

INVENTOR
FRANK GRAY
By *C. G. Sprague*
ATTORNEY

April 5, 1938.

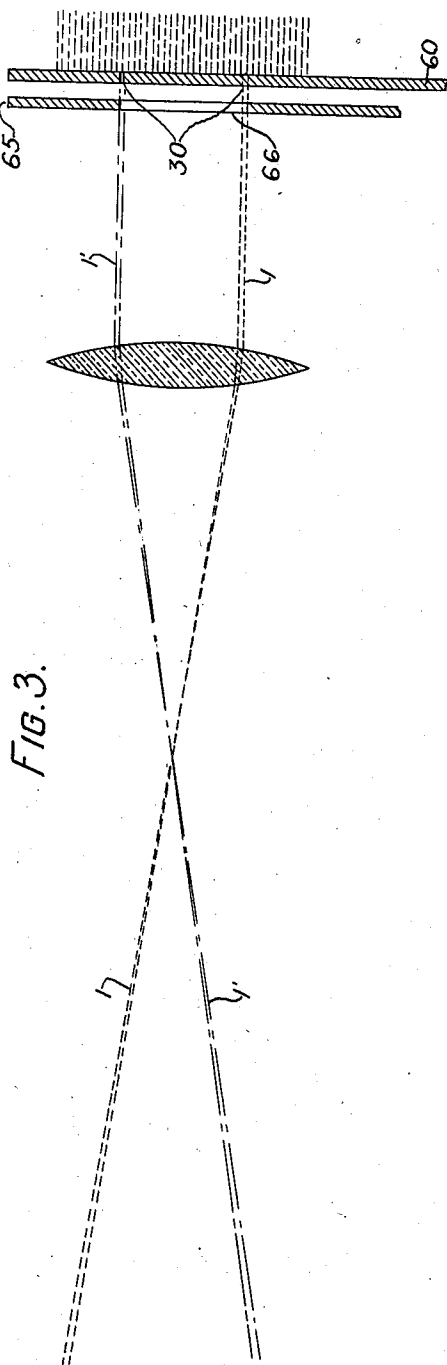
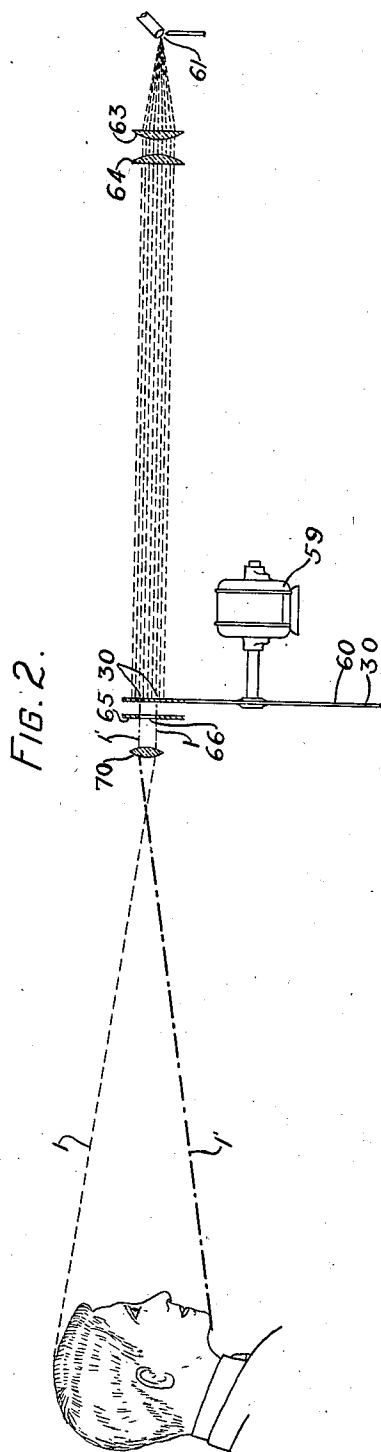
F. GRAY

2,113,254

TELEVISION SYSTEM

Filed Oct. 21, 1927

4 Sheets-Sheet 2



INVENTOR
FRANK GRAY
BY *C. E. Sprague*
ATTORNEY

April 5, 1938.

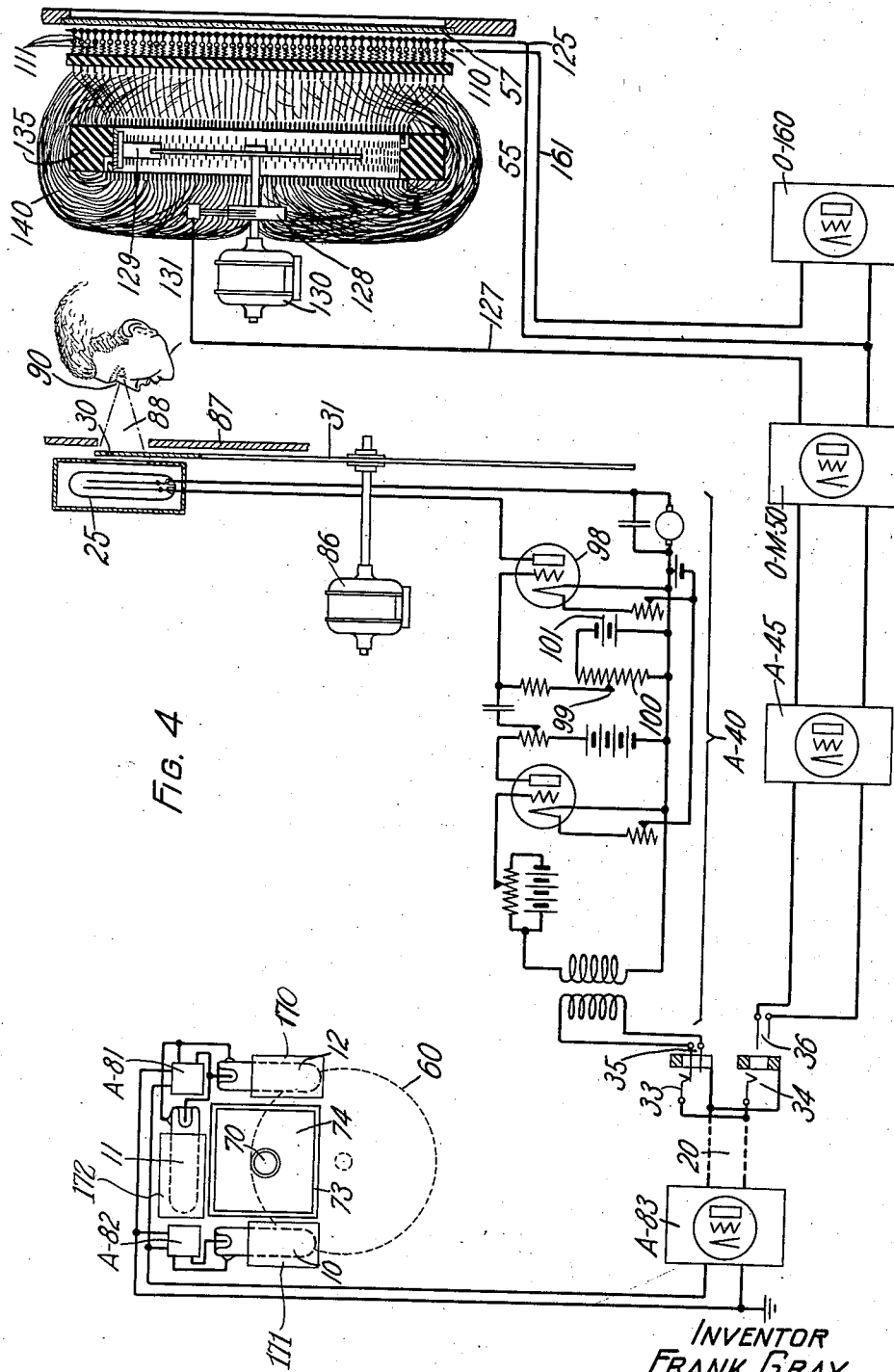
F. GRAY.

2,113,254

TELEVISION SYSTEM

Filed Oct. 21, 1927

4 Sheets-Sheet 3



INVENTOR
FRANK GRAY
By *C. H. Sprague*
ATTORNEY

April 5, 1938.

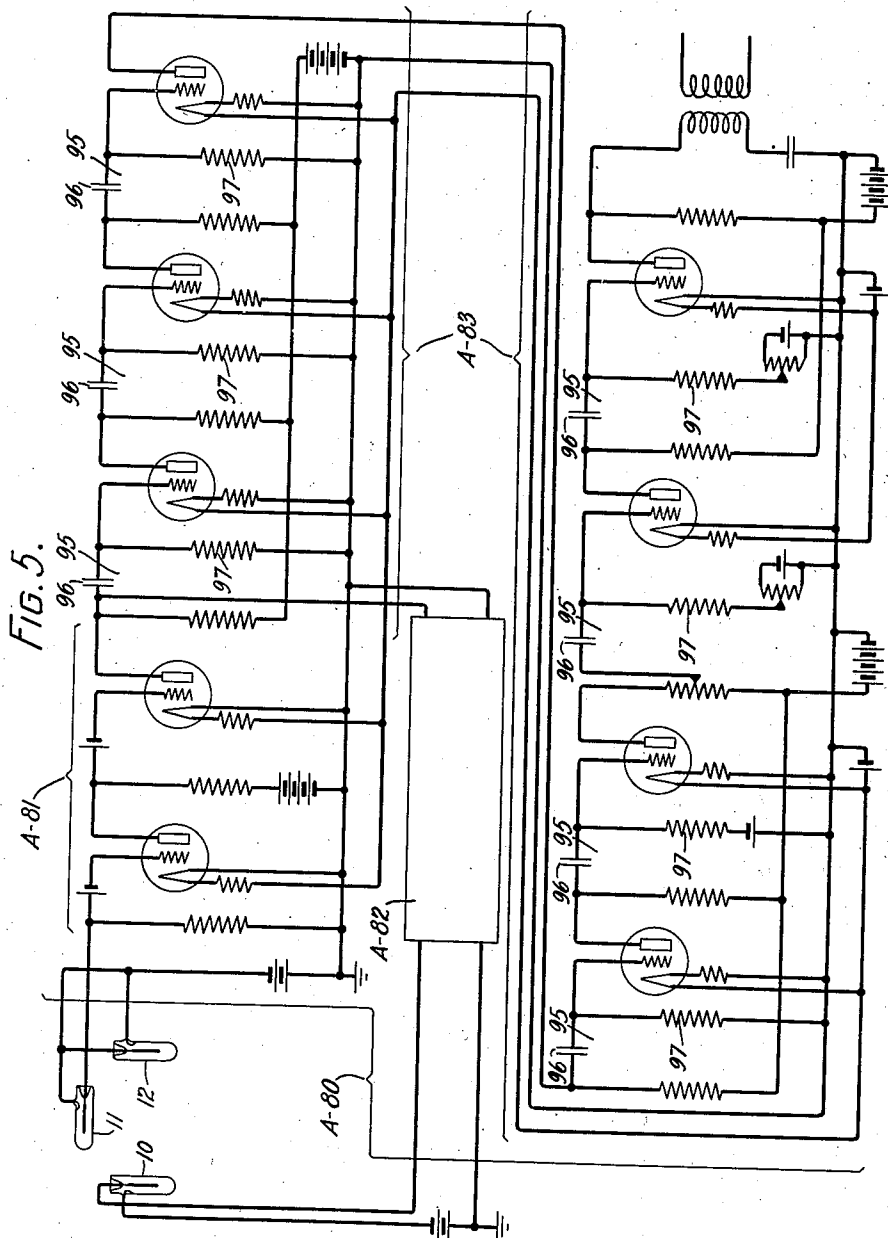
F. GRAY

2,113,254

TELEVISION SYSTEM

Filed Oct. 21, 1927

4 Sheets-Sheet 4



INVENTOR
FRANK GRAY
By *C. E. Sprague*
ATTORNEY

UNITED STATES PATENT OFFICE

2,113,254

TELEVISION SYSTEM

Frank Gray, New York, N. Y., assignor to Bell
Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application October 21, 1927, Serial No. 227,649

18 Claims. (Cl. 178—7.1)

This invention relates to the art of television and more particularly to methods of and apparatus suitable for scanning three dimensional objects.

5 The problem of television of three dimensional objects is to be distinguished from the problem of telephotography or the electrical reproduction of pictures at a distance, and the extension of that problem that is concerned with the production of
10 motion pictures from a motion picture film run at a distant point. These problems involve the scanning of a plane surface on which is the picture whose likeness is to be reproduced at a receiving point. They do not involve the complications
15 incident to shadowing of portions of the field by other portions as does the problem of television of three dimensional objects.

In attempting television of three dimensional objects, either stationary or moving, the tendency
20 has been to follow the practice of telephotography and first to produce through an optical system an image of the object in a focal plane and to scan the focal plane in which the image of the object appears rather than the object itself. This
25 appeared to be the best solution of the problem.

The general object of the present invention is to do away with defects inherent in the focal plane system of viewing. It reverses previous practice, in that, instead of illuminating the object with a
30 flood of light such as is produced by ordinary illumination, forming an image on the plane surface and scanning this surface point by point, the object is by this invention illuminated point
35 by point by a thin concentrated beam of light of great intensity which because of the great rapidity with which it sweeps the object causes no discomfort or inconvenience.

The use of a moving beam of light for scanning a plane fixed surface, the reflected light being
40 directed therefrom to light sensitive means of the selenium cell type, has previously been proposed for picture transmission and like problems for the purpose of decreasing the effect of lag of the cell, but no one has heretofore employed a moving
45 beam of intense light to scan three dimensional objects or fields, in which case the problem of proper intensity, direction and mode of illumination is relatively complex, especially when the object scanned is a person's face. The suitability
50 for this purpose of the principle of light beam scanning was not appreciated until the discovery was made that the optical effect is the same as though the light were being emitted by the light sensitive surface and the field were
55 being viewed from the point from which the beam

of scanning light emanates. With this discovery as a starting point it became possible to perfect a practical and reliable television system. Among the features of this system are: an arrangement utilizing the space-discharge type of
5 light sensitive cell, which is relatively insensitive but free from lag; the distribution of the light sensitive surface so as to give the effect of proper illumination; elimination of the lens system between the field scanned and the light sensitive
10 surface, thus permitting the surface to be properly located and greatly extended when necessary; a beam of scanning light of such concentration that the subject might be injured if illumination of this strength were continuously
15 applied.

The following is a detailed description of a television system embodying the invention and illustrated in the accompanying drawings.

Fig. 1 is a perspective showing of the apparatus
20 at the transmitting and receiving ends of the system, with a diagrammatic showing of the circuits connecting the apparatus; Fig. 2 is a diagrammatic longitudinal view of the optical system of the scanning apparatus at the transmitting
25 end of the system of Fig. 1 partly in cross-section; Fig. 3 is a similar showing of a portion of the optical system of Fig. 2, drawn to a larger scale; Fig. 4 is a circuit diagram of the system of Fig. 1, with reproducing apparatus at the receiving
30 end of the system shown in cross-sectional side elevation; and Fig. 5 is a diagram of the circuits at the transmitting end of the television system, including means for amplifying electrical
35 variations produced in the photoelectric cells.

Referring to the drawings and especially to Fig. 1, the subject or object 5 to be pictorially represented is positioned in front of the cabinet 73 which contains screened compartments 75 in which are located the large photoelectric cells
40 10, 11 and 12 (see also Figs. 4 and 5). An intense beam of light (preferably slightly converging for the purpose of conserving light) from arc lamp 61 is directed, by means of the optical system shown in detail in Figs. 2 and 3, upon a small
45 area of the scanning disc 60 in alignment with the subject 5. This disc has a series of very small circular apertures arranged near the periphery in the form of a spiral through which, one at a time, a portion of the beam from the
50 arc passes in the form of a thin beam which is caused to pass through opening 74 in cabinet 73 and to sweep horizontally across the subject or object 5, successive apertures thus scanning
55 adjacent horizontal paths. The subject is com-

pletely scanned about 16 times per second. A portion of the diffusely reflected light falls upon the photoelectric cells and sets up photoelectric currents which are amplified by amplifier A—83. The amplified current is impressed upon the line 20. At the receiving station there are provided two image producing devices 91 and 56, the former being designed to produce a small image to be viewed at close range by one person, and the latter, to produce a large image suitable for presentation before an audience. Either or both of these may be associated with the line 20 through multiple jacks 33 and 34. Devices 91 and 56 may be located at the same or different stations. Device 91 may, if desired, be used for monitoring incoming currents.

The image producing apparatus 91 contains a neon glow lamp 25 to which current from amplifier A—40 is supplied (see Fig. 4). Light from this lamp illuminates small circular apertures 30 in a large disc 31 similar to disc 60, these apertures moving synchronously with the spots of light produced on the subject 5 by corresponding apertures in disc 60. Since complete images are formed at the rate of 16 per second, the subject can be seen in motion. For a more detailed description of this viewing arrangement reference is made to Patent Number 2,037,471 to H. E. Ives and Frank Gray. Amplifier A—45, in conjunction with an oscillator and modulator O—M—50, operates receiving apparatus 55, described herein-after.

The system will now be described in greater detail on the assumption that plug 35 is in jack 33 and plug 36 is removed from jack 34, as indicated in the drawings, so that the glow lamp 25 is in use and the receiving apparatus 56 is not in use.

Specific values of dimensions and constants mentioned below are given by way of example, and the invention is not limited thereto.

At the transmitting end of the system the 14" diameter disc 60 is rotated by a motor 59 at a speed of 16 times per second. This disc has a series or row of 50 small circular apertures 30 arranged in the form of a spiral extending around the disc near its rim. The apertures are .026" in diameter and have equal angular spacings around the disc and a 1/50" spacing in a radial direction. Light from an arc 61 in a metallic housing 62 passes through an opening in the housing and is directed onto the disc by two plano-convex lenses 63 and 64, each of three inch diameter. There is thus produced a slender, intense beam of substantially parallel light rays through each aperture as the aperture moves across the illuminated area. See Fig. 2, which is drawn on a reduced scale, and Fig. 3, which is full scale. A screen 65 of opaque material in front of the disc contains a rectangular opening 66, about 1 inch by 3/4 inch, that permits light to pass from one aperture only at a time, the distance between the apertures being equal to the width of the opening 66 and the radial width of the spiral of apertures being equal to the height of the opening. A double convex lens 70 of two inch diameter and three inch focal length forms an image of the moving apertures on the subject 5. As a result of this arrangement, the subject is completely scanned in a series of successive parallel lines by a rapidly moving spot of light once for each revolution of the disc, and, on account of the transient nature of the illumination, the man whose face is being

scanned is scarcely aware that he is being exposed to the scanning light.

The subject may conveniently be about three feet from the lens 70. It is not necessary that the subject be at the exact position of the aperture images. The optical system is such that the slender beams of light sweeping across the region in front of the lens 70 just barely overlap each other. In this respect, within wide limits no confusion results as the subject moves toward or away from the lens. In Figs. 2 and 3 the beam 1 is the beam coming through the outermost aperture of the disc and the dotted lines 1' show the beam which will be formed by the innermost aperture of the disc.

The cells 10, 11 and 12 are shown arranged one at the top and one at each side of a rectangular metallic casing 73 which has a rectangular opening 74 through its central portion, for passage of the scanning beams, such as 1 and 1', from the lens 70 to the subject 5. The photoelectric cells may be of the type disclosed and claimed in Patent Number 1,942,501 to G. R. Stilwell. Each cell is a cylindrical glass tube about 15" long and 3" in diameter. The photo-sensitive surface in each cell extends over about half the area of the cylindrical surface of the cell. The cell has an aperture about 3" x 15" so that the whole of the large photo-sensitive surface is effective, and the cell does not require the use of an auxiliary system to condense the light to which the photo-sensitive surface is to be exposed. The light reaches the photo-sensitive surface of the cell through screened openings 75 in the front wall of the case 73. The walls of the case are double, being composed of iron sheeting lined with copper, with a layer of wool felt between the iron and the copper. The case not only shields the cells from light other than that entering from the screened openings 75 in the case, but also shields the cells and conductors which connect them in circuit from extraneous electrical disturbances. If desired, the character of the reflected light may be modified by placing screens or light filters 170, 171 and 172 between the subject and the photo-electric cells 10, 11 and 12 for the purpose of changing the character or tone value of the received picture. For example, if the light is too rich in dark blue, a yellow screen will change the characteristic to produce a more satisfactory picture.

It was rather evident that this method of scanning with a moving beam of light gives a good reproduction of a plane surface or its equivalent such as a transparent picture, photograph or painting. It did not appear however that it would be suitable for a three-dimensional subject until the discovery was made that the system is the same as if all the rays of light were reversed in direction. The generated picture current is exactly the same as if:—each photo-electrical cell were replaced by a lamp to throw an intense illumination on the subject; the image of the subject formed on the disc by the lens 70 were scanned by the moving apertures; and the light passing through the lens fell on a photoelectric cell placed in the position of the arc. It may be shown that not only is there reversibility geometrically but that the light intensities involved at any instant are also reversible; that if light incident to an element of surface in a given direction contributes a definite fraction of its value to light leaving the surface in another direction, then light passing to the surface in the

second direction will also contribute the same fraction of its value to light leaving the surface in the first direction. With this reversed but equivalent optical system in mind, the following characteristics of the television apparatus may readily be understood.

The lights and shadows seen on the subject are the same as if the illumination came out of the photoelectric cell and the observer were looking at the subject from the direction of the lens 70. The size of the transmitted image decreases as the subject moves away from the lens 70. The brightness of the image, however, is determined entirely by the distance of the subject from the photoelectric cells and bears no relation to the distance from the lens 70. For subjects, such as the human face, that reflect very little photo-active light, the cells may conveniently be used at a distance of about three feet from the subject.

The photoelectric currents generated by the photoelectric cells are substantially proportional to the intensity of the reflected light received from the subject, and are amplified at the transmitting end of the system by an electric space discharge amplifying means A—80 as shown in Fig. 5. The amplifying means A—80 comprises two similar two-stage amplifiers A—81 and A—82, and a seven-stage amplifier A—83 fed by the amplifiers A—81 and A—82 in parallel. The amplifier A—82 has its input circuit connected to the photoelectric cell 10, and the other two photoelectric cells are connected to the input circuit of amplifier A—81 in parallel with each other. By thus using two separate amplifiers to furnish the initial stages of amplification, the conductors of the portion of the circuit between the photoelectric cells and the output side of the second stage of each of the amplifiers A—81 and A—82 can be made very short in spite of the fact that the cells are 15" long. Therefore, the electrical pick-up of extraneous disturbances can be kept small for that portion of the circuit or until the signals have been amplified to a considerable power level. In order that the conductors connecting the photoelectric cells to the amplifiers A—81 and A—82 may be as short as possible, as indicated in Fig. 4, the amplifier A—82 is located in case 73 directly above the photoelectric cell 10 which feeds it, and the amplifier A—81 is located in the case 73 above one of the other photoelectric cells 12, and consequently at the adjacent ends of the photoelectric cells 11 and 12.

The efficiency that must be secured in a scanning system is determined by three factors: the amount of detail that is to be transmitted, the sensitivity of the light sensitive cell, and the inherent limit set by noise current produced by thermal movement of electrons in the resistance or other coupling member which must be used to couple the cell to an amplifier. The first factor, the amount of detail that is to be transmitted, decides the elemental area from which light may be collected at any one instant. In the system of television herein disclosed the scene is scanned in a series of fifty lines, and, at any one instant, light can be collected from only

1
2500

of the view. The second factor is determined by the sensitivity of the photoelectric cell. The gas-filled space discharge photoelectric cell is the most sensitive cell capable of following rapid

variations in light intensity without a time lag. Measured in terms of the electric current produced for a given luminous flux, this type of cell does not have the efficiency of certain sluggish types of cells, notably selenium. In accordance with the present invention the space discharge type of cell is made available for television of objects which are likely to be injured by continuous intense illumination, the effective sensitivity of the cell being pushed up to such a relatively high value that the limitation set by the thermal agitation of the electrons (the third factor mentioned above) is overcome.

When the attempt was made by the present inventor to obtain television images by the method of lighting and scanning the subject involving so-called flood lighting (the only method which then appeared practical), no image could be obtained. The image field resembled a snow storm through which the image could not be discerned. It was found that this effect was due to the noise current set up in the resistance employed to couple the photoelectric cell to the amplifier and that when the resistance was increased to increase the voltage impressed upon the amplifier, the current resulting from the thermal agitation of the electrons increased at the same rate. In other words, the image currents from the cell were so minute as to be comparable with the noise current set up by the thermal agitation of the electrons in the resistance. It was discovered that this was not due to the fact that larger currents could not be obtained with the cell but to the fact that sufficient illumination of a subject being scanned could not be utilized. In the flood lighting system of illumination and scanning, an image of the object is formed upon the scanning disc by means of a lens or lens system. The efficiency of the system is ultimately limited by the aperture of the lens. Moreover the rapidity of scanning demands a small image and consequently a small focal length lens. The matter of efficiency in this case comes back to that of the familiar limit of the ratio of aperture to focal length in practical lens construction. Experiments show that, with the best f/1.9 lens available to form an image that is to be scanned in fifty lines, it would be necessary to illuminate the subject with a 16,000 candle-power arc at a distance of four feet in order to secure enough current output from a space discharge photoelectric cell to raise the photoelectric current level above that of the noise current produced by thermal agitation in the resistance or other element employed to couple the cell to the amplifier. It therefore seemed hopeless to attempt to use a photoelectric cell of the space discharge type in a system of this kind. Therefore a thiosulphide cell was used, which is much more sensitive than a photoelectric cell but is objectionable because of the time lag. With such a cell it was just possible to obtain an image with all the light upon the subject that could be used without danger of injury to the eyes. When the amount of light was reduced the above mentioned snow storm effect immediately occurred.

In accordance with the present invention the necessity for placing a lens or lens system between the light reflected from the subject and the photoelectric cell is eliminated. A distribution of the photoelectric surface around the subject to obtain desired lighting effects is made, the system behaving in this respect as though the light were emanating from the photoelectric surface, as explained above, although the light

is being obtained from a forty ampere Sperry arc on the other side of the scanning disc and optical system. A very intense illumination may be used without danger of injury to the subject and the optical efficiency of the system is not limited by the aperture of a lens but may be increased by using large photoelectric cells and more than one cell connected in parallel. With three photoelectric cells which present an area of forty square inches, which is utterly beyond the aperture of any lens that might be used to form an image, the cells give an electrical output that though still extremely small, is safely above the level of the current produced by thermal agitation.

In practice it is not necessary that the rays illuminating the rotating disk 60 be parallel. If the rays are not parallel the small beam of light emerging from the aperture will in general be divergent. The principle of operation however remains the same. That is, the light from a source is utilized to form a beam emerging from a plane upon which the image of three dimensional objects within the field of view would be formed by the lens 70 if the objects were illuminated as a whole (the arrangement of lens and image plane with respect to the object being like that in a camera) and a beam emerging from the image plane is caused to pass through the lens to the field where it illuminates an elemental area and is rapidly and repeatedly moved over the elemental areas of the field in succession. Efficient illumination can be secured by arranging the system so that the condensing lens 63, 64 throws an image of the light source 61 in the vicinity of the lens 70.

The picture current arriving at the receiving end of the system is amplified in an electric space discharge amplifier A—85 which feeds the neon glow lamp 25 located directly behind the disc 31 which is like the disc 60 at the transmitting end of the system, except larger. The disc 31 is rotated by a motor 86 so that the apertures in the two discs are in synchronism. Any suitable means, not shown, may be used to maintain the discs in synchronism, such, for example, as the arrangement disclosed in a copending application of H. M. Stoller and E. R. Morton, Serial No. 181,314, filed April 6, 1927. In front of disc 31 is an opaque screen 87 having an opening 88 two inches by two and one-half inches through which the apertures in the disc 31 are viewed by the receiving operator or observer 90, the size of the opening being such that only one aperture at a time can be in the field of view. The glow lamp 25 may be of any suitable type having a light radiating area slightly larger than the field of view on the disc 31 or of sufficient size to cover the opening 88, and the radiating area may be made of sufficient size either by making the glowing elements of the lamp itself of proper size or by having the lamp illuminate a ground glass or other surface of the proper size. Preferably, the lamp 25 is of the type disclosed in my Patent Number 1,865,516, in which the cathode is slightly larger than the field of view of the disc, and the glow discharge covers the entire front surface of the cathode. The two inch by two and one-half inch television field illuminated by light coming through the moving apertures, is viewed through the opening 88 from in front of the disc without the aid of any optical system. The observer 90 sees at any instant a single aperture in the same relative position as the spot of light on the subject 5 at the transmitting

end of the system, and the brightness of the aperture corresponds to the amount of light reflected from that particular element of the subject. On account of the persistency of vision the observer consequently sees an apparent image of the subject on the front surface of the disc. The front surface of the neon lamp may be frosted so that the image can be seen even at a wide angle from the normal to the disc. To avoid undue annoyance from the sound of motor hum, the entire receiving apparatus is enclosed in a felt lined wooden case 91 shown in Fig. 1, and an observer views the picture through a large aperture 92. The picture can easily be seen in even a lighted room. The line structure that otherwise would appear in the pictures is practically eliminated by making the apertures in the receiving disc overlap each other. They are one-sixteenth inch in diameter or about one-fourth greater than the one-twentieth inch separation between the lines. With this overlap the line structure can scarcely be seen.

The system herein shown and described makes use of an invention disclosed and claimed in Patent Number 2,037,471 to H. E. Ives and F. Gray. Very briefly stated this comprises suppressing the direct current and very low frequency components at the transmitter and compensating at the receiver for the effect of the suppression of the direct current component in such a manner as to give the desired tone values to the images produced at the receiver. Each object viewed presents a mean degree of illumination productive of the mean direct current value in the photoelectric cells 10, 11 and 12 upon which is superposed a pulsating current produced by the point by point variations in the reflective power of the object. This mean direct current or direct current component will not have a constant value but will change from time to time during transmission as the general aspect of the field or views changes, rising with a greater proportion of bright areas in the field and falling with an increasing proportion of dark areas. Furthermore, as is disclosed in the above mentioned patent, it was found that when an amplifier having a large number of stages was employed, small slow changes in the potentials of the batteries used in connection with the first stages of the amplifier were so greatly amplified as to introduce prohibitive bias in the final stages of the amplifier and by suppressing the direct current component by means inserted in one of the earlier stages of the amplifier, it becomes possible to transmit television current over a commercial telephone line which is not designed to carry direct current or very low frequencies and also to eliminate the distortion introduced by amplification of the slow potential variations of the amplifier batteries. The suppression is brought about by condenser 96 in the output of the second stage of amplification which is so designed that it gives a gradual cut-off of frequencies below 10 cycles. The condensers 96 in the remaining stages may be proportioned to give a similar effect or if suppression is accomplished sufficiently well by the first condenser the other condensers may, if desired, be larger. In general, the amplifier is of the type embodying resistance-condenser coupling by virtue of the use of condensers 96 and resistances 97.

The photoelectric cells 10, 11 and 12 are so connected in the input circuit of amplifier A—81 that the anode rather than the cathode is connected to the grid of the amplifier and the cath-

ode is connected through the photoelectric battery to ground, thus avoiding the large capacity between the cathode and ground which would be present if a direct connection were not provided.

At the receiving end a direct current component is inserted by operating the tube 98 about a current value near the center of the operating point of its characteristic curves, and varying the operating point of the characteristic curve of the tube 98 to insert the correct direct current component. To accomplish this variation the receiving operator varies the negative grid potential of the tube 98 by means of a contact 99 connected to the grid of the tube and movable along resistance 100 in circuit with battery 101 which has its positive pole connected to the filament, and by adjusting the potentiometer in the output of the first stage of the amplifier to maintain the correct amplitude of the impressed voltages. For a more detailed discussion of this adjustment reference is made to the above mentioned Patent 2,037,471 to H. E. Ives and F. Gray.

In viewing a subject it is not necessary to shield the subject from any steady illumination, such as daylight or the light from the usual incandescent lamps. Since the alternating current transmission circuits transmit only the currents corresponding to variations in light intensity, and additional steady illumination produces no effect on the received currents, the apparatus can be used when the subject is in a well lighted room just as well as if the subject were shut up in a dark room while being scanned by the moving spot of light.

Each of the amplifiers A-81 and A-82 is carefully protected against picking up extraneous electrical and mechanical disturbances. For example, to guard against electrical disturbances the amplifiers are included in copper shielding cases within the case 73, which is of sheet iron lined with $\frac{1}{16}$ " copper; and the first vacuum tube of each amplifier is enclosed in a copper cylinder as described below. As a protection against sound disturbances and mechanical jars, the amplifier cases are supported within the double walled case 73 on felt and rubber pads and the latter case is deadened to sound coming through the air by a layer of felt between its iron and copper walls. Particular attention is paid to the vacuum tube of each amplifier, fine leads being soldered to it directly to avoid the use of a socket. The tube is suspended by these leads in a glass container stopped up air tight. The container is packed with cotton inside of the $\frac{1}{16}$ " copper cylinder, suspended by a single rubber band, and left free to swing like a pendulum. The swinging is damped by a single piece of rubber tape dragging on the mounting below. In addition to the above precautions, the disc 60 and driving motor 59 are enclosed in a felt lined steel cabinet 105, shown in Fig. 1, to protect the amplifier A-80 from electrical disturbances and the high frequency hum coming from the motors.

Instead of using the single stationary source of light 61, small lamps (not shown) can be attached to the disc 60, one behind each aperture in the disc, so that a beam of light emerges from each aperture. This modification is disclosed and claimed in my Patent No. 1,957,953.

By withdrawing plug 35 from jack 33 and inserting plug 36 in jack 34 the amplifier A-40 and receiving glow lamp 25 are cut out of circuit and the picture current arriving at the receiving end of the system is delivered to the amplifier

which feeds into the oscillator and modulator device O-M-50. The device generates a high frequency current, which is modulated by the picture current from the amplifier A-45. The wave from device O-M-50 is applied to the receiving or reproducing device 55, which may be termed a grid glow lamp since it comprises a long neon-filled tube 110 having say fifty parallel sections 111, which form rectangular surface on which an image of the subject 5 is seen when the picture current modulated high frequency wave from the oscillator-modulator is applied to the tube 110. The sections 111 are shown as horizontal and may be, say, 22 inches long and one-half inch in diameter, and spaced about one-sixteenth inch apart. Each section has an internal electrode in the form of a wire helix, extending throughout the length of the section and has, say, 50 external tin foil electrodes cemented along the back of the section adjacent edges being separated by about one-sixteenth inch. Each electrode extends about half way around the section. The internal electrodes are all connected by a conductor 125 to one of the output terminals of oscillator-modulator O-M-50, which has its other output terminal connected by a conductor 127 and slip ring 128 to a commutator brush 129 driven by a motor 130 and maintained in synchronism with the disc 31 by any suitable means (not shown). The brush sweeps over the segments such as 131 of the commutator 135. Each segment is connected through a conductor such as 140 to an individual one of the external electrodes of tube 110. There are 50 times 50 or 2500 of these electrodes and consequently 2500 commutator segments 131 and 2500 of the conductors 140. As the brush 129 contacts with a segment connected to any given electrode the area in front of that electrode glows with an intensity dependent upon the magnitude of the picture current modulated wave from oscillator-modulator O-M-50, or in other words, in accordance with the magnitude of the modulating picture current. Consequently, since the brush is in synchronism with the moving spot of light produced on the subject 5 by the scanning beam, due to persistence of vision an apparent image of the subject is seen on the grid 110 or on a ground glass viewing screen 57 preferably positioned in front of the grid as the front of the housing 56 shown in Fig. 1.

The frequency of oscillator O-M-50 may be for example 1,000,000 cycles per second.

In order to continuously energize each of the sections 111, an oscillator O-160 having a frequency of for example 1,500,000 cycles per second has one of its output terminals connected to each of the internal electrodes of tube 110 by the conductor 125 and has its other output terminals connected by a conductor 161 to a tinfoil strip cemented to the exterior of each section at one end of the section. This constant excitation of the grid substantially eliminates any lag in the response of the grid when the individual external electrodes are energized by the signal currents.

The grid glow lamp and the associated commutator and high frequency circuits are disclosed in greater detail, and claimed, in my Patent No. 1,759,504 and Patent No. 1,707,486 to A. W. Kishpaugh.

Although there is at present a very great advantage in omitting lenses between the object scanned and the light-sensitive surface, it is possible that lenses could be made of such size as

to accomplish, in part at least, the function of the enlarged light-sensitive surface, thus permitting smaller cells to be used, but at increased cost of apparatus. Other advantages of applicant's improved method and system would still be present and the invention is not limited, except in a narrow aspect, to the omission of this lens system.

The term television as used herein is intended to include the recording of the successive images produced at the receiver as well as viewing them as they are formed. The term light is used in its broader sense to cover waves of frequency above and below those to which the human eye responds as well as those within the so called visible spectrum.

This application is a continuation in part of the copending application Serial No. 181,538, filed April 6, 1927 which in turn is a continuation of application Serial No. 111,731, filed May 26, 1926.

What is claimed is:

1. Television apparatus for scanning a three dimensional field of view comprising a light source, means including said light source for producing a single moving beam of light for successively and rapidly illuminating elemental areas of three dimensional objects in said field of view, and means for utilizing light reflected from said objects to set up image currents comprising a plurality of means spaced apart for simultaneously receiving light reflected in such widely different directions that the image currents produced are representative of said objects illuminated from separate light sources.

2. Television apparatus comprising means for generating and moving a single beam of light progressively over a field in which different surface elemental areas therein to be scanned are differently oriented to successively and repeatedly illuminate the elemental areas of said field, and means for gathering light reflected from the field thus illuminated and utilizing it for setting up separate and distinct image currents comprising a plurality of light receiving means for simultaneously receiving reflected light from materially different directions respectively.

3. The method of television which comprises repeatedly moving a single narrow beam of light progressively over a field in which different elemental surface areas therein to be scanned are in differently oriented planes and at different distances from the source of light, gathering light reflected from the field thus fractionally illuminated upon a plurality of light receiving means spaced apart, and utilizing the received light to set up image currents which are representative of the appearance of said field when illuminated simultaneously from the positions of said light receiving elements and viewed from the position of said source.

4. In an image producing system, means for intensely illuminating a small area of the object at one time and a plurality of such areas successively, means for supplying at said time a constant illumination to the whole area of the object, and means for eliminating the effect of said constant illumination over said whole area.

5. The method of television which comprises illuminating a human subject by rapidly and repeatedly moving a spot of intense light successively over elemental surface areas of said human subject within the period of persistence of vision, the intensity of the light being so great that said subject might be injured if the spot of light were stationary, and utilizing the light reflected from the subject to set up image currents.

6. The method of scanning an optical field for television comprising forming upon the field a moving minute spot of light of great intensity which moves repeatedly over the entire field in a path of minute width compared with the dimensions of said field, the intensity being so great that a person located within the field and being scanned might be injured if light of that intensity were applied and kept stationary.

7. The method of television which comprises repeatedly moving a beam of light progressively and within the period of persistence of vision over a field in which different elemental surface areas therein to be scanned are in differently oriented planes and at different distances from the source of light, gathering light upon two light receiving means spaced apart, utilizing the light received by each of said means to set up image currents individual thereto, causing these currents to be of different value when light is received simultaneously by the light receiving means from an elemental area within the field similarly positioned and oriented with respect to said means, and continuously combining the currents from said light receiving means to set up a composite image current.

8. A television system comprising means for cyclically illuminating in succession and within the period of persistence of vision the elemental surface areas of a field in which different ones of said areas are differently oriented, and means for gathering reflected light throughout wide solid angles directly upon a plurality of light sensitive electric elements spaced apart and respectively forming the bases of said solid angles, and means electrically connecting said elements in parallel to produce a composite image current.

9. A television system comprising means for cyclically illuminating in succession and within the period of persistence of vision the elemental surface areas of a field in which different ones of said areas are differently oriented, said means comprising means for projecting a moving beam of light within the field from a position outside the field, the various paths of said beam being generally divergent from said position, and means for utilizing reflected light from said field to set up image currents comprising light sensitive means upon opposite sides of said light paths and in the general location of the position from which they are projected.

10. The method of television which comprises repeatedly moving a single narrow beam of light progressively and within the period of persistence of vision over a field in which different elemental surface areas therein to be scanned are in differently oriented planes and at different distances from the source of light, and gathering reflected light upon light receiving means which are spaced apart and lie respectively upon two sides of a vertical plane passing through the light source and the center of the field, and utilizing the received light to set up image currents.

11. Television apparatus for scanning three dimensional objects comprising means for successively and repeatedly illuminating elemental areas of objects in a three dimensional field of view, said means comprising light focussing means which would image said field in a plane if the elemental areas of said objects were simultaneously illuminated, means including said focussing means for causing a beam of light to pass from said plane to said focussing means and from there to said field to move said beam to cause it to successively and repeatedly illuminate the

elemental surface areas therein, and means receiving reflected light from said field to set up image currents comprising means for simultaneously receiving light reflected in widely different directions from said field.

12. Television apparatus for scanning three dimensional objects comprising means for successively and repeatedly illuminating elemental areas of objects in a three dimensional field of view, said means comprising light focussing means which would image said field in a plane if the elemental areas of said objects were simultaneously illuminated, means including said focussing means for causing a beam of light to pass from said plane to said field and to move said beam successively and repeatedly over the surface elemental areas therein, said beam being divergent from said plane to said focussing means, means for utilizing light reflected from said field to set up image current comprising light sensitive electric means and a plurality of light collecting and directing means for receiving reflected light from different directions from said field and directing it to said light sensitive electric means, and means for simultaneously supplying a constant illumination to said field as a whole.

13. Television apparatus for scanning three dimensional objects comprising a light source, means including said light source for producing a single moving beam of light for successively and repeatedly illuminating elemental areas of an object in a three dimensional field of view, and means for utilizing light reflected from said object to set up image currents comprising a plurality of light focussing means so positioned as to receive reflected light from materially different directions and light sensitive means for receiving light from said light focussing means.

14. Television apparatus for scanning three dimensional objects comprising a light source, means including said light source for producing a moving beam of light for repeatedly and successively illuminating the objects in a three dimensional field of view, means for utilizing light reflected from said objects for setting up image currents including light sensitive electric means, and means for simultaneously supplying a constant illumination to said field as a whole.

15. Television apparatus for scanning three dimensional objects comprising a light source, means including said light source for producing a moving beam of divergent light for repeatedly and successively illuminating objects in a three dimensional field of view, means for utilizing light reflected from said objects to set up image currents including light sensitive electric means and light directing means of large effective area

compared with that of said light sensitive electric means for receiving light reflected from the objects and directing it to said light sensitive electric means.

16. Television apparatus which comprises a source of light, means for generating and moving a beam of light progressively over a field in which different surface elemental areas therein to be scanned are in differently oriented planes, said beam illuminating one elemental area of said field at each instant, means for gathering light reflected from the field thus illuminated and utilizing it for setting up separate and distinct image currents comprising a plurality of light receiving means spaced apart to respectively receive reflected light from materially different directions, and means for causing the light received upon one of said light receiving means to control the production of image currents of smaller amplitude than the light received upon another of said means, and means for combining said currents to form a composite current which is representative of the appearance of said field when illuminated by a plurality of separate sources of light of different intensity.

17. Television apparatus for scanning three dimensional objects comprising a light source, means including said light source for producing a moving beam of light for successively and repeatedly illuminating elemental areas of objects in the three dimensional field of view, and means for utilizing light reflected from said field in widely different directions to respectively set up a plurality of separate and distinct image currents the amplitude of each of which varies in accordance with the tone values of successively scanned areas, said currents having different relative values at different times but the amplitude variations of the different currents being always in phase with each other.

18. Television apparatus for scanning a field of view comprising a light source, means including said light source for producing a single moving beam of light for successively and repeatedly illuminating elemental areas of objects in said field of view, means for utilizing light received from said field in widely different directions to respectively set up a plurality of separate and distinct image currents, the amplitude of each of which varies in accordance with the tone values of successively scanned areas, means for continuously combining said currents to form a composite image current, and light filtering means in the path of the effective light to modify the character of the image currents and of the image produced at the receiving station.

FRANK GRAY.