

June 16, 1942.

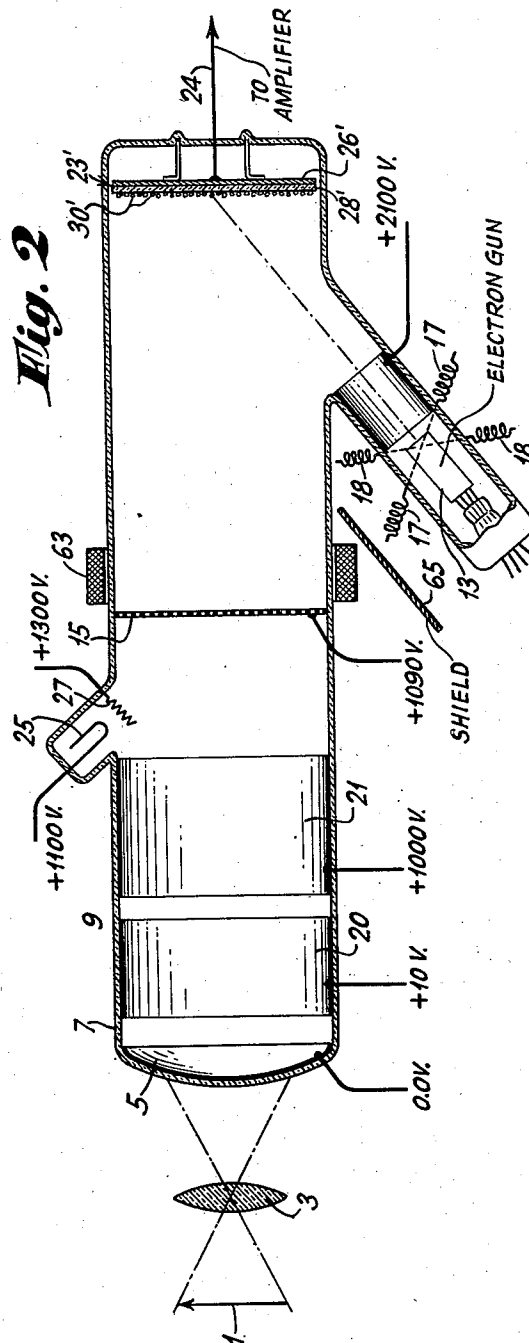
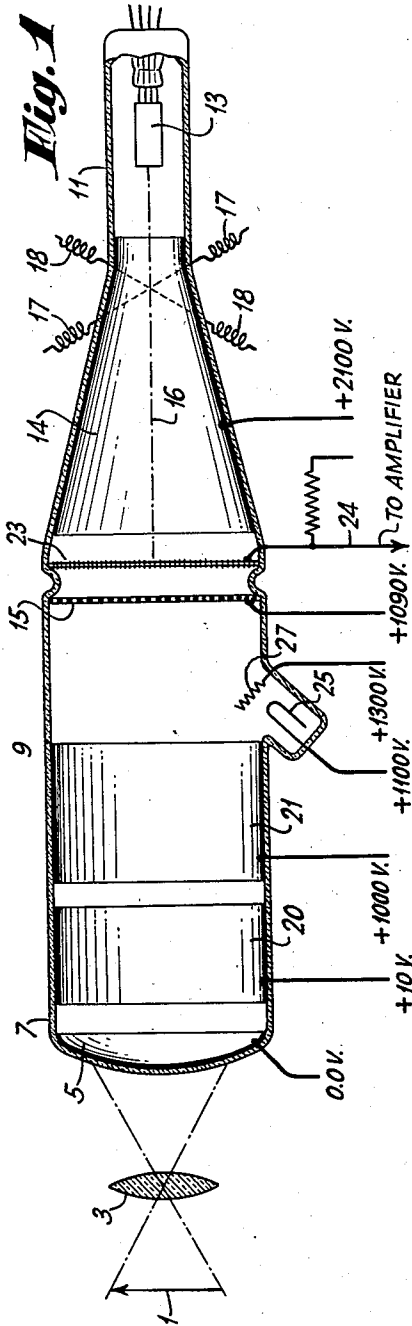
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2,286,280

ELECTRONIC DEVICE

Filed Dec. 14, 1937

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3

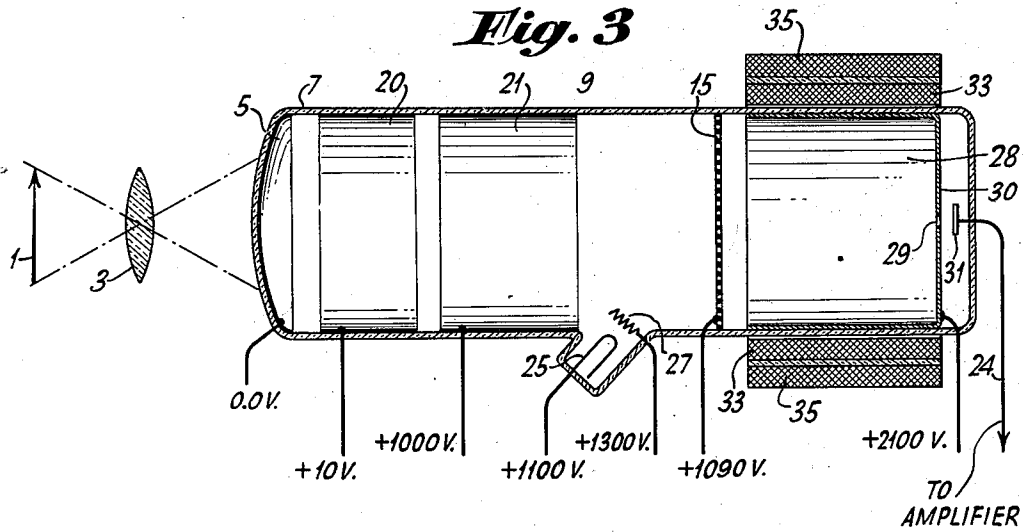


Fig. 4

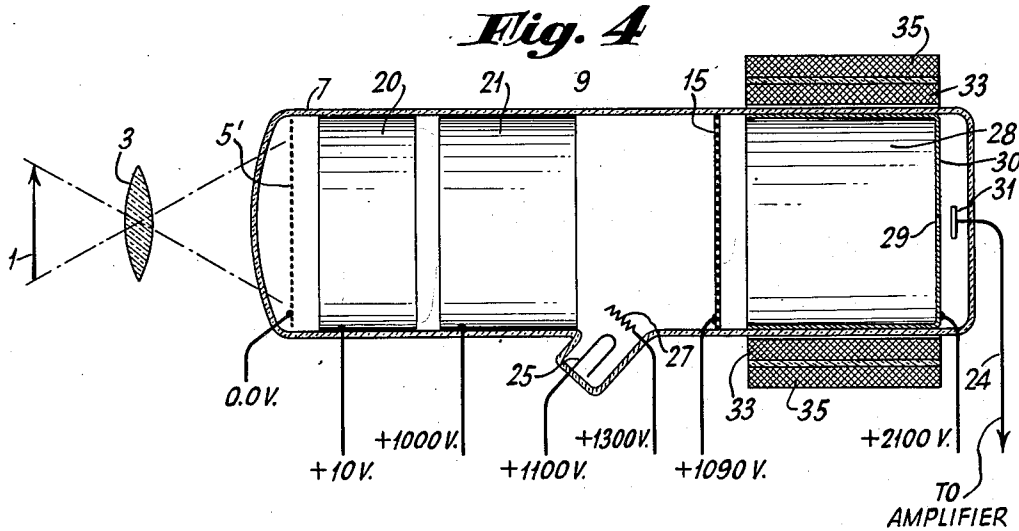
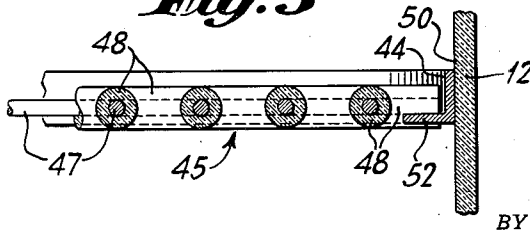


Fig. 5



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UNITED STATES PATENT OFFICE

2,286,280

ELECTRONIC DEVICE

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Application December 14, 1937, Serial No. 179,679

1 Claim. (Cl. 178—7.2)

The present invention relates to image amplifying tubes and is concerned primarily with electronic devices for scanning and transmitting image signals.

In the past it has been customary in electronic types of scanning devices to provide electronic image transmitting tubes of either the storage or non-storage type and to use either the resultant electrostatic charges produced from storage or to use the current image signals from the non-storage type of device to develop signalling impulses for transmission. While the storage type tube of the aforesaid character offers some considerable increase in the magnitude of the output signal energy obtained under scansion from that of the current type tube, nevertheless, it has been found in many instances that the signal to noise ratio is not as high as would be desirable for transmission purposes. Accordingly, the present invention provides ways and means for obtaining, without introducing distortion, extremely high ratios of output signal energy compared to any possible noise developed in the system as due, for example, to thermal agitation in coupling resistors and the like.

In the prior art, where a storage type of tube has been used as the light translating element, such tube has usually been construed as a device formed with a mosaic electrode comprising a signal plate, an insulating sheet member mounted upon the signal plate and a photosensitive coating of isolated minute size particles of photoelectric material separated from the signal plate by the dielectric. An optical image projected upon the mosaic electrode causes charges to be developed between the photosensitive particles and the signal plate and these charges are released during scansion by a cathode ray beam which is directed to traverse the photosensitive surface of the mosaic in a two dimensional path. In order to utilize the stored charges which are released by the cathode ray beam scanning action, it is possible to produce the signal output directly from the secondary emission which is released from the impact side photosensitive surface of the mosaic by the impact of the scanning beam thereon or to utilize a potential drop occurring across an output resistor connected to the signal plate of the mosaic electrode and across the input circuit of the associated signal amplifier.

With a tube of the non-storage type a light image is projected upon a photosensitive surface to release electrons which are caused to flow in the direction of a target electrode, the center of

which is apertured and behind which is a collecting pin or target. The complete electron image in the form of a current image is caused to sweep the aperture in the target in two directions and by virtue of the voltage drop across the resistor connected with the target electrode signals are transmitted to the input circuit of the amplifier whose input connects across the resistor.

The present invention makes use to some extent of a combination of each of the aforesaid types of devices in that there is initially produced an electron current image which is converted into a charge image and this charge image is then magnified in intensity to produce the magnified charge image and is scanned by a scanning beam. This invention relates, insofar as it uses for the purpose of producing the initial charge image an insulated grid structure which is flooded by an uncontrolled stream of electrons, to the structure which has been described for a receiving type tube by my copending application, Serial No. 116,689 filed December 19, 1936 (now U. S. Patent No. 2,259,507).

When the charge image has been produced upon the insulated grid the uncontrolled flooding stream of electrons then carries over to form on a two-sided mosaic electrode structure an additional magnified charge image and this charge image is then scanned point by point by means of a scanning electron beam in a manner already explained in connection with the scanning of the so-called two-sided mosaic structures in the patent granted to W. Hickok 2,047,369 of July 14, 1936. In an alternative form of the device the optical image is focussed upon a semi-transparent photosensitive cathode and the released photoelectrons are projected upon an insulated grid structure of the general character shown and described in my aforesaid application. The insulated grid structure is also subjected to the flooding effect of an uncontrolled intensity but high density field of flooding electrons and the resultant magnified current image determined in accordance with the charges accumulated upon the insulated grid structure is then projected as a magnified intensity current image through deflecting fields. Further, the magnified current image is suitably focussed so that when deflection in two mutually perpendicular directions takes place, the electron current image representing the elemental section or area of the optical image may fall through an aperture in an accelerating electrode to impinge upon a collecting target. In each of the above mentioned forms of

image amplifying devices suitable for translating an optical image into a train of electric signal impulses magnification of the resultant electric signal impulse takes place within the scanning tube. As a result, the signal intensity produced in the first stage of the external amplifier is considerably increased and a more satisfactory ratio of signal to noise level is obtained.

From the above it will be appreciated that included among the objects of this invention or those of obtaining directly within a scanning tube a magnification of the effects of electrical signals resulting from the translation of the light values of an optical image into either electrostatic charges, which are to be released to an external circuit, or an increase in the electronic current flow which it is to cause the resultant electric signal impulses.

A further object of the invention is to provide a purely electronic type of conversion device for converting optical images into electrical images of either the current, voltage or static type, which images are to be translated into electric signalling impulses.

Still a further object of the invention is to obtain a light translating and scanning device which will simplify translation of optical effects into signalling impulses and simultaneously amplify the resultant signalling impulses directly within the scanning device.

Still a further object of the invention is to provide within a scanning tube a multiplication of the normal signal output resulting from scanning an optical image by a purely electronic device of the character now known.

Still other objects and advantages of the present invention will become apparent and at once suggest themselves to those skilled in the art to which the invention is directed by reading the following specification in connection with the accompanying drawings; wherein,

Figure 1 represents conventionally a light image conversion scanning device wherein the signals result from the scansion of an electrostatic image;

Figure 2 represents a modification of Fig. 1 providing for scanning from the opposite side to that used with the device of Fig. 1;

Figure 3 represents a modification wherein the electric signalling impulses result from the scansion of an electronic current image;

Figure 4 represents a modification of Fig. 3; and

Figure 5 illustrates conventionally the structure of the insulated grid electrode by which the magnification of the signal effects produced within the scanning device results.

Referring now to the drawings, and first to Fig. 1 thereof, for a further understanding of this invention, light representing any subject 1, which may be some person, object, film, a transparency or the like, is directed by way of a suitable optical system 3, adjustable either for increasing or decreasing the size of the image and for focussing the image, so as to be projected upon a semi-transparent photo-cathode surface 5 suitably supported on the inner surface of one end wall 7 of a scanning tube envelope 9. This photosensitive cathode surface is usually curved concavely with respect to the plane at which scansion of the resulting charges or currents take place in order to avoid any diminution distortions such as those known, for example, as pin-cushioning.

About midway between the end 7 of the scan-

ning tube 9 having the photosensitized coating 5 and the opposite end 11 of the tube whereat an electron beam is developed by means of a suitable electron gun 13 comprising the usual electron emitting cathode, a control grid and an anode arranged in a cooperative relationship with a second anode 14 to provide more accurate beam focussing, there is positioned an insulated grid electrode 15 of the general character shown and described by my copending application Serial No. 116,689 filed December 19, 1936. Suitable potentials are applied to the electrodes forming the electron gun structure and to the second anode for causing the development of an electron scanning beam 16 which is deflected in each of two mutually perpendicular directions by means of suitable electromagnetic deflecting coils pairs positioned in two mutually perpendicular directions which are connected in the usual and well known manner to suitable sources of deflecting current.

The electrons released from the photosensitive surface 5 at the end of the tube which is illuminated by the light of the subject to be scanned are directed toward the insulated grid electrode through a plurality of electrode members 20 and 21 preferably formed in the nature of conducting bands around the inner surface of the tube wall intermediate the photoelectric surface 5 and the insulated grid 15. These bands are maintained at progressively higher potentials (of which suitable examples are indicated by the drawings) relative to the photoelectric surface so as to accelerate electrons released by the light and to focus these electrons upon the insulated grid 15. Intermediate the insulated grid 15 and second anode 14 of the scanning tube but closely adjacent the insulated grid is positioned a two-sided mosaic electrode 23, which, for instance, may be of the general nature described by Flory or Hickok in U. S. Patents Nos. 2,045,986 and 2,047,369. This double mosaic electrode 23 may be of any general form and shape but preferably is made in accordance with the structure described by the above mentioned Hickok patent. So constituted, the two-sided mosaic electrode is formed from a mesh-like surface in which the wires constituting the mesh are suitably enameled and have supported in the interstices of the mesh suitable conducting packings which extend through the mesh and on the surface thereof toward the insulated grid electrode there is a photoelectric coating. The photoelectric coating covering the metallic packing of the mesh interstices constitutes a series of actual photoelectric areas which are insulated from each other by the enameled coating upon the wires forming a mesh.

Within the portion of the scanning tube between the semi-transparent photosensitive cathode member 5 and the insulated grid 15, there is positioned an electron emitting cathode 25 in cooperative relationship with respect to a control electrode element or grid 27 so that electrons released therefrom will flood the insulated grid electrode structure 15.

As was explained in my copending application Serial No. 116,689 with respect to the charges produced upon the insulated grid structure by a scanning electron beam, the photoelectrons moving from the photosensitive cathode 5 toward the insulated grid 15 and accelerated thereto and focussed thereupon by means of the electrodes 20 and 21 also cause charges to be accumulated upon the insulated grid structure simultaneously

with the emission of a dispersing stream of electrons from the electron emitting thermionic cathode 25, which releases an electron stream of high density arranged to flood the insulated grid 15. The flooding electron stream from the emitter 25, as accelerated by the control electrode 27 would normally tend to penetrate equally all of the interstices of the insulated grid 45 except for the potentials which are acquired at elemental sections thereof due to the projection thereupon of the intensity controlled stream of electrons due to photoelectric emission caused by light impinging upon the photosensitive cathode 5. Since the photoelectrons moving toward the insulated grid 15 from the photo-emitting cathode 5 are accelerated toward the insulated grid 15 and focused thereon by electrodes 20 and 21 so as to strike thereupon at relatively high impact velocity secondary electrons are caused to be emitted on the surface of impact. The number of secondary electrons which are released by the impact of the arriving photoelectrons being greater than one secondary electron per arriving primary electron causes the surface of the insulated grid to acquire at different elemental areas thereof different positive potentials relative to the wires on which the enamel or insulated coating is supported so that there is thus developed between the insulator and the supporting mesh an electrostatic charge image of the light image, although this charge image while tending to be dissipated within a short time period due to leakage within the tube during predetermined time intervals is preserved by the continued arrival of the photoelectrons upon the insulated grid. Naturally, the magnitude of the electrostatic charge image developed on the insulated grid 15 is a function of the electron density of the photoelectric current due to the light image and consequently in view of the fact that the release of secondary electrons takes place from the insulated grid when it is subjected to impact of photoelectrons, the flooding electrons are drawn rapidly toward the insulated grid structure by reason of the positive charge acquired thereon. In view of the fact that the flooding electron stream is of substantial magnitude some of the electrons of the flooding stream will be lost in neutralizing or replacing the secondary electrons, lost to produce the charge, but still other flooding electrons will be passed through the interstices of the insulated grid. Electrons of the flooding beam or stream which pass through the electrode 15 are thus of a magnitude which is governed in accordance with the charges acquired by elemental sections of the insulated grid structure. This results in an electron flow toward the double mosaic electrode of the character above described which is of greater magnitude than would be any stream of electrons due to the light image alone. The action of the stream of electrons which passes through the insulated grid structure 15 whether this stream of electrons be due to the photoelectrons emitted from the surface 5 or to the flooding stream from the source 25 or to both, causes charges to be acquired upon the impact side of the double mosaic electrode structure 23 which type of electrode 23 has already been described by Flory and Hickok.

In general, the double mosaic electrode 23 is maintained at a potential relative to the photosensitive cathode surface 5 which is substantially the same as that of the second anode 14 of the scanning portion of the tube (as illustrated

herein by way of example this may be of the order of 2100 volts positive). While it has not been shown herein it is also contemplated by this invention that there may be located between the insulated grid member 15 and the mosaic electrode 23 (or the equivalent electrode of Fig. 2) a coarse mesh conducting electrode in order to collect the secondary electrons which are emitted from the mosaic electrode 23 when the magnified electron flow passing from the insulated grid 15 strikes or impinges upon the mosaic electrode. Such a grid electrode would normally be operated at a potential of the order of 20 to 100 volts positive relative to the potential of the mosaic electrode 23 (or the anode 14).

In order to release from the double mosaic 23 a signal to an external circuit which is representative of the charges acquired by the insulated grid 15 and then transferred to the double mosaic, the latter electrode is scanned by the scanning beam or cathode ray 16 developed within the tube and impinging upon the double mosaic 23 from the opposite side from that which is initially subjected to electron impact representative of the light image. In accordance with the arrangement of Fig. 1 this scanning takes place by virtue of the application of suitable deflecting currents passed through the deflecting coils 17 and 18 so that the beam 16 traverses the double mosaic in a bi-directional path in well known manner to release the stored charge signal to an external circuit 24.

However, it should also be appreciated that after the manner disclosed by Fig. 2 and following the broad principles set forth by Bedford in application Serial No. 746,094 filed Sept. 29, 1934, or in the British Lubszynski Patent #442,666 the scanned electrode element 23 need not necessarily be a double mosaic electrode but may be one of the type known as the single sided mosaic 23' in order that the electron stream representative of the light image impact from the same side which is to be subjected to the impinging electrons of the scanning electron beam. In such an event as disclosed by either Bedford or Lubszynski, the surface of the electrode element 23' will then be merely one which embodies a single signal plate 26' and a suitable dielectric element 28', such as a mica sheet upon which the charges may be directly accumulated or upon the surface of the insulator or mica 28' toward which the impinging electrons representative of the image are directed, there may be a coating of minute or microscopic size conducting particles 30' each electrically insulated from the other as has been disclosed by Essig, for example, in U. S. Patent #2,065,570. However, in this instance the metallic particles produced need not be photosensitized as described by Essig. In this way it is possible to cause the single sided electrode 23' to be scanned from the same side as that from which it is initially activated by the impinging electron stream and the scanning by the cathode ray 16 in this event will then serve merely to remove the accumulated charges from the single sided mosaic as is the case with the arrangement of Fig. 1 wherein the charges from the double mosaic are removed by scanning the double mosaic electrode from the rear side. It should be understood, however, that suitable correction for the "keystoning" effect, as set forth by Ogloblinsky Patents 2,040,813 or 2,069,460, for example, should herein be used.

With the arrangement of Fig. 2, since the insulated grid 15 is separated from the mosaic

electrode 23' (due primarily to the geometry of the tube) it is usually desirable, in order to obtain high definition images resulting from scanning, to employ a focussing field, such as that developed by the coil 63 to focus the magnified electron flow passing to the right of the insulated grid electrode 15 (as shown) upon the mosaic electrode 23'. Also, in order that the stray magnetic field from the focussing coil 63 may be shielded from the gun section 13 of the tube section wherein the scanning beam 16 is developed, as well as the deflecting coils 17 and 18, a magnetic shield member 65, such as a soft iron member, is located in the manner conventionally represented by Fig. 2. This then prevents any substantial distortion of the normal scanning pattern of the mosaic electrode 23' which would be traced by the beam 16 when deflected by the currents flowing through the deflecting coils 17 and 18.

In Fig. 3 a slightly modified form of the invention has been illustrated wherein instead of providing a double mosaic electrode 23 for the purpose of translating a dense electron current image into a charge image which is to be scanned, the magnified electron current image is directed through the accelerating field provided by the conductive coating 28 extending from a portion of the tube beyond and away from the insulated grid electrode 15 so that such electron stream constitutes a dense current image which then may be scanned by deflecting the complete magnified current image in bi-directional paths across an aperture 29 behind which is positioned an electron current target 31. In the form which the arrangement has been shown by Fig. 3 the portions of the tube which are located to the left of the insulating grid structure are substantially like that of Fig. 1. However, instead of providing in Fig. 3 the scanning cathode ray beam 16 and the double mosaic electrode 23 of Fig. 1 the inner surface of the tube wall to the right of the insulated grid electrode is a conducting coating 28 and maintained at a relatively high positive potential with respect to the insulated grid member 15 itself. Suitable operating potentials have been indicated by the drawings, although these suggested voltages are not in any sense to be considered as limiting but rather as illustrative. The end of this coating 28 terminates in an inner coating on the end inner surface of the tube wall which is apertured at its central portion 29 or the coating may terminate in a disc-like electrode member 30 which extends transversely of the tube for substantially its complete width. Under such circumstances the electrode 30 is apertured at its centralmost portion 29. Behind the aperture 29 is positioned a collecting target 31 in accordance with the teachings of Roberts, Farnsworth or Deickman. In order to focus the magnified current image passing through the conducting coating 28 in order that elemental sections may be passed through the aperture 29 for scanion as the magnified current image is deflected any suitable focussing coil such as that which has been conventionally illustrated at 33 may be used. In addition, there is positioned to surround the focussing coil (or internally of the focussing coil where desired) suitable deflecting coils 35 which are of substantially similar characteristics to the coils 17 and 18 shown with respect to Fig. 1 and which may be, for example, of the general nature described and shown by U. S. patents to Tolson #2,074,764 and Urtel #2,100,618.

In still another modification of the invention as it has been shown by Fig. 4, the arrangement is closely analogous to that of Fig. 3 with the exception that photosensitive mesh-like electrode 5', which may be of substantially the same character as shown by copending application of V. K. Zworykin, Serial No. 468,610 filed July 17, 1930, is positioned and supported within the end 7 of the tube 9 to replace the semi-transparent photosensitive coating 5 suggested by the arrangements of each of Figs. 1 and 2.

The construction of the double mosaic electrode 23 suggested for the arrangement of Fig. 1 is too well known and too universally adopted and so fully disclosed in the above mentioned Flory and Hickok patents that anymore than conventional illustration herein is believed to be necessary. However, the insulated grid structure 15 while having been disclosed in several of its preferred forms by my copending application Serial No. 116,689, above referred to, has been schematically illustrated in one of those forms by Fig. 5 of these drawings. Referring to Fig. 5 it will be seen that this electrode comprises preferably a ring-like outer supporting element 44 which preferably rests against the inner surface 50 of the tube wall 12. The ring-like member 44 has one edge 52 bent or flanged inwardly so that it can be secured or welded to the wires 47 of the mesh to support the mesh, and strung from its outer ring-like member are a greater number of fine mesh wires 47. The wires forming the mesh 47 for the insulated grid electrode 45, after the mesh has been suitably rolled and flattened so that the wires thereof are substantially flat, are preferably coated with a suitable insulating material 48. The insulating material will then also coat the flange 52 of ring 50, as shown. The enameling process may be carried forward to a predetermined degree by dipping the mesh-like grid into enamel to provide a coating of enamel thereon of desired and suitable thickness. This insulator in the case of the enamel coating is then baked in suitable manner prior to assembling the tube. When the tube is assembled the mesh and support ring are positioned within the tube and fit tightly therein. In the glass blowing process the tube wall may be heated to cause the glass of the tube wall 11 to fit tightly about the ring 44 to hold it and position it.

It should further be appreciated that while the general arrangements described by each of Figs. 1 through 4, for example, set forth only a single magnification of electronic image resulting from subjecting a photosensitive cathode to a light image, it is of course within the scope of this invention to utilize several magnifications of the resultant electronic image and, accordingly, reference is herein made also to my copending application filed concurrently herewith (Docket 13206) wherein, as applied particularly to an image amplifier tube provision has been made for magnifying the resultant electronic image to a still further degree by the incorporation within the tube of a plurality of insulated grid electrodes and a plurality of sources of flooding electrons. In this way it is possible to obtain a first magnification of the current flow resulting from subjecting a photosensitive cathode to a light image and then magnifying the previously magnified light effect to a still further degree, whereby the magnification is such that for two stages, for example, the magnification would be substantially a square function

of that which is obtained with the arrangements of Figs. 1 through 4 and a three stage tube would provide a cube function of the magnification obtained with the arrangements illustrated by Figs. 1 through 4, etc.

Further than this, as set forth by my copending application (D-13206) filed concurrently herewith, it is also contemplated that the insulated grid structures conventionally illustrated at 15 in each of Figs. 1 through 4 and described more particularly with respect to Fig. 5 may be either photoelectric or non-photoelectric. In addition, it is also contemplated as being fully within the scope of this disclosure to curve the end of the tube and provide suitable curvature of the field distribution therein so that the end of the tube upon which the light image is directed relative to the final positioning of the insulated grid member is not in direct line with the portion of the tube wherein scanning takes place so that where the insulated grid member is photoelectrically responsive such grid member will not be exposed directly to the light of the image in order that improved operation may result and further this prevents any re-generation within the tube which would be due to light from the fluorescent screen reacting back upon the photoelectron surface producing the initial current flow.

Many other and further modifications in this invention are naturally possible and accordingly

I believe myself to be entitled to make and use all of such inventions and especially which follow from my copending applications hereinabove referred to to which reference is made for the purpose of completing this disclosure, provided, of course, such inventions and changes fall fairly within the scope and spirit of the herein-after appended claim.

What I claim is:

10 In an electronic light image translating and scanning system, means for producing a controlled intensity electron flow corresponding to the light densities of an optical image, an insulated grid structure positioned to receive the
15 controlled intensity electron flow whereby electrostatic charges of a magnitude proportional to the intensity of the electron flow are produced over elemental areas of the insulated grid, an electron source for flooding the insulated grid
20 structure with a substantially constant density electron flow to produce in accordance with the charges acquired an intensified electron flow substantially like the originally produced electron current flow, a mosaic electrode means to
25 receive the intensified electron flow and to produce an intensified substantial duplicate of the initially developed electrostatic charges and means for translating the intensified electrostatic charges into electrical signals for trans-
30 mission.

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