Feb. 14, 1933. V. BUSH 1,897,236

SIGNALING SYSTEM

Original Filed Nov. 6, 1928

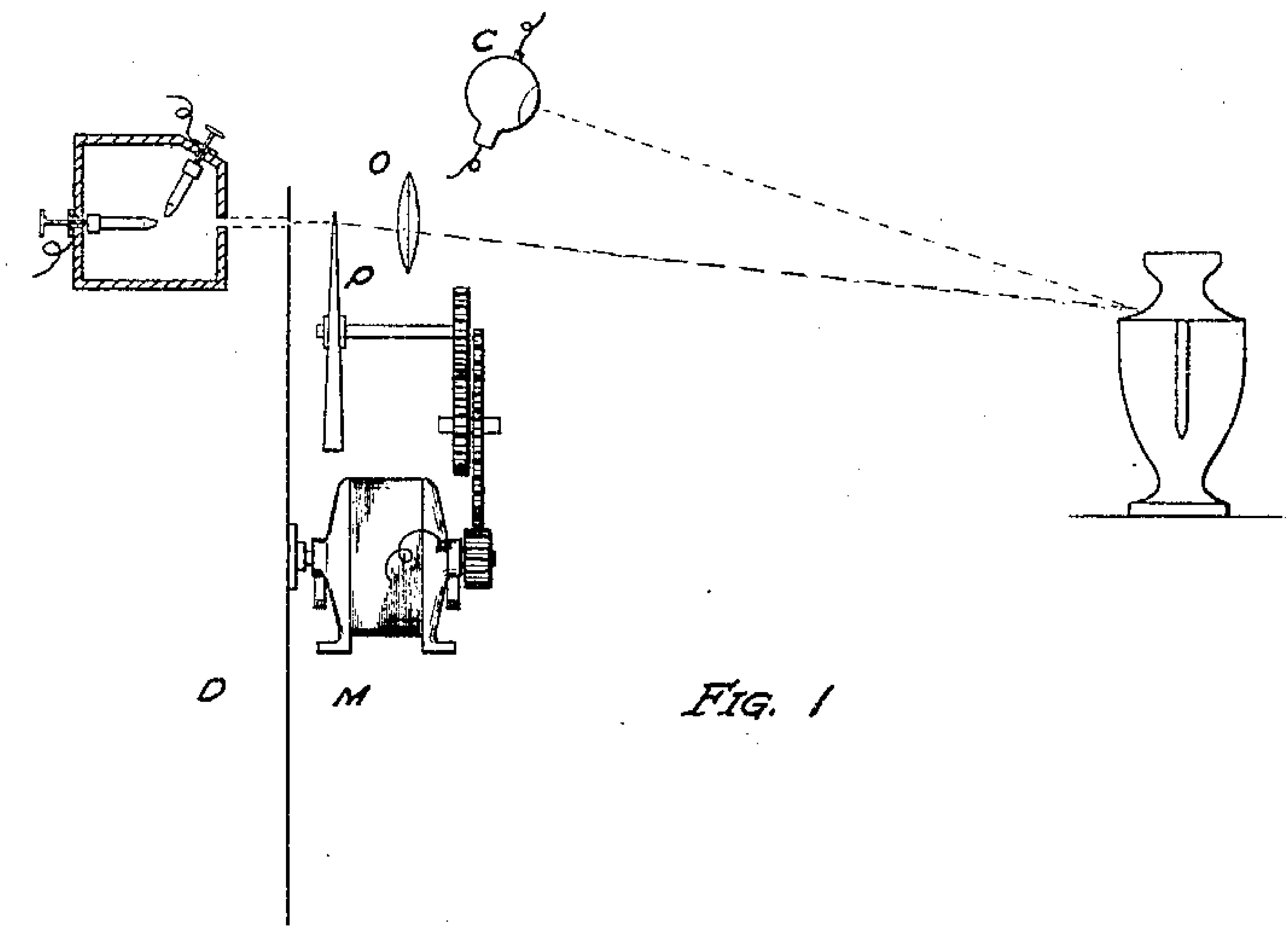

FIG. 1

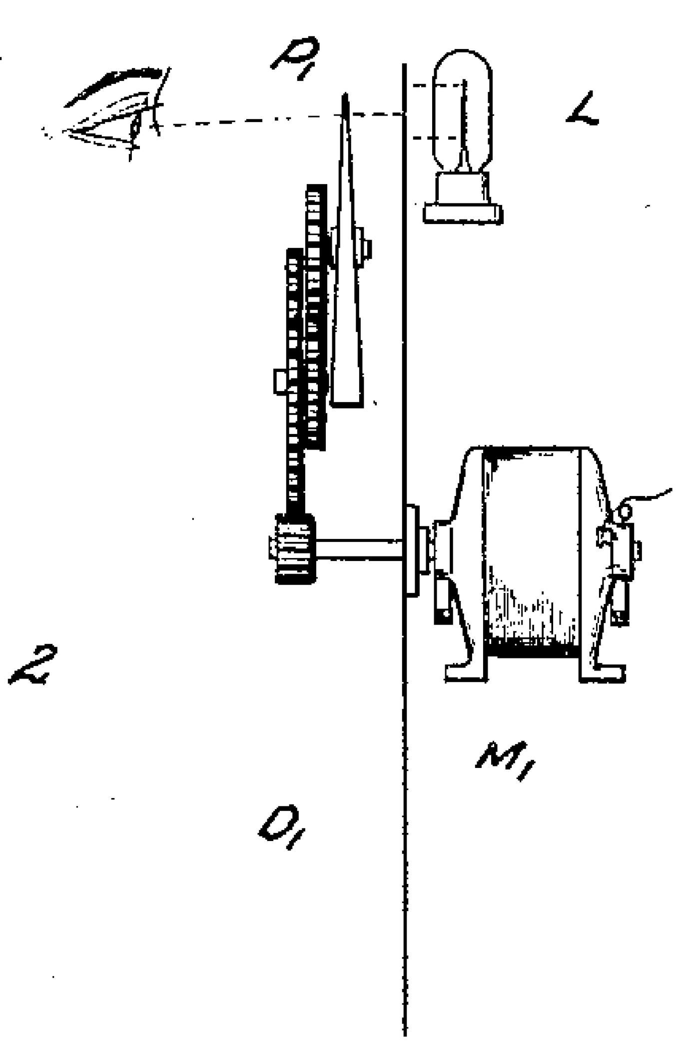

FIG. 2

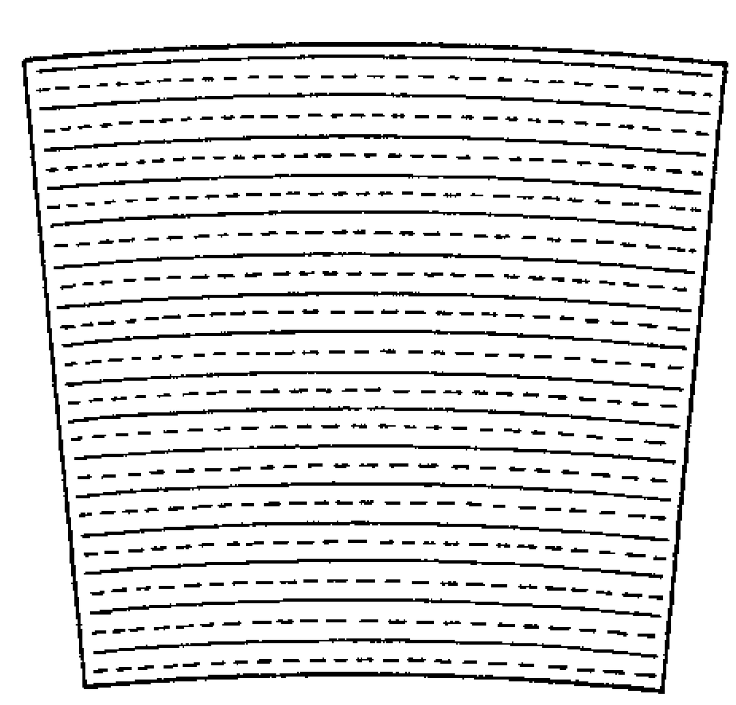

FIG. 3

INVENTOR
VANNEVAR BUSH
BY
ATTORNEY

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VANNEVAR BUSH, OF BELMONT, MASSACHUSETTS, ASSIGNOR TO RAYTHEON, INC., OF CAMBRIDGE, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS

SIGNALING SYSTEM

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This invention relates to signaling systems and especially to that class of systems wherein images either stationary or movable are transmitted by wire or wireless to a receiving station and there recreated. Although my invention is applicable to the transmission of stationary images, it finds its greatest application in the transmission and reception of movable images, that is, television.

It is well known that in order to transmit a scene which is constantly changing, it is essential to transmit about sixteen complete pictures per second in order that the observer at the receiving end shall see a continuously changing scene without substantial flicker. It is customary in all systems to divide up the scene into a large number of tiny unit areas comprising discrete scenic elements and successively transmit each of these elements. The division of the scene into the tiny unit areas is dependent upon two coordinates since the entire scene is to be scanned.

In certain systems, the mechanisms serves to break up the scene along the two coordinates to thus obtain the unit areas. In other systems, however, the mechanism only operates along one coordinate. The other coordinate is determined by the width of the transmission band. Thus it is evident that in a scene in which frequent contrast occurred, the light modulated currents would have a high frequency which of course could be no wider than the transmission band. These areas may be taken in any manner whatsoever either along a substantially straight line which covers the entire scene or else in spirals. In either case, each unit area is considered as a discrete and separate scenic element. The entire composite is very much like the well known and ordinary cuts for printing. There the entire picture is made up of a large number of tiny mounds or projections of varying height. The greater the number of unit areas, the clearer the picture becomes as regards detail.

Assume for example that the transmitting portion of the television system sub-divides the object scene into 2,500 unit elements—50 elements in each one of 50 rows. An impulse proportional to each element must be transmitted every $\frac{1}{16}$ of a second. With 2,500 elements, it is evident that to transmit the scene once, it will be necessary to transmit 2,500 separate impulses every $\frac{1}{16}$ of a second and in order to obtain a continuous picture, it will be necessary to transmit 40,000 impulses per second. If reproduced as an image one inch square such a picture will be equivalent to a half-tone print taken with a 50 mesh screen. This is regarded as very poor even for newspapers, which as a rule, use the coarsest screens of all for half-tone work. With such an image, considerable detail is impossible. If the image is enlarged without increasing the number of elements, at best, no additional detail is obtained.

With a system as above, using 40,000 impulses or cycles per second, it is evident that the width of the channel for transmission purposes over wire or radio is 40,000 cycles. For ordinary speech or music, a range of 8,000 cycles is very amply sufficient and in ordinary transmission of telephone messages, this channel is cut down considerably below this figure. Thus it will be seen that one of the disadvantages under which television labors is the necessity for having an extremely wide transmission channel even for the purpose of obtaining poor detail. If detail were to be improved in ordinary systems, the channel would of necessity have to be increased. If the transmission is over wires, it is evident that the cost of transmission will be very much greater. If the transmission is by means of radio, the number of channels available for simultaneous use will be greatly restricted.

An object of my invention is to effect a substantial decrease in the width of channel necessary for the transmission of television or other impulses without losing any detail. A further object is to introduce considerably more detail without substantially increasing the width of the channel necessary for transmission.

My invention in general is based upon the following fact. Assume that an observer is looking at something either movable or immovable and has an ordinary screen or metal gauze in front of him through which he must look. Under these circumstances much of the detail of the scene will be lost because the total visible area has been reduced by the breaking up of the scene into a large number of discrete unit areas. Now suppose that the screen is shaken in a small circle, the plane of the circle being parallel to the plane of the screen. Immediately the detail of the scene comes back.

The reason for this is as follows. With the screen stationary, the entire scene is broken up into a large number of discrete unit areas that are relatively immovable with respect to the scene itself. The portion of the area which is invisible and which represents the intervening areas between discrete unit areas of visibility always cover the same portion of the scene. Hence, the entire image as seen through the screen represents a substantially constant average of the true scene. When the screen is moved as described, the discrete unit areas of visibility as well as the blocked out areas representing the intervening areas, no longer have an invariable relation to the original scene. The visible image through the screen becomes a constantly shifting average of a constantly changing number of discrete unit scenes of area. With the screen stationary, the screen itself interferes with the visibility of the picture. With the screen movable, the screen merely represents a dull shadow which is over the entire picture and reduces its brightness but does not reduce its detail.

This same procedure may be adapted in television systems in order to eliminate the disadvantages outlined above. This may be applied to any type of system and in general would be applied as follows. Assume that the system employs a fine beam of light which illuminates only a unit area of the scene and which is constantly playing over the entire scene to be transmitted. Any light deflecting means such as a small prism may be disposed between the customary scanning disk and the object or scene. This prism is given a circular motion in a plane parallel to that of the disk and relatively slowly thereto such that the fine beam of light from the scanning disk will illuminate different rather than superposed unit areas. Hence when the beam of light has scanned the entire scene once in $\frac{1}{16}$ of a second and starts to repeat the cycle, it will not follow the preceding cycle exactly as regards illuminating certain definite unit areas.

What will happen is that the new unit area will be displaced a fraction of the dimension of a unit area away from the preceding corresponding unit area. At the receiving end a duplicate prism will move in synchronism with the prism at the transmitter. This receiving prism is placed in front of the image to be observed or in line between the observer and the glow tube used. Both prisms may be conveniently operated in synchronism by gearing them to the scanning disk so as to be actuated thereby. In general the prisms would be rotated at a greatly reduced speed to that of the disks. If the disks ran at 16 revolutions per second, the prism might be revolved as slowly as three revolutions per second.

The image as seen at the receiving end will be stationary because of the fact that the two prisms are in synchronism and compensate for each others effects.

It is evident that this invention is applicable to any type of picture transmitting and receiving systems. At all transmitters the prism or other equivalent means would be actuated so as to affect the normal position of the unit element of the scene to be transmitted. At the receiving end the prism or other equivalent means would be so disposed as to affect the normal position of the light impulses occurring at a particular instant.

Referring to the drawing, Figure 1 is a diagrammatic figure showing my invention as applied to an ordinary television transmitting system.

Figure 2 is a diagrammatic view showing the receiver.

Figure 3 is a scanning diagram.

The system shown in the drawing is one in which the mechanism itself operates to change only one coordinate of the scene. In other words, it divides up the scene into elongated elements which in this case would be arcs of a circle. The contrast of the scene itself operates to break up the elongated elements. It is evident that if one of the elongated elements of the scene is pictorially uniform, then there will be no breaking up of the elongated elements.

The transmitting system comprises a source for the production of a powerful and concentrated beam of light. This source is conveniently represented as an arc lamp but may be any source which is convenient and desirable.

The concentrated beam impinges or may be focused upon a disk D rotated by motor M. This disk is the usual well known scanning disk with holes punched out along a single turn of a spiral. The beam impinging on the disk should, therefore, be at least great enough to go through any of the holes in the disk. Normally the beam after going through disk D is collected and concentrated by an optical system here shown as lens O and allowed to play as a fine point of light upon the scene to be transmitted. As the disk rotates sixteen or more times a second, the varying distance of each hole from the center of the disk would result in a different portion of the scene being scanned. The beam through each hole in the disk would sweep across an arc of a circle on the scene to be transmitted. As the position of different holes varied with respect to the center of the disk, the position of the arc on the scene would be varied. Each arc thus represents an elongated scenic element. This is diagrammatically shown in Figure 3. The continuous lines within the rectangle indicate the path of a beam playing on the scene after passing through a hole in the disk. The amount of light reflected from the scene to a photo-electric cell C modulates a current.

To apply my invention to this system, it is merely necessary to introduce small prism P capable of rotating on an axis and geared to motor M as shown. The prism is large enough so that as it rotates, there will always be a portion of the prism between any hole in the disk and the unit area scanned.

The deflection suffered by a beam of light at any portion of the prism is constant, assuming the light to be mono-chromatic. With an ordinary beam of light containing many wave lengths, this would not strictly be true but since the prism has a very small angle and since only a very small portion of the prism is used at any one time, it is evident that no matter which portion of the prism is used, the deflection of the entire beam will be substantially constant. Hence, as the prism is rotated, the beam of light through it, if disk D is stationary, would be rotated in a small circle. Since the beam is repeatedly changing position, it is evident that the rotation of the prism will serve to constantly deflect the beam in a varying direction; that is, while the amount of deflection or angle of deflection will be constant, the direction in which the deflection occurs will always vary, due to rotation of the prism.

Impulses from the photo-electric cell are transmitted to the receiving system in Figure 2 in any suitable manner. Motor M_1 synchronized with motor M drives a disk D_1, a duplicate of disk D. A glow lamp or any source of illumination L whose intensity varies with the impulses from the photo-electric cell emits light which is visible through the holes of disk D_1. Between the disk and the observer is a prism P_1, a duplicate of prism P. Since both systems are synchronized, it is evident that the positions of P and P_1 will correspond in the same manner that positions D and D_1 are made to correspond. As disk D_1 revolves, it places or orientates the varying beams of light from lamp L in a certain portion of the entire field of vision. Prism P_1 introduces the additional variation by slower shift of the position of the spots in order to compensate for any tendency of the image to rotate.

As previously stated the solid lines in Figure 3 represent the paths of the light beams playing upon the scene. They may also represent the paths of light transmitted through one hole of the disk at the receiving end. In prior systems, these lines represented the portions of the scene which were always transmitted. With a system employing my invention, this is no longer true. After one complete revolution of the disk, the rotating prism operates to move the elongated scenic elements relatively to the scene to be transmitted. This is shown by the dotted lines which represent the elongated elemental areas of another cycle. Due to the comparatively slow speed of revolution of the prism, the shape of the elongated scenic elements is changed very little.

Although for simplicity sake, the dotted lines are shown as midway between the full lines, it is evident that their relative positions will depend upon the speed of the prism as compared to the scanning disk. The prism may be driven at such a speed relative to the disk that precisely superimposed scenic elements may occur as often as desired. In any event, the revolution of the prism operates to introduce a relative motion between the scene to be transmitted and the transmitting system. This motion is reversed in the receiving system so that while the image is stationary, all portions of the scene may be scanned at some cycle or other. It is evident that the relative motion between the scene and the transmitting apparatus and between the receiving apparatus and the observer may be obtained by purely mechanical means such as moving the apparatus relative to the scene or the observer. If the scene to be transmitted is a still picture, the latter may be moved around to obtain the relative motion.

While I have shown the prism as having a substantial angle, in actual practice, it should merely be large enough so that one elongated scenic element will be displaced a space less than the distance between normally adjacent scenic elements.

Instead of a prism, a vibratory mirror may be used. The mirror would be disposed in the light path either between the disk and object scene or between the object scene and cell. At the receiving end, the mirror would be between the disk and screen upon which the image is observed or between the disk and observer in the system shown. In the latter case, the mirror would be so arranged that all the light coming through the disk would be reflected by it in order to be observed. It would also be possible to have a mirror at one station and a prism at the other station.

The system to which my invention may be applied may be any of the well known systems. Thus some systems illuminate the entire object scene and shield the cell in such a way that reflections from unit areas only impinge thereon at any one time. The system may break up the elongated scenic elements in unit elements without relying upon the contrast of the object scene to do that.

It is evident that with my invention it is possible to obtain considerable more detail in the transmission of pictures without at the same time increasing the width of the channel necessary for transmission purposes. In fact, it is possible to obtain greater detail and cut down the width of the channel. It is also possible to retain the same detail as obtainable at present by greatly decreasing the width of the channel.

While I have shown the prisms as giving a circular motion to the unit area, it is evident that substantially the same results may be obtained by giving the spot of light a linear motion. Thus, if a mirror were to be used, it would be very easy to so vibrate the mirror that the spot of light travels back and forth in a straight line and which may be substantially perpendicular to the direction of the elongated pictorial elements. In the case of the analogy of looking through the screen, it is equivalent to vibrating the screen in a straight line rather than in a circle. By taking the line of motion of the screen so that it is at an angle to both of the wires making up the screen, substantially the same detail will be visible as with circular motion. The same thing may be done by suitably moving the spot of light.

I claim:

1. In a system of the character described, means for resolving an object scene into discrete scenic elements, said means operating continuously and repeatedly over said scene, means for creating electrical impulses corresponding to said scenic elements, means for creating light impulses corresponding to said electical impulses, means for orientating said light impulses to recreate said object scene, and additional independent means including a prism to cause the scenic elements corresponding to one cycle of said resolving means to be displaced relative to the scenic elements of a succeeding cycle.

2. In a system of the character described, means for resolving an object scene into discrete scenic elements, said means operating continuously and repeatedly over said object scene, means for creating electrical impulses corresponding to said scenic elements, means for creating light impulses corresponding to said electrical impulses, means orientating said light impulses to recreate said object scene, and additional independent means including a prism for continuously displacing corresponding scenic elements relative to said scene.

3. In a system of the character described, means for resolving an object scene into a plurality of discrete scenic elements, said means operating continuously and repeatedly, means for creating electrical impulses corresponding to said scenic elements, means for creating light impulses corresponding to said electrical impulses, means for orientating said light impulses to recreate said object scene, and additional independent means including a revolving prism disposed between said scene and said resolving means to cause a displacement of the scenic elements of one cycle relative to the scenic elements of a succeeding cycle.

4. In a system of the character described, means for resolving an object scene into discrete scenic elements, said means operating continuously and repeatedly over said scene, means for creating electrical impulses corresponding to said scenic elements, means for creating light impulses corresponding to said electrical impulses, means for orientating said light impulses to create said object scene, and additional means for deflecting light and for continuously varying the angle of deflection of said light in the same direction during a plurality of cycles to cause the scenic elements corresponding to one cycle of said resolving means to be displaced relative to the scenic elements of a succeeding cycle.

5. In a system of the character described, means for resolving an object scene into discrete scenic elements, said means operating continuously and repeatedly over said object scene, means for creating electrical impulses corresponding to said scenic elements, means for creating light impulses corresponding to said electrical impulses, means orientating said light impulses to recreate said object scene, and additional means for deflecting the light and for continuously varying the angle of said deflection in the same direction during a plurality of cycles for continuously displacing corresponding scenic elements relative to said scene.

6. In a system of the character described, means for resolving an object scene into a plurality of discrete scenic elements, said means operating continuously and repeatedly, means for creating electrical impulses corresponding to said scenic elements, means for creating light impulses corresponding to said electrical impulses, means for orientating said light impulses to recreate said object scene, and means for deflecting the light disposed between said scene and said resolving means, said deflecting means continuously varying the angle of said deflection in the same direction during a plurality of cycles to cause a displacement of the scenic elements of one cycle relative to the scenic elements of a succeeding cycle.

In testimony whereof, I have signed my name to this specification.

VANNEVAR BUSH.