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H. NYQUIST

1,773,785

ELECTROOPTICAL SYSTEM

Filed July 13, 1928

Fig. 1.

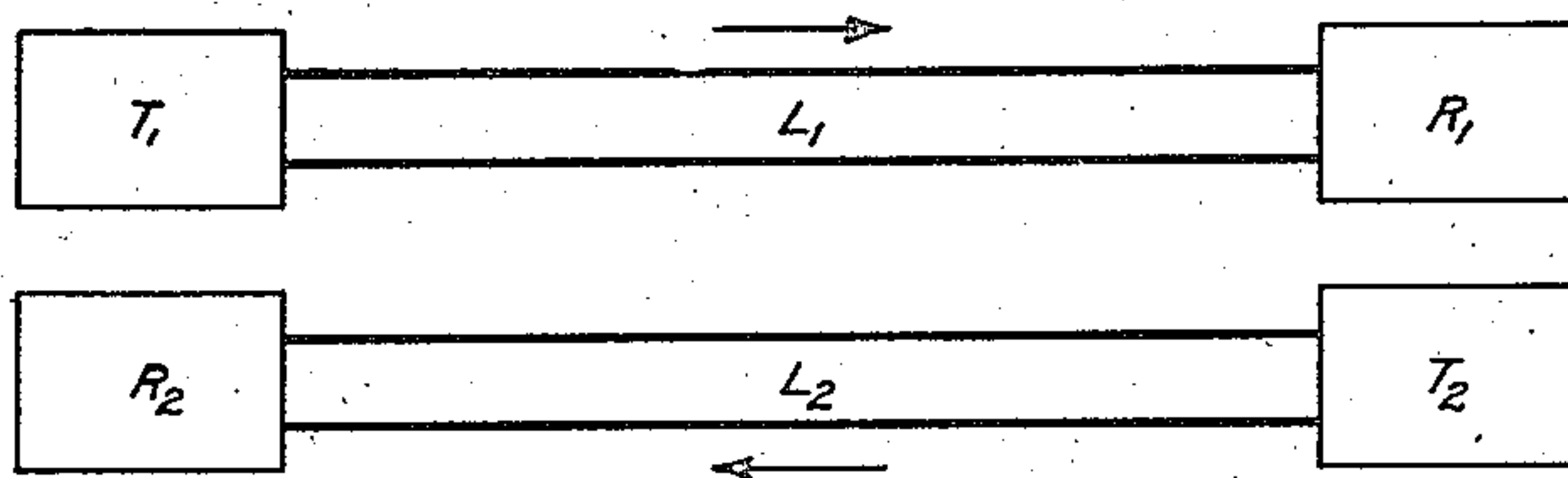


Fig. 2.

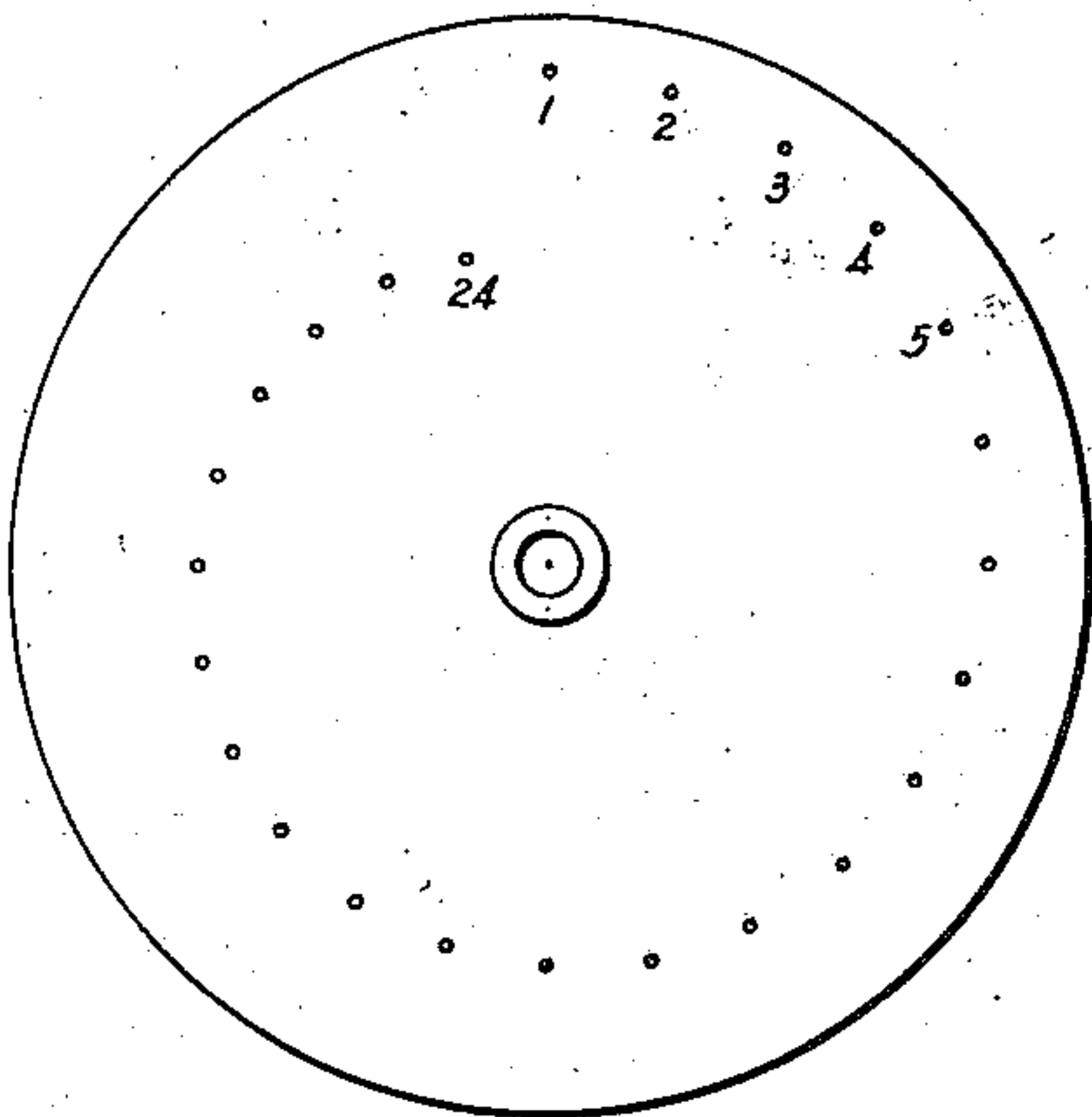


Fig. 3.

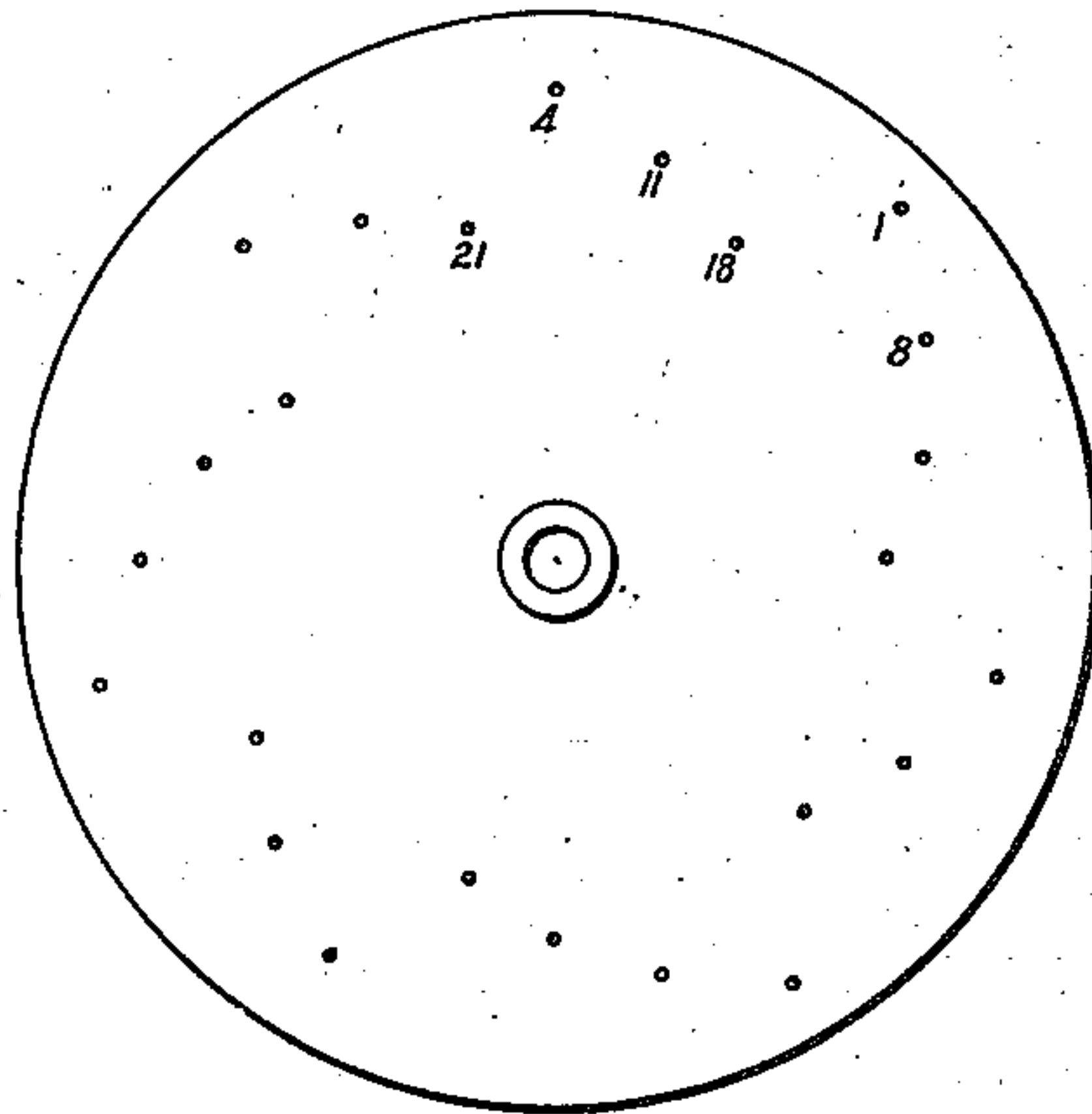


Fig. 4.

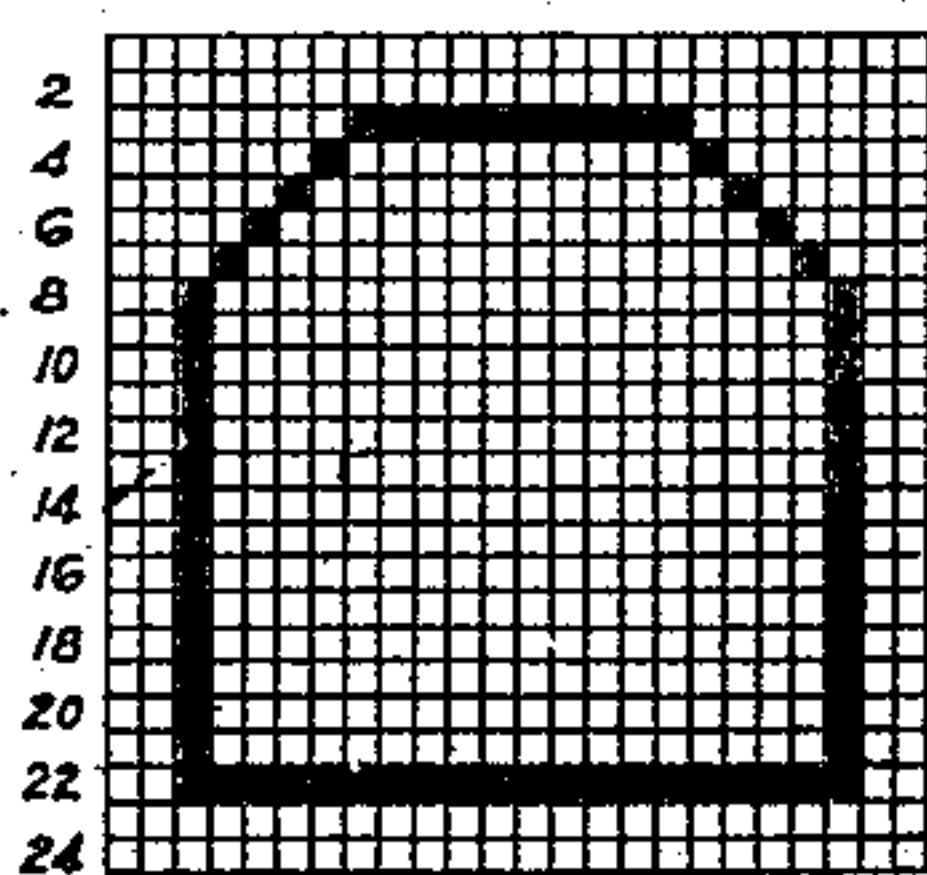


Fig. 5.

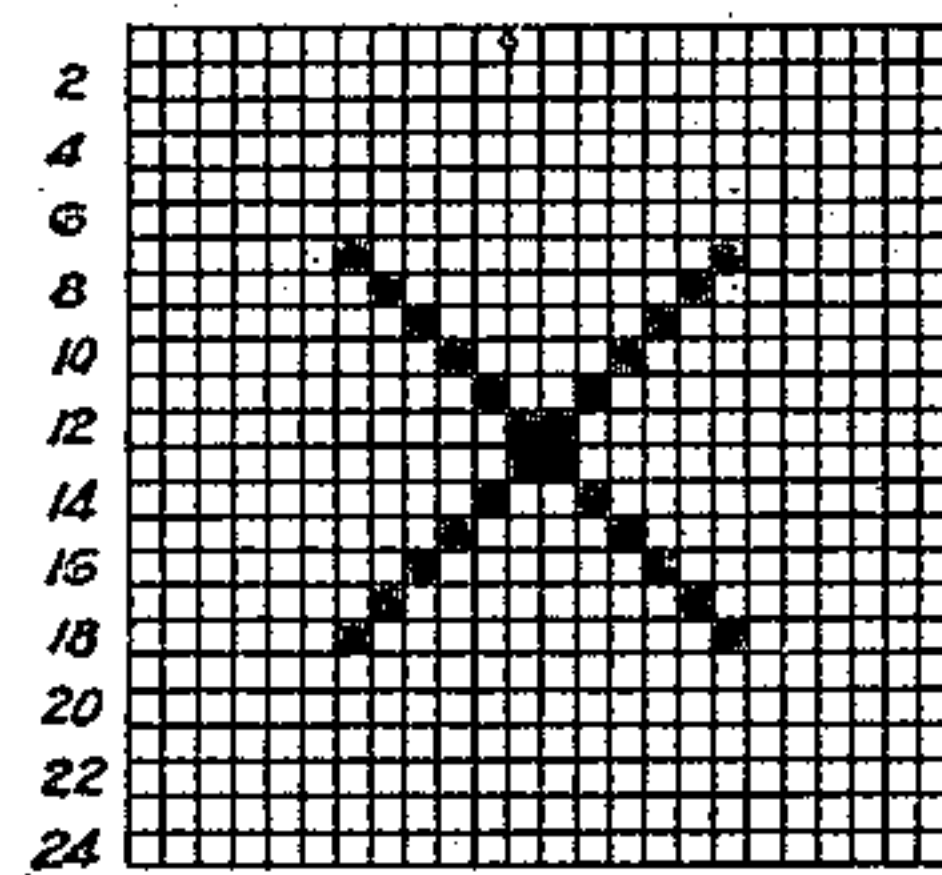


Fig. 6.

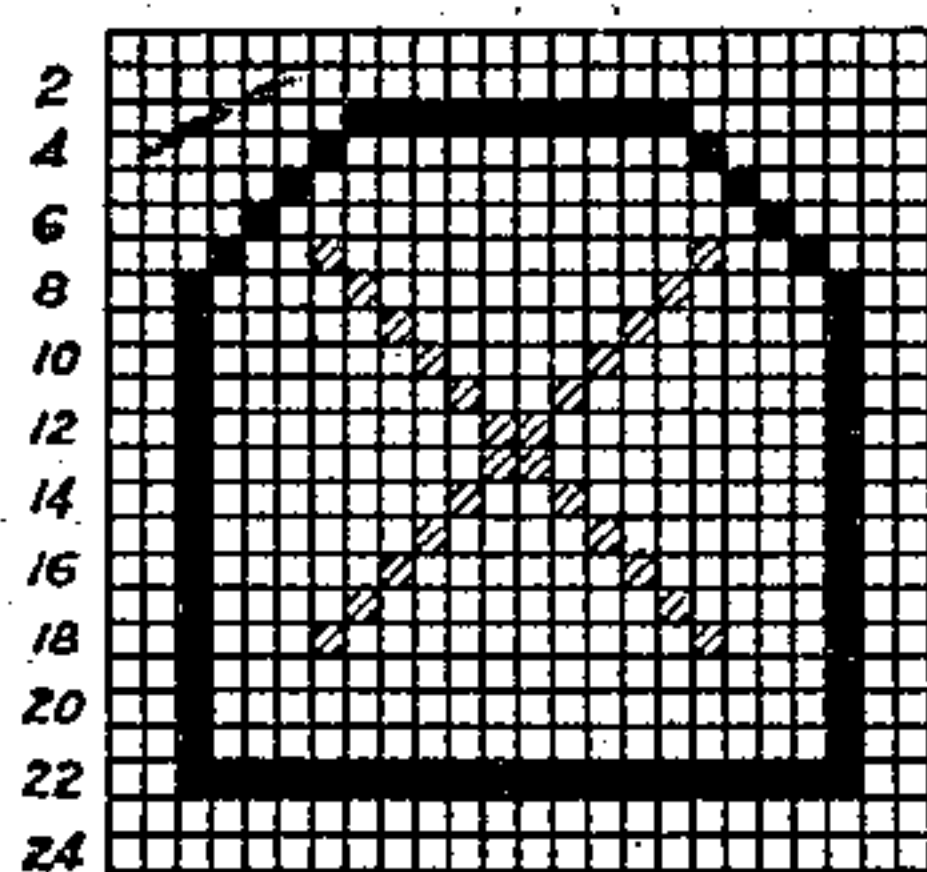
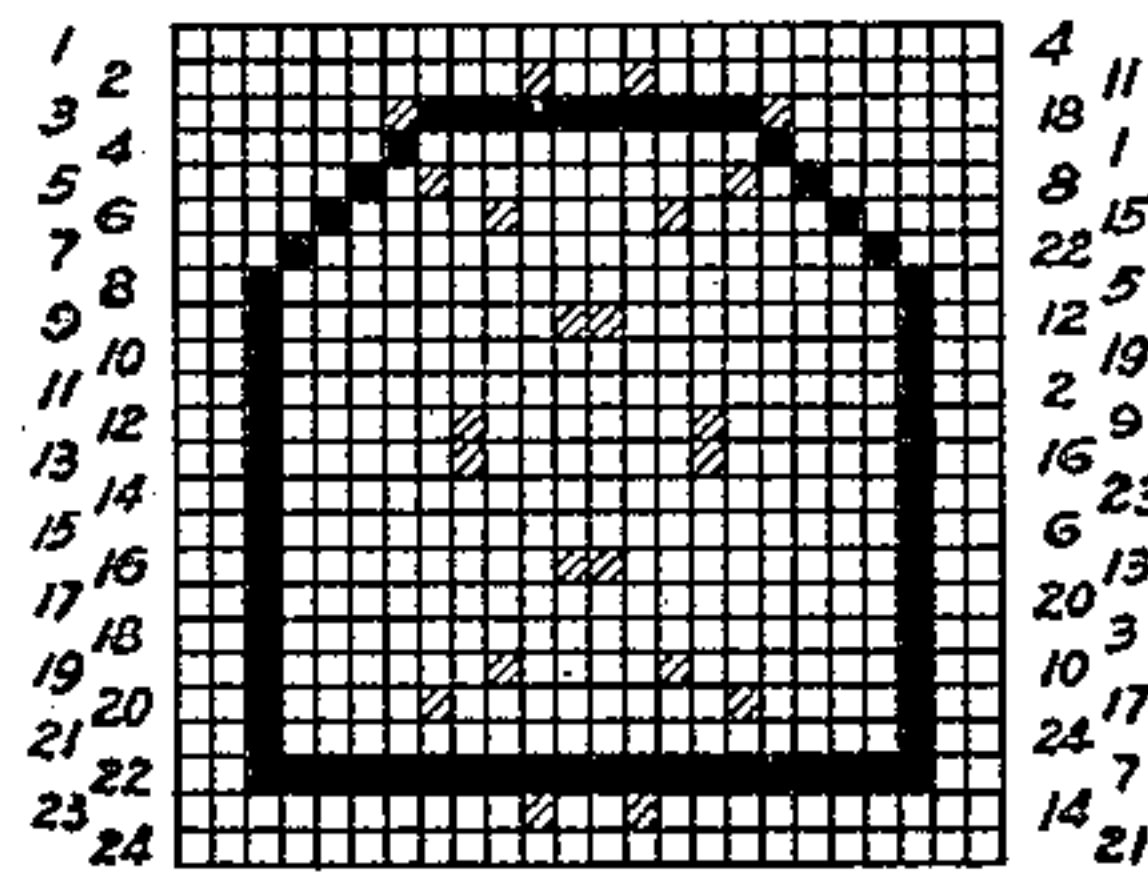


Fig. 7.



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ELECTROOPTICAL SYSTEM

Application filed July 13, 1928. Serial No. 292,540.

This invention relates to electro-optical systems, and more particularly to television.

An object of the invention is to reduce interference effects, or "ghost" effects, in an electro-optical image producing system caused by currents set up by an interfering image wave of another system or channel. A further object is to provide simple means for rendering television transmission secret.

Steps have been taken to prevent interference in television systems heretofore devised. In general, such systems employ current selective means so that the interfering energy is prevented from producing any interfering image whatsoever. In another arrangement heretofore known the image currents are produced intercurrently or alternately for elemental periods and accordingly no interference images are produced.

It is well known that a faint irregularity in the flat portion of a picture is considerably enhanced in visibility by being in the form of a definite pattern. In the same way faint interference is enhanced in visibility if it is in the form of an intelligible image such as results from interference from one television transmission channel in another. In accordance with this invention the effect in the image field resulting from interference is caused to bear little or no resemblance to the interfering image and to be unintelligible. In general, this is accomplished by arranging the scanning differently in the two channels or systems.

In a particular arrangement illustrative of the invention scanning discs having the scanning apertures differently arranged for the two channels are employed, each channel being substantially like that disclosed in a co-pending application of H. E. Ives and Frank Gray, Serial No. 181,581, filed April 6, 1927. The apertures for the discs of one channel are arranged in a single turn while those in the disc for the other channel are arranged so that the adjoining elemental lines are not scanned successively but preferably successively scanned lines are separated as much as possible. The discs at the transmitter and receiver of any one channel are substantially identical.

While the invention is particularly useful for television, it is applicable to other types of electro-optical systems, for example, photo-telegraphic systems.

A more detailed description of the invention follows and is illustrated in the accompanying drawings.

Figure 1 is a schematic representation of a plurality of transmitting and receiving television stations which may be simultaneously operated and between which interference may occur. It may, for example, be a single two-way system.

Fig. 2 is a drawing of a scanning disc having apertures arranged to successively scan adjacent line series of elemental areas and adapted for use in one of two interfering channels in accordance with this invention.

Fig. 3 is a drawing of another form of a scanning disc which may be used in one of two interfering channels in carrying out this invention. It has apertures arranged to successively scan non-adjacent line series of elemental areas.

Fig. 4 is a drawing of a simple form of received image transmitted over one of two interfering channels of a system such as that shown in Fig. 1 when no cross pick-up interference occurs between channels.

Fig. 5 is a drawing of another simple form of received image such as might be transmitted over one of two interfering channels of systems exemplified in Fig. 1 when no cross pick-up interference occurs between channels.

Fig. 6 is a drawing of the received image shown in Fig. 4 with a cross pick-up image superimposed thereupon resulting from interference from the channel over which the image of Fig. 5 is transmitted when ordinary terminal apparatus is employed.

Fig. 7 is a drawing of the image field under the same conditions as that of Fig. 6 but with the use of terminal apparatus in accordance with this invention.

The schematic representation of Fig. 1 of a two-way television system illustrates in a very simple way conditions under which "crosstalk" or cross pick-up interference may occur in a television system between a plural-

ity of channels of a single system or between a plurality of separate interfering systems. T_1 represents a transmitting station connected by channel L_1 with a receiving station R_1 ; and R_2 represents a transmitting station connected by channel L_2 with a receiving station R_2 , the transmission channels being in such proximity that cross talk or cross pick-up interference may occur. While the two systems are shown as transmitting in opposite directions interference might equally well occur if both were simultaneously transmitting in the same direction. In a more elaborate system or a larger network of systems a larger number of channels would simultaneously be in operation and a larger amount of interference might occur. This invention makes unintelligible any interference effect occurring under any of these conditions.

The image areas shown in Figs. 4, 5, 6 and 7 are cross ruled into elemental areas in order to facilitate an understanding of their description. Fig. 4, and likewise Fig. 5, represents both the picture or object whose image is transmitted and also the received image when no crosstalk or cross pick-up interference occurs. Figs. 6 and 7 show a received image similar to that of Fig. 4 and the effects of cross pick-up from the image of Fig. 5. In Fig. 6 the cross pick-up image of Fig. 5, while not as distinct as the main image of Fig. 4 directly transmitted, is similar in form to the original and consequently intelligible. The received image in Fig. 7 for the main image is the same as in Fig. 6 but the cross pick-up image of Fig. 5 has been rendered unintelligible by a repositioning of its elemental areas which results in lessening its disturbing effect. The received main and cross pick-up images as shown in Fig. 6 occur when the scanning arrangement is identical in operation for the interfering channels; while the received image and the cross pick-up effect as shown in Fig. 7 result when the scanning disc aperture arrangements are different for each of the interfering channels simultaneously in operation.

The scanning disc shown in Fig. 2 has a plurality of apertures arranged to successively scan adjacent line series of elemental areas and the apertures in this case are arranged in a uniform spiral. This uniform spiral arrangement of the apertures is only one of a number of arrangements which may be used. The scanning disc shown in Fig. 3 has a plurality of apertures arranged to successively scan non-adjacent line series of elemental areas. An essential requirement in this type of apparatus is that the arrangement of the relative positions of the apertures of the scanning discs of two or more systems be such that successively scanned lines are in different positions and are preferably widely separated for the different systems between

which interference may occur. The specific arrangement of the apertures as here shown for the two scanning discs with relation to each other in part is as follows: Considering the angular position of the apertures in the order as numbered on the scanning disc in Fig. 2, aperture in position No. 1 in Fig. 3 has a radial distance from the center of the disc the same as that of aperture No. 4 in Fig. 2, aperture in position No. 2 in Fig. 3 the same as that of No. 11 in Fig. 2, aperture in position No. 3 in Fig. 3 the same as that of No. 18 in Fig. 2, aperture in position No. 4 of Fig. 3 the same as that of No. 1 of Fig. 2, etc., as indicated by these two figures. A complete comparison between the angular positions of the apertures and their radial positions as indicated on the scanning discs in Figs. 2 and 3 is given in Fig. 7. The numbers on the left-hand side of Fig. 7 indicate the annular positions from the point of reference at the top of the scanning discs of Figs. 2 and 3. The numbers at the right-hand side of Fig. 7 indicate the interchange or scrambling of the radial positions for each angular position following the arrangement in Fig. 3. Other arrangements of the positioning of the apertures or the order of scanning to break up interference between images may obviously be made in any suitable manner. If either of the scanning discs shown in Figs. 2 and 3 is used at the terminal apparatus of each of the stations T_1 , R_1 , T_2 and R_2 of Fig. 1, the received main and cross pick-up images are as shown in Fig. 6, while if the scanning disc shown in Fig. 2 is used at the terminal apparatus T_1 and R_1 and the scanning disc as shown in Fig. 3 is used by the terminal apparatus T_2 and R_2 the received main image and the cross pick-up effect are as shown in Fig. 7. In Fig. 7 the faintly reproduced crosstalk elemental areas of Fig. 5 are equal in number to the elemental areas of Fig. 5, but are differently positioned. Two of them are superimposed upon the lower line of elemental areas in the main image at line position 22 of the image field and are therefore not distinctively visible in the drawing. These superimposed cross pick-up elemental areas occur at position 7 from the left and 7 from the right side of the image area.

The numbers shown at the left of Figs. 4, 5, 6 and 7 represent the scanning lines of the apertures 1 to 24 in the scanning disc of Fig. 2, while the numbers at the right of Fig. 7 represent the scanning lines as successively produced by the apertures in the scanning disc shown in Fig. 3.

It is obvious that the principle of making the received cross pick-up interfering effect unintelligible as set forth herein may be carried out by various modifications of the scanning operation without departing from the principles of this invention. It should be noted too that in one aspect this invention

permits the secret transmission of images, in that a station such as R_1 , Fig. 1, not equipped with a scanning disc such as those used at the terminals of the specially equipped system such as $T_2 R_2 L_2$ can not pick up currents from the latter which will produce an intelligible image. Likewise a system such as $T_2 R_2 L_2$ can not be successfully "tapped" with ordinary television apparatus. If it were desired to maintain secret transmission over $T_2 R_2 L_2$ the arrangement of apertures could be kept secret and also changed at will by substituting different discs if desired.

In case the interfering systems or channels are part of the same general system and it becomes desirable to enable each terminal station or radio station to communicate with each other such station, a plurality of discs may be made available at each station so that a choice of discs may be made such that communication with any desired station and reduction of cross-interference effects in interfering channels may both be effected. In such case all receiving sets and all transmitting sets may be similar in every respect except the scanning discs.

What is claimed is:

1. An electro-optical image producing system comprising means for causing image currents produced in said system by an interfering image wave to set up in the image field of said system an effect which bears little or no resemblance to the interfering image and is unintelligible, said means comprising moving scanning members for respectively setting up and utilizing desired incoming image waves, said interfering wave being set up by a system similar to that in which interference is set up except for the arrangement of the apertures of the scanning members.

2. In an electro-optical image producing system comprising a plurality of channels, means for scanning successively the elemental areas of an image field in one order for one of said channels of said system and means for scanning successively the corresponding elemental areas of another similarly shaped image field in a different order for another of said channels of said system, the orders being such that the image currents for transmission over one channel can produce only unintelligible images in the receiving terminal apparatus of the other channel.

3. In an electro-optical image producing system, equipment for two-way television over separate transmission channels, means for scanning successively the elemental areas of the image field in one order for one direction of transmission and in a different order for the opposite direction of transmission, the orders being such that the image currents for transmission in one direction can produce only unintelligible images in the equipment for transmission in the other direction.

4. In an electro-optical image producing

system, two channels located in such proximity to one another that image currents in one channel produce interfering currents in the other channel, scanning discs for one channel having scanning apertures arranged in a single spiral for scanning adjacent lines successively, and scanning discs for the other channel synchronized with those of the first channel and having apertures arranged so that successively scanned elemental areas are widely separated, whereby interfering currents in either of the channels can produce only unintelligible images.

5. An electro-optical system arranged for simultaneously producing electrically a plurality of different images respectively of different fields of view of the same shape, and means for rendering unintelligible an interference effect which may be superimposed upon one of said images by interference energy set up by the image currents used in the production of any other image.

6. An electro-optical system having a plurality of channels and arranged for simultaneously transmitting and producing electrically a plurality of different images respectively of different fields of view of the same shape, and scanning means comprising moving apertured members and arranged to diversify the order of the scanning of the elemental areas of said fields of view so that the scanning order is substantially different in any channel from that of any other channel.

In testimony whereof, I have signed my name to this specification this 12th day of July, 1928.

HARRY NYQUIST.