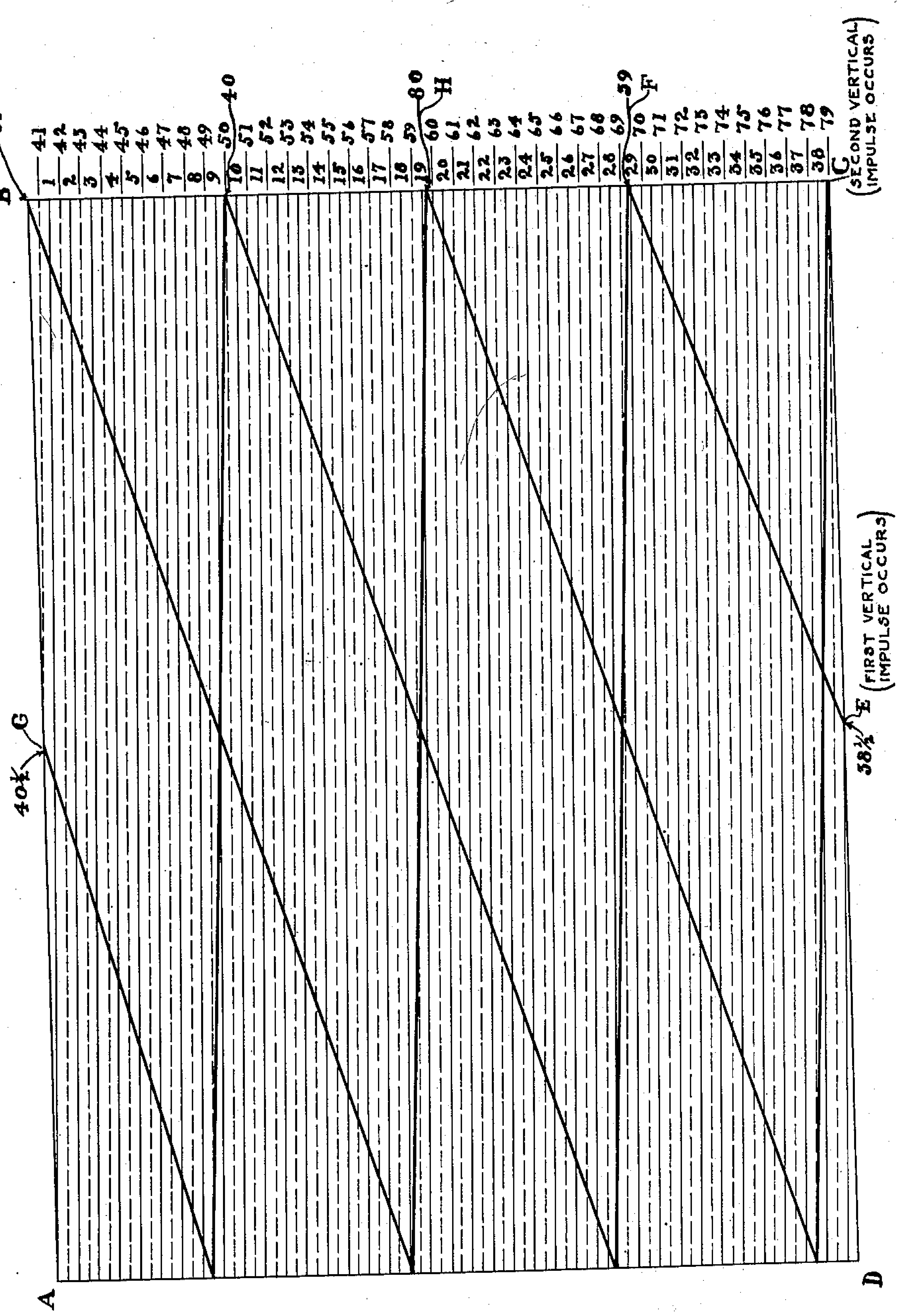
Fig. 4



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2,152,234

TELEVISION SYSTEM

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Application July 19, 1932, Serial No. 623,325

14 Claims. (Cl. 178—7.6)

My invention relates to improvements in television systems and, more particularly, to an improved method of scanning.

In the art of television, wherein a moving picture film with a sound track thereon is the object televised, satisfactory results have been obtained by using a scanning disc at the transmitting station for transmitting the picture and a cathode ray tube at the receiving station for reproducing the picture. An important advantage of the cathode ray tube for receiving purposes resides in the feature of retentivity of fluorescence of the fluorescent screen with which the tube is provided, which screen is scanned by the cathode ray. In this connection, it has been determined that, for the purpose of making use of this fluorescence to the best advantage, the received picture frequency should not be materially greater than sixteen pictures per second. However, when using standard sound-film, it is necessary, at the transmitter, to run the film at the usual normal rate of 24 frames a second to reproduce the sound faithfully.

Various methods and constructions have been proposed for the purpose of permitting simultaneous occurrence of the two conditions of operation referred to, that is, scanning the film at a rate not greater than sixteen pictures per second, and running the film at the usual rate of 24 frames per second.

One of these methods proposed heretofore has been to run the film at the normal rate of 24 frames a second, but to scan only every second, third, or fourth picture of the film. Another method proposed has been to make a slow-speed film from the standard film, in which case the correct reproduction of the sound was obtained with the film running at a speed not greater than sixteen pictures per second, and every picture was scanned. These methods, as well as the various other methods proposed heretofore, are costly and/or cumbersome.

With the foregoing in mind, it is one of the objects of my invention to provide an improved television system, for the transmission of standard sound-film, wherein the film is run at the normal rate and is scanned in such a manner as to obtain full advantage of the fluorescent effect in a cathode ray tube at the receiving station.

Another object of my invention is to provide an improved television system for the transmission of sound film, wherein the frequency channel required for television is reduced without changing from the standard rate of 24 pictures a second at which the film is run.

Another object of my invention is to provide an improved method of operation whereby the number of picture lines can be substantially increased without necessitating an increase in the required frequency channel.

Another object of my invention is to provide an improved method whereby the optical effect, referred to as "flicker", is eliminated or reduced to a negligible degree.

Other objects and advantages will hereinafter appear.

For the purpose of illustrating my invention, an embodiment thereof is shown in the drawings, wherein—

Figure 1 is a diagrammatic view of a television transmitting system constructed and operable in accordance with my invention;

Fig. 2 is an enlarged elevational view of the scanning disc in Fig. 1, looking toward the left in this figure;

Fig. 3 is a diagrammatic view of a television receiving system constructed and operable in accordance with my invention; and

Fig. 4 is a schematic illustration of the manner in which the cathode ray scans the fluorescent screen in Fig. 3.

My invention resides in the improved system and method of operation of the character hereinafter described and claimed.

The transmitting system shown in Fig. 1 comprises a scanning disc **10** provided with apertures at its edge arranged on a circle concentric with the axis of rotation of the disc. Light from a suitable source **12** passes through these apertures and through a standard sound film **14** onto a photoelectric cell **16**. Picture signals are thereby developed and, after passing through a plurality of amplifiers **18** and **20** and a modulator **22**, may be radiated by a suitable radio transmitter **24** or otherwise conveyed to distant receiver-locations.

The film **14** is supported in the usual manner, and is fed along at the normal rate of 24 pictures a second.

For the purpose of developing and transmitting synchronizing and framing impulses, the disc **10** is provided with other apertures through which light from a source **26** passes to a photoelectric cell **28**. These impulses are amplified by an amplifier **30**, and then pass to the amplifier **20** by way of a connection **32**. In this manner, the synchronizing and framing impulses are transmitted in the same radio channel with the picture signals.

Coming now to a more detailed explanation of the construction and manner of operation of the disc 10, reference is made to Fig. 2.

Assuming that it is desired to reproduce an 80 line picture at the receiving station, the disc 10, for this purpose, is provided with 81 apertures A_1 to A_{81}, and is rotated at the rate of twelve revolutions a second, or ½ the picture frequency at which the film 14 is run. The operation, therefore, is such that each picture of the film is scanned along 40.5 lines.

The disc is also provided with a plurality of apertures a_1 to a_{81}, equal in number to the picture apertures, these apertures being so arranged, as will be well understood, that a synchronizing impulse is developed and transmitted at the end of each picture line. One of these apertures, that is, the aperture a_{39}, for example, is made substantially larger than the others for the purpose of developing a framing impulse. The disc 10 is provided with another framing aperture or opening 34, disposed as shown, diametrically opposite the opening a_{39}, and between synchronizing apertures a_{79} and a_{80}. The reason for this particular arrangement will be understood during the course of the following description and explanation.

The disc 10 is rotated at the rate of one revolution for every two frames of the film. As the disc is provided with an odd number of pictur apertures, that is, 81, each picture of the film will be scanned along 40.5 lines. At the end of the scanning period for the first 40.5 lines, the framing opening 34 will be in position between the light source 26 and the photoelectric cell 28 to effect transmission of a framing impulse. At the end of the next scanning period, during which the next picture of the film is scanned along 40.5 lines, the aperture a_{39} will be in position to effect transmission of a second framing impulse. This second framing impulse occurs at the end of the 81st scanning line, at the end of each complete revolution of the disc.

In the receiving system, as shown in Fig. 3, the transmitted picture signals and the synchronizing and framing impulses are received by a suitable radio receiver 36, and appear across resistances 38, 40 and 42. The picture signals, which are positive in sign, are taken from the resistance 38 and are applied, by a connection 44, to the control grid 46 of a cathode ray tube 48. In this manner, the intensity of the ray 50 is varied in accordance with the picture signals.

The synchronizing and framing impulses do not interfere with reproduction of the picture for the reason that they are negative in sign and, furthermore, occur at the ends of the scanning lines and between frames, respectively.

The cathode ray tube is provided, at its large end, with a fluorescent screen 52 which the ray 50 is caused to scan in a manner simulating the scanning action at the transmitter. For this purpose, the ray is deflected horizontally 972 times a second by causing a saw-tooth current wave, at this frequency, to pass through a plurality of horizontal deflection coils 54. These coils are supplied from a suitable generator 56 for this purpose, which is locked in step with the line-scanning frequency at the transmitter by the received synchronizing impulses taken from the resistance 40 and applied to the input circuit of this generator. The frequency of 972 cycles is required on account of the fact that the transmitting disc has 81 picture apertures and rotates at the rate of twelve revolutions a second.

The ray 50 is deflected vertically at the rate of 24 times a second by electromagnetic coils 58 through which a saw-tooth current wave at this frequency is caused to pass. A suitable generator 60 operates to generate this wave, and is locked in step with the framing frequency at the transmitter by taking the framing impulses from the resistance 42 and applying the same to the control circuit of this generator. The synchronizing impulses are not effective to influence the generator 60 for the reason that the same is constructed and adjusted to be responsive only to the framing impulses. The frequency of 24 cycles is required on account of the fact that the film at the transmitter is run at the rate of 24 picture frames a second. Since the specific construction of the generators 56 and 60 and the manner in which their action is controlled forms no part of my present invention, they are not illustrated in detail.

The scanning action at the receiving station will now be explained, with reference to Fig. 4, which is a schematic representation of the approximate path along which the ray scans the fluorescent screen 52, the figure being considered as a view looking toward the left in Fig. 3.

The area of the fluorescent screen which is scanned by the ray 50 is always the same, that is, the area ABCD.

The ray 50 is deflected to the right, for scanning line 1, during the time that the picture aperture A_1 is effective at the transmitter. Similarly, the raw is deflected to the right again, for scanning line 2, during the time that the picture aperture A_2 at the transmitter is effective, and so on. For the line 39, however, the ray is only deflected half way to the point E, at which instant the screen will have been scanned along 38.5 lines. This action is caused by the fact that, at this instant at the transmitter, the aperture 34 comes into position to effect transmission of a framing impulse, whereupon the vertical deflecting coils 58 cause the ray to return upwardly. The period for upward return is not instantaneous, but requires a length of time corresponding to several scanning-line periods. The ray, therefore, reaches the point F as the picture aperture A_{39} completes its scanning action at the transmitter for the line 39. The next scanning line 40 at the receiver takes place during the period of operation of the picture aperture A_{40} at the transmitter. At the completion of the scanning action at the receiver for 40.5 lines, that is, at the point G, the ray is started downward again, as before. The next scanning of the screen 52, therefore, begins from the point G rather than from the point A, the lines of this second scanning being represented in the figure by dash lines. On account of this action, the line 40.5–41 and the lines 42 to 79, all comprising the second scanning, are interwoven with respect to, or occur between the lines 1 to 38.5 of the first scanning. At the completion of the line 79, the aperture a_{39} at the transmitter is in position to effect transmission of a second framing impulse, whereupon the ray is returned vertically to the point B along the path shown. The ray reaches the point H at the instant of completion of what would have been the scanning line 80, and reaches the point B at the completion of what would have been the line 81. In the present explanation, it has been assumed that return deflection of the ray horizontally occurs in zero time. From the point B, therefore, the ray returns to the point A, and the cycle, corresponding to one complete revolution of the transmitting disc 10, is completed.

From the foregoing it will be seen that the screen 52 is scanned horizontally along 77 effective lines, and that a time period corresponding to 4 lines is used in the vertical return of the ray. The result is that, to the eye, the cathode ray tube presents what appears to be a normal 77-line picture. Actually, however, the tube is presenting a series of 38.5 line pictures which intermesh or are interwoven with each other. Due to the persistence of the fluorescent screen, the optical effect is the same as though the picture were comprised of 77 lines occurring in succession. At the outset, it was stated that an 80-line picture was to be reproduced. This assumption was for convenience.

The frequency channel required for a 77-line picture in my improved system will be that corresponding approximately to a 40-line picture. With such a low limit of channel requirement for a 77-line picture, it would be feasible to change to a picture of more lines, up to the limitation imposed by transmission requirements.

From the foregoing, it will be seen that by my improved method and system it is possible to substantially increase the number of picture lines without increasing the required frequency channel. Furthermore, by using my improved method of scanning, the optical effect, referred to as "flicker", is eliminated or reduced to a negligible degree.

Another advantage of my improved method and system resides in the fact that standard sound film can be run at the normal rate, and the fluorescent screen in the cathode ray tube at the receiving station can, at the same time, be scanned in such manner as to obtain the full advantage of the fluorescent effect, all without requiring cumbersome and costly constructions, as heretofore.

The term "apertures" or "opening" is used in the specification and claims in a broad sense, and is intended to cover the various well-known modifications such, for example, as the disc construction with lenses inserted in apertures or openings. The term "vertical deflection cycle", as used in the claims, means the complete cycle of deflection caused by the vertical deflecting means, this complete cycle consisting of a useful deflecting period and a return line period.

The terms "horizontal deflection" and "vertical deflection", as used in the claims, refer to the fast and slow deflections, respectively, and are not limited to the direction of viewing or space location of the deflections.

Various modifications, within the conception of those skilled in the art, are contemplated.

I claim as my invention:

1. A system for producing television images utilizing a skip line scanning which comprises a cathode ray tube having a fluorescent screen and having means to develop a cathode ray and means for causing the developed ray to produce the effect of varying intensities of light and shadow on said fluorescent screen, means for producing a deflection of the ray in its passage through the tube to cause the ray to traverse the said screen in paths bearing an angular relationship to each other, and means coordinated with the deflecting means for alternately changing the predetermined control paths of position at which the ray produces the fluorescent effects to cause successive traversals of the complete predetermined pattern traced upon the fluorescent screen to be interspersed.

2. A television receiver comprising the combination of a cathode ray tube having a target element and means to develop a cathode ray and means for causing the cathode ray to traverse in a series of adjacent lines a predetermined pattern on the target element, and means for causing at the completion of each of a plurality of lines of travel corresponding substantially to an entire image representation, a separation between successive complete paths of traversal so as to produce an interspersed series of complete traversals wherein the individual lines of each image representation alternate.

3. In the art of television wherein it is required that synchronizing and framing impulses be developed during the succeeding picture periods; the steps in the method of operation which comprise developing during every other picture period a framing impulse originating substantially simultaneously with a synchronizing impulse, and developing during the remaining intervening picture periods a framing impulse originating between succeeding synchronizing impulses.

4. In a television transmission system for moving picture film, means for supporting and imparting feeding movement to a film, means for developing picture signals comprising a rotatable disc for scanning said film, said disc being provided with picture apertures all of which are disposed on a single circle concentric to the axis of rotation thereof, and means for rotating said disc; said system being characterized by the fact that the rate of feeding movement of the film, in terms of pictures per second, is twice the rate of rotation of said disc, in terms of complete revolutions per second, and further characterized in that the number of said apertures divided by said rate of feeding equals a whole number plus one-half.

5. A television receiver comprising a cathode ray tube having therein means to develop a cathode ray and a fluorescent screen to produce luminous effects, means arranged in cooperative relationship with the cathode ray tube for causing the developed cathode ray to traverse the screen along a series of substantially parallel paths, and means to produce at the completion of a predetermined number of parallel paths of traversal a second series of substantially parallel paths interlaced with respect to the first series of parallel paths so that alternately produced series of complete traversals of the screen by the cathode ray are interspersed.

6. A system for producing television images utilizing skip-line scanning which comprises a cathode ray tube having means to develop a cathode ray and means for causing the developed ray to produce the effect of varying intensities of light and shadow on the fluorescent end wall of the tube, means for producing a deflection of the ray in its passage through the tube to cause the ray to traverse the screen in paths bearing an angular relationship to each other, and means coordinated with the deflecting means for alternately changing the predetermined controlled paths of position at which the ray produces the fluorescent effects to cause successive traversals of the complete predetermined pattern traced upon the tube wall to be interspersed.

7. A television receiver comprising the combination of a cathode ray tube having means to develop a cathode ray and means for causing the cathode ray to traverse in a series of adjacent

lines a predetermined pattern on the fluorescent tube wall, and means for causing at the completion of each of a plurality of lines of traversal corresponding substantially to an entire image representative a separation between successive complete paths of traversal so as to produce an interspersed series of complete traversals wherein the individual lines of each image representation alternate.

8. In the art of television, the method of scanning a picture area which comprises deflecting a scanning ray vertically and simultaneously causing the scanning ray to traverse the entire width of said area a plurality of times and a fraction of said width once during a vertical deflecting cycle, said fraction being greater than one-eighth, and next causing said ray to again traverse the entire width of said area a plurality of times and a fraction of said width once during the next vertical deflection cycle, said last-mentioned fraction being the same as the first-mentioned fraction, and interlocking said vertical deflection and said width traversals to maintain a fixed frequency relation therebetween, said fraction having a numerator and a denominator each of which is a whole number.

9. In the art of television, the method of scanning a picture area which comprises causing a scanning ray to traverse said area both horizontally and vertically to produce during a vertical deflection cycle a plurality of scanning lines each having a certain length and an additional scanning line having a length which is a fraction of the length of any one line of said plurality of lines and next causing said ray to again traverse said area both horizontally and vertically to produce during a vertical deflection cycle a plurality of scanning lines each having a certain length and an additional scanning line having a length which is a fraction of the length of any one line of said plurality of lines, and maintaining a fixed frequency relation between said horizontal and vertical traversals, whereby the scanning lines produced by one scanning of said area lie between the scanning lines produced by a preceding scanning of said area to produce a plurality of interpersed scanning lines, the repetition of said scanning being fast enough and said fraction being large enough to cause all of said interspersed lines to be visible to an observer due to persistence of vision.

10. In a television system, means for causing a scanning ray to traverse a given area horizontally x times per second, means for causing said ray simultaneously to traverse said area vertically y times per second, and means for interlocking said first means and said second means to maintain a fixed frequency relation between x and y, where

$$\frac{x}{y}$$

is equal to a whole number plus ½, and where y is at least equal to the rate at which persistence of vision substantially causes flicker disappearance whereby said scanning ray produces a scanning pattern which appears to be a fixed stationary pattern of interspersed scanning lines.

11. In a television system, a cathode ray tube, means for deflecting the cathode ray at a frequency rate of x, means for deflecting the cathode ray simultaneously at a frequency rate of y, means for maintaining a fixed frequency relation between the deflection at the rate x and the deflection at the rate y, where

$$\frac{x}{y}$$

is equal to a whole number plus ½, and where y is at least equal to the rate at which persistence of vision substantially causes flicker disappearance whereby said cathode ray produces a scanning pattern which appears to be fixed stationary pattern of interspersed scanning lines.

12. In a television system, means for producing horizontal synchronizing impulses occurring at a frequency x, means for producing vertical synchronizing impulses occurring at a frequency y, and means for interlocking said first means and said second means to maintain a fixed frequency relation between x and y, where

$$\frac{x}{y}$$

is equal to a whole number plus ½, and where y is at least equal to the rate at which persistence of vision substantially causes flicker disappearance.

13. In a television system, a cathode ray tube having means for producing a cathode ray, means for deflecting said ray to cause it to traverse a given area horizontally x times per second, means for deflecting said ray simultaneously to traverse said area vertically y times per second, and means for interlocking said two deflecting means, where

$$\frac{x}{y}$$

is equal to a whole number plus

$$\frac{A}{K}$$

whereby said area is scanned successively K times with the scanning lines of said successive K scannings of said area interspersed or interlaced, A being a whole number less than K, and where y is such a value that and where K is a whole number greater than 1 which is so small that the K number of scannings are repeated at a rate at least equal to that at which persistence of vision substantially causes flicker disappearance.

14. In the art of television, the method of scanning a picture area which comprises deflecting a scanning ray vertically and simultaneously causing the scanning ray to traverse the entire width of said area a plurality of times and a fraction of said width once during a vertical deflection cycle, said fraction being greater than one-eighth, and next causing said ray to again traverse the entire width of said area a plurality of times and a fraction of said width once during the next vertical deflecting cycle, said last-mentioned fraction being the same as the first-mentioned fraction, interlocking said vertical deflection and said width traversals to maintain a fixed frequency relation therebetween, and completing the cycle of scanning by repeating the vertical traversal n times per cycle of scanning where

$$\frac{1}{n}$$

is the selective fraction.

RANDALL C. BALLARD.