

Nov. 25, 1941.

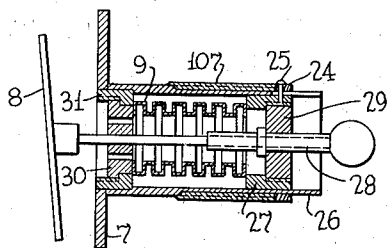
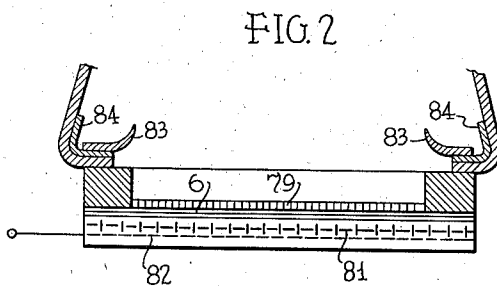
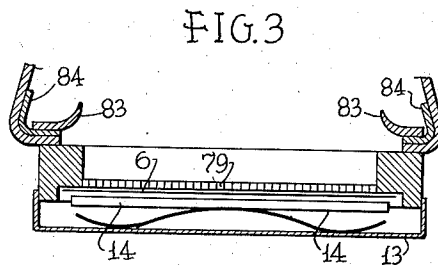
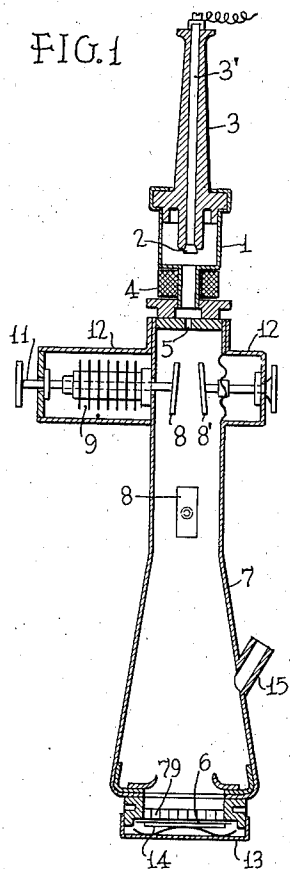
M. KNOLL

2,263,733

CATHODE RAY OSCILLOGRAPH

Original Filed Nov. 18, 1929

3 Sheets-Sheet 1



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MAX KNOLL

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Nov. 25, 1941.

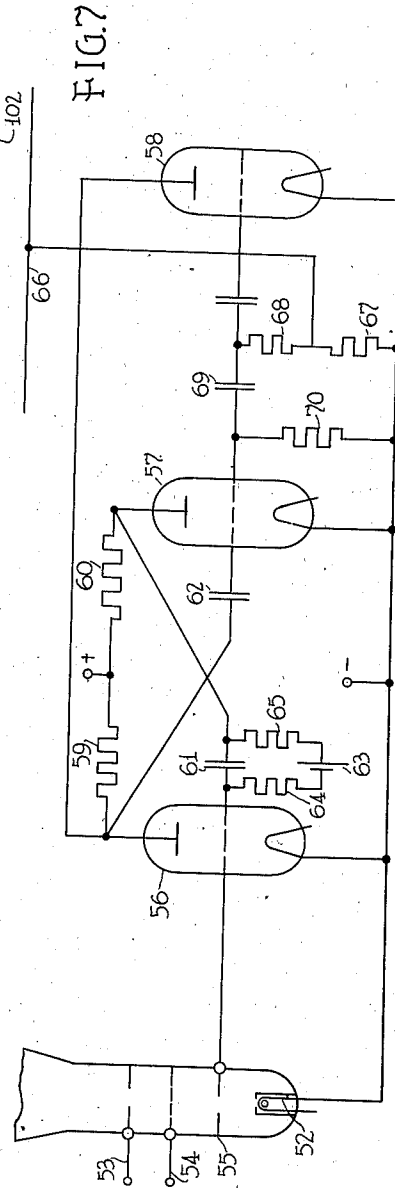
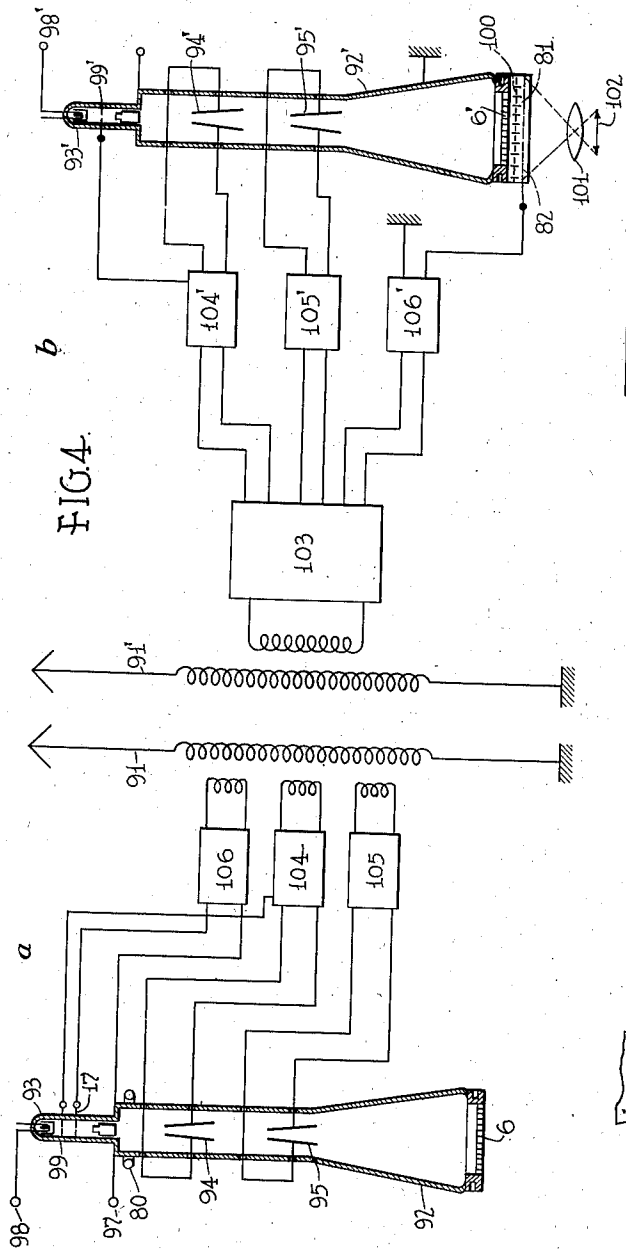
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2,263,733

CATHODE RAY OSCILLOGRAPH

Original Filed Nov. 18, 1929

3 Sheets-Sheet 2



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3 Sheets-Sheet 3

FIG. 6

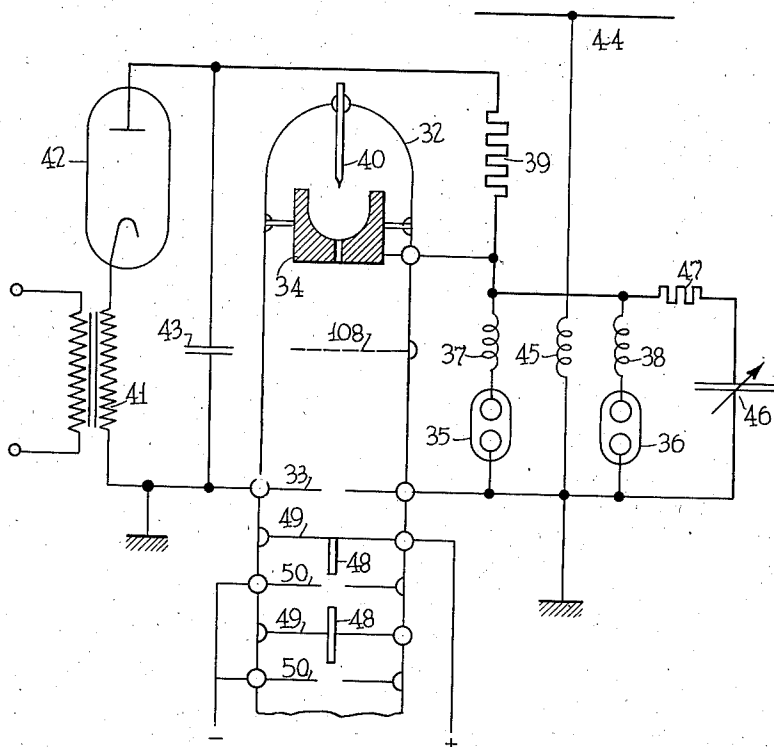


FIG. 8

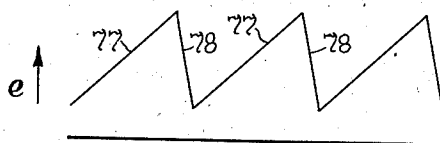
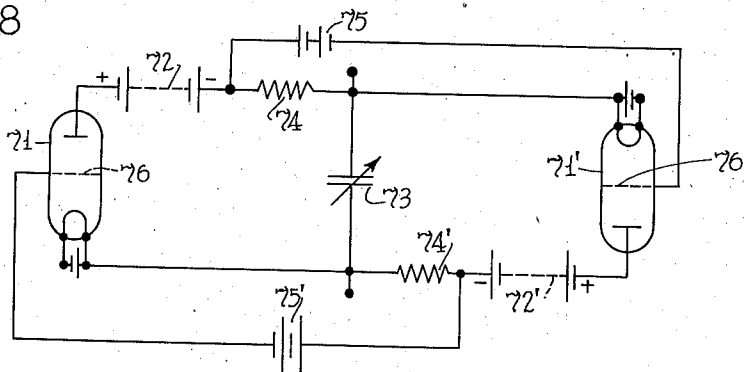


FIG. 9

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UNITED STATES PATENT OFFICE

2,263,733

CATHODE RAY OSCILLOGRAPH

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Application February 5, 1935, Serial No. 5,136,
now Patent No. 2,152,487, dated March 28,
1939, which is a division of application Serial
No. 408,006, November 18, 1929, now Patent No.
2,036,532, dated April 7, 1936. Divided and this
application February 25, 1939, Serial No. 258,528

6 Claims. (Cl. 178—7.2)

This invention has for its object improvements in cathode-ray oscillographs, and is a division of my copending application, Serial No. 5,136, filed February 5, 1935, which issued as Patent No. 2,152,487 on March 28, 1939, and which was a divisional application of Patent No. 2,036,532, which issued April 7, 1936.

According to the invention special means are provided in order to keep the focus, so long as it is not moving at its great recording or scanning speed, diverted from the window or other electron beam receiving member. This may be effected in a manner known per se, by diverting the electronic rays sideways by means of a constant magnetic or purely electrical field or a combination of both. Preferably a plate of beryllium or other substance of low atomic weight may be arranged, against which the rays strike during their diversion, in order to prevent as much as possible the generation of X-rays. For the further protection of the observer and of the photographic layer against X-rays this plate is in turn covered with an envelope of material of high atomic weight, e. g. lead.

According to the invention the protection of the window may be effected by intercepting the electron rays instead of diverting them, i. e. by arranging in the path of the electronic rays a beam intercepting means in the form of a bored-through negatively charged stopping-electrode, the negative charge of which is let off at the beginning of the recording operation. As the cathode-ray oscillograph which is the subject of the invention is intended to be used for rendering visible or recording extraordinarily rapidly occurring phenomena, or for television purposes, the switching on or off of the diverting or stopping device has to be effected in an extraordinarily short space of time, e. g. in 10^{-6} sec. This problem may be solved by a purely electrical switching device with two stable positions of equilibrium, e. g. by the employment of electron tubes, glow-lamps or spark gaps. The invention provides for this purpose a specially simple and rapidly reacting electron-tube device, which is actuated simultaneously with the start of the voltage to be recorded by the oscillograph. In this way the voltage of the grid-potential of another valve (the so called "deflector" tube) can at the same time be maintained at the same value, and its saturation current made to flow through a condenser connected in parallel with the controls, the voltage of which is thus varied proportionally with the time.

With apparatus for picture-telegraphy or television in which the whole area of the picture both in transmitter and receiver is scanned by the focal spot in a zig-zag path consisting of upward and downward straight-line branches, one set of branches, say the upward, can be described at a constant relatively slow velocity, and the other set, the downward, at a constant relatively high velocity by suitably varying the control voltage, as by charging or discharging inserted condensers by means of a constant current, e. g. the saturation current of electron tubes. This must be effected by employing two different constant intensities of current. Thus only the one set of parallel branches is valid for the chemical and physical effects, in contrast to the hitherto used sinusoidal records, in which, on each of both branches, the recording velocity and the distance from the neighboring branch are continually changing.

The cathode-ray oscillograph forming the subject of this invention can be used in picture-telegraphy and television and also in the transmitting station for scanning the picture to be transmitted, and further for frequency multiplication for secret telegraphy and the like by scanning separated electrodes arranged in checker board fashion behind the window and easily exchangeable.

Since neither for transmission nor reception need any mechanical parts be moved, the new cathode-ray oscillograph, especially for picture-telegraphy and television offers a number of such important advantages as to enable both these operations to be carried out with hitherto unattainable perfection.

The synchronization which must be maintained between transmitting and receiving apparatus, is obtained with the utmost ease and with absolute exactitude by simultaneously affecting the corresponding controls of the transmitter and the receiver by the voltage either directly by wire, or indirectly by wireless waves.

The recording velocity obtainable is so great that e. g. a picture of 6 x 6 cm. may easily be scanned in $\frac{1}{1000}$ sec., or even in $\frac{1}{10000}$ sec., and reproduced with sufficient intensity.

If a picture-frequency of not more than 16 pictures per second (which is adequate for the human eye) is required, pictures of such intensity may be obtained, that they may be projected on a much enlarged scale on to a screen and made visible to a large company of spectators.

Picture-telegraphy can be extraordinarily cheapened and its field of application extended beyond all anticipation.

For instance, the transmitting of a picture, which hitherto required about ten minutes, can be reduced to $\frac{1}{1000}$ of a second. An entire news-sheet, for instance, can be swiftly transmitted by picture-telegraphy, provided only the sheets to be transmitted and the receiving film are moved with sufficient velocity.

Cinematographic films can be copied by wireless transmission at any distance.

The speed with which the pictures can be scanned in the transmitter and receiver makes it possible to scan, transmit, and reproduce in one continuous line pairs of stereoscopic pictures, so that either static or in-process-of-production plastic picture-telegraphy and plastic television are made possible in the simplest manner by one and the same apparatus.

The extraordinary speed with which a picture can be scanned at the transmitting station and recorded at the reception station, and the possibility of extremely rapid withdrawal of the focus after the picture has been completely scanned, enable also the transmitting and reception devices to be used for super-speed recording of "slow motion" pictures, in which case a much greater number of pictures per second can easily be recorded, than has been possible with "slow-motion" apparatus hitherto used.

If a very high number of pictures per second is to be obtained, it is, for instance, only necessary, firstly, in the receiving apparatus, to double the length of the picture, that is to say the sum of the intervals between all the branches of the zig-zag path, so that with a stationary photographic plate one would obtain a distorted picture double the width; and secondly, to run the receiving film constantly at half speed. This gives the "slow motion" pictures, the optical compensation otherwise required being here replaced by the swift withdrawal of the focus.

The invention is exemplified in the drawings.

Fig. 1 shows schematically a cathode-ray oscillograph, such as can be employed for the various above mentioned purposes.

Fig. 2 shows on a larger scale—schematically drawn—an example of the window of a cathode-ray oscillograph used for the transmission of pictures or for television.

Fig. 3 shows a window of the same sort in the receiving apparatus, for the photographic record of the wirelessly transmitted picture.

Fig. 4 shows schematically, how the cathode-ray tube of the transmitter and the cathode-ray tube of the receiver work together in picture telegraphy or television.

Fig. 5 shows on a larger scale a vacuum-proof pliable device for shifting movable parts, such as, e. g., a deflector plate.

Fig. 6 is the schematic representation of a tube for auto-electronic discharge with a cold cathode and supplied with electrostatic concentrating device.

Fig. 7 represents a thermionic cathode-ray tube with an intercepting electrode, the latter actuated by a tip-action electron-tube device.

Fig. 8 shows a connection-scheme for the production of oscillations with linear variations of voltage, as used especially for television or picture telegraphic apparatus.

Fig. 9 shows the wave-shape of the linear oscillations produced by means of such a connection.

In the cathode-ray oscillograph represented in

Fig. 1 the cathode-ray beam is produced in the metallic discharge-tube 1, which serves at the same time as an anode, and into which the cathode 2 is introduced by means of the bushing 3. The cathode 2 is connected with the feed-voltage by means of the rod 3' lodged in the bushing 3. The coil 4 serves to concentrate the ray beam before it passes through the narrow aperture of the diaphragm 5 into the actual diversion-chamber 7 and onto the electron-permeable window 6.

As electron-permeable substances the same materials may in general be used as were formerly employed for the Lenard tubes already mentioned. These are, first of all thin metal foils, e. g., aluminium, chromium-nickel, steel alloys, beryllium. Also foils of insulating material, Celluloid, Cellophane, cellulose products, etc. may be used. Porous materials, such as paper, can also be used the pores of which are just fine enough to oppose to the passage of gases a relatively high, and to that of electrons a relatively low, resistance. In the latter event the slight quantity of gas admitted through the pores must of course be constantly drawn off by an air-pump. Owing to their comparatively low atomic weight, glasses may also be used, especially such with components of particularly low atomic weight, as for example the Lindemann glass so often employed for X-ray tubes, consisting of beryllium, lithium and boron.

In general it will be necessary to reinforce the thin foil required for the purpose described by a framework to sustain the outer atmospheric pressure. This framework may, for instance, consist of a wire-netting, which may in its turn be reinforced by means of a bearing cross, supporting grid or the like. For the reinforcement of the foil it is possible also to employ a thin metal plate perforated plentifully with small holes. For the making of such a plate, appropriately perforated, a new process had to be devised. The purpose of the framework as employed in the invention is to make it possible to use, for the window, foil of extreme thinness, in order thereby to insure that the window shall be permeable to the electrons to a corresponding maximum degree. Further, in the framework, the ratio of the total area of the perforations or apertures of admission to the total area of the non-perforated non-permeable portion of the framework, has to be as great as possible. Further also the apertures of admission must lie as densely as possible together and be of such small size, that the focal spot covers simultaneously several adjacent apertures. The making of such plates involves special difficulties. To make such perforated plates the present invention employs a process similar to that used in autotype printing for the making of the printing-blocks. As is known, it is possible, by means of stippling-process photography, to engrave upon a surface adjacently, at extraordinarily minute intervals, dots of any desired form—square, for instance, the ratio of the width of the dots to the width of the lines of the network of clear spaces between the dots depending upon the degree of illumination of the photographed surface. It is possible thus to cover a surface with an extremely dense network of dots of uniform size. Whereas, however in the making of a printing-block the network of lines is etched into the block, in making a perforated plate for the purpose here in view the network of lines is imprinted or copied on to the plate, and the dot-surfaces etched through the plate. The

line-work can also be engraved into the plate, the lines of engraving covered with a protecting layer, and the dot-surfaces lying between the lines etched through the plate.

The thin foil forming the window can also, instead of being reinforced subsequently by the grid, be made directly upon the outer surface of the grid. For this purpose the holes of the perforated plate forming the grid can be filled in with a substance which may be later on removed (for instance, wax, paraffin), and a thin layer, e. g. of beryllium, iron, or silicon, deposited galvanoplastically or by cathode-sputtering over the entire outer surface of the plate. A thin layer of some acid-proof substance such as gold, for instance, can be deposited on the plate previous to perforation and the holes then etched out in the manner already described. In this way are obtained an extraordinarily intimate vacuum-proof connection between foil and grid, perfect reinforcement, and the maximum abduktion of heat. The thickness of the foil can be reduced to as little as $\frac{1}{10,000}$ mm. So thin a foil would, unless by so uniting it with the grid, be extraordinarily difficult, or practically impossible to mount. Windows made in this way are permeable to electrons to a degree hitherto never even remotely approachable; they are, further, owing to the effective abduktion of the heat, not liable to be burnt through; they are easy to make and to use; and thanks to their perfectly plane form enable sharply defined photographs to be taken with ordinary plates or films.

8, 8' are the deflector plates, which can be adjusted under a high vacuum with the help of elastic bodies 9 or membranes 10 by means of screws 11, which are lodged in supporting tubes 12. 15 is a spy-hole, through which the oscillogram to be recorded can be observed also while the photographic record is being taken, provided that the inner side of the electron-permeable layer 6 or parts of the grid 79 are overlaid with a phosphorescent substance. The photographic layer (plate or film 14) is situated during the taking of the record in the shutter 13.

Fig. 2 shows on an enlarged scale in section an example of a photoelectric-cell arrangement for taking pictures. Close behind the electron-permeable window 6, which is also held by the grid 79, is situated the photo-electric mosaic plate 81, which is subdivided by means of insulation-layers indicated in Fig. 2 by the short vertical lines, into as many small fields or photo-electric cathodes as picture-stippling points are desired. These small photo-electric cathodes forming the plate 81 are scanned successively by the electronic beam passing rapidly across them, with the result that a current of varying intensity flows through the cathodes to the common grid anode 82. Thus across each element is developed a potential having a value according to the resistance effective at any given moment dependent on the exposure of the cell in question. The developed potential between the anode 82 and ground is supplied to the amplifier 106' as shown in Fig. 4.

Instead of a photo-electric cell an exchangeable electrode arrangement of any desired formation can also be fixed on the recording apparatus behind the electron-permeable window, enabling a definite succession of current impulses to be sent out for which the receiving apparatus must be arranged accordingly.

A simple method of transmitting pictures also consists in first copying the picture according to a certain process onto a metal plate in such a

manner that definite conductivity-values at different points of the surface of the metal plate correspond to the varying intensities of light on different parts of the picture. For example, the picture on the metal plate may be a photographic reproduction in carbon or other resistance substance, or a print made with resistance substance. Some forms of printing ink may have sufficient electrical resistance for the purpose. The electronic beam passing through the electron-permeable window and the resistance image to the plate can excite directly fluctuations of current in the amplifier 106' (Fig. 4) which will serve to vary the intensity of the cathode-ray in the receiver.

A further possible method of application of the invention to picture-telegraphy consists e. g. in utilizing the travelling point of light produced outside the transmitter-tube on the fluorescent screen over a system of lenses for scanning the picture to be transmitted and having the reflected rays gathered up by one single large photo-electric cell.

Fig. 3 shows on an enlarged scale in section an example of the construction of an electron-permeable layer 6 for cathode-ray oscillographs with a supporting grid 79 of metal strips placed edgewise. The electronic beam when not in use falls behind one of the aluminum blades 83; the X-rays then generated are screened off by a lead mantle 84. The oscillogram or picture appears on a fluorescent layer fixed onto the exterior side of the electron-permeable foil 6. If photographic records have to be made, the light sensitive film or plate 14 is pressed closely onto the electron-permeable window 6 by means of the light-proof shutter 13.

Fig. 4 shows an example of an arrangement for a cathode-ray oscillograph in accordance with the invention, applicable for picture telegraphy and television, *a* denoting the receiver arrangement, *b* the transmitter arrangement; both are, wireless transmission being pre-supposed, connected with each other by way of antennae 91' and 91. For sending and receiving there serve respectively the cathode-ray oscillographs 92' and 92 with hot-cathode discharge devices 93' and 93 respectively, pairs of deflector plates 94', 95' and 94, 95 for producing a scanning movement of the cathode-ray beams of the respective oscillographs and electron-permeable windows 6' and 6. The pairs of deflector plates 94', 95', and 94, 95 respectively shown in the diagram for the sake of clearness as parallel lie in the actual apparatus in each tube in planes at right angles to each other. The feed voltage for the discharge tubes lies at points 97', 98', and 97, 98 respectively.

By means of intercepting-electrodes 99' and 99 respectively, arranged between the hot-cathodes in the tubes 93' and 93 respectively, and the corresponding anode 97' and 97, the generation of electronic-rays during the pauses in the scanning movement as controlled by plates 94' and thereby the fusing of the window, is prevented in a manner to be hereinafter described. The electrons passing through the electron permeable layer 6' of the transmitter tube 92' fall upon a photo-electric mosaic of known construction 100, the photo-electrically active layer 81 of which is divided in a manner known per se (for example, as disclosed in Patent No. 1,691,329 to Zworykin dated November 13, 1928, and Patent No. 1,780,364 to Reynolds dated November 4, 1930), into a large number of small separate areas shown enlarged in Fig. 2. On the photo-electric

layer there is formed by means of lenses 101 according to the known laws of optics, a picture of the object 102 to be reproduced, so that there falls upon each of the areas a definite, in general varying intensity of light. The illumination of each area takes place through the wide-meshed grid 82, which serves as common anode for all the small photo-electric cells. The actual transmission is effected by means of the high-frequency transmitter 103, of any known or suitable form for multiple signal transmission, as for example that described in the Zworykin patent above referred to, and provided with a common transmitting antennae 91' and modulated in known manner by the oscillators 104' and 105' as well as by the fluctuations of the photo-electric cells 81 conducted by way of amplifier 106'. Both oscillators 104' and 105' produce, by means of a device known per se, and represented diagrammatically in Fig. 8, oscillations with a time-proportional voltage-variation of the wave-shape sketched in Fig. 9. In this manner there is insured, in contrast to what happens in the case of the sinusoidal oscillations frequently used for such purposes, a precisely time-proportional scanning of the picture to be transmitted.

The transmission of a picture from the transmitter to the receiver takes place in the following manner:

The deflecting or sweep circuit oscillator 105' produces continuously oscillations of a definite frequency, about 10^5 per sec., which affect the pair of deflector plates 95' of the transmitter tube 92', and are transmitted by way of the high-frequency transmitter 103, the transmitting antenna 91', the receiving antenna 91, and the selective amplifier 105 operating in known manner as for example the selective amplifier 67—71 of the Zworykin patent above referred to, to the pair of plates 95 of the receiver tube 92. When oscillator 105' is alone working, the scanning sweep or oscillations of the electronic beam describe a stationary line equal to the height of the picture to be transmitted, both in the transmitter tube and receiver tube.

If now the deflecting or sweep circuit oscillator 104' is also switched on (frequency about 10^3 per sec.), which effects the second pair of deflector plates 94' standing at right angles to 95' of the transmitter tube, these oscillations are transmitted by way of the same path as those from oscillator 105', through a selective amplifier 104, to the pair of deflector plates 94 of the receiver tube 92 and the original line is once again transformed into a progressive zig-zag record. If the frequency of the oscillator 104' is properly adjusted, the record produced has the width of the picture transmitted. If in addition the sweep of the oscillator 105' is not greater than about the height of the line described by the focus spot, each point of the picture being transmitted, both in the transmitter tube and in the receiver tube, is scanned simultaneously and for an equal period by the cathode-ray beam.

The interception of the electronic beam when not being used is here effected by means of the intercepting electrodes 99 and 99' respectively by way of a—not here shown—tip-action electron-tube device similar to that represented in Fig. 7, which is controlled by means of the oscillator 104' and the amplifier 104 which latter two elements produce the scanning movement of the beams. As the cathode-ray beam on its way through the transmitter tube 92' meets with varying degrees of resistance according to the

conductivity of the photo-electric cell with which it happens to be in contact, fluctuations of current take place corresponding to the occurring differences of intensity. These fluctuations are transmitted by way of the amplifier 106', the high frequency transmitter 103', the transmitting antenna 91', the receiving antenna 91, and a selecting amplifier 106, onto the control grid 17 of the receiver tube 92, there giving rise to corresponding fluctuations of the beam-intensity, which in turn cause the requisite fluctuations in intensity of the picture reproduced on the fluorescent screen 6.

The arrangement schematically represented in Fig. 4—both the transmitting and the reception apparatus—allows also in the simplest manner possible of transmitting stereoscopic pictures to any distance and likewise of stereoscopic television. A stereoscopic picture, as is well known, consists of a pair of pictures side by side, representing respectively the right and left eye views of a scene or object. If the window 6' and 6 are made so long in one direction, e. g. in a direction perpendicular to the plane of the drawing, that a pair of stereoscopic pictures can be scanned adjacently and adjacently reproduced in the receiver, then both pictures may be scanned by the focal spot in one continuous line in each of both apparatus. The stereoscopic transmission of pictures and stereoscopic television may be thus realized by simply transmitting as a single picture, a pair of stereoscopic pictures side by side. The pair of stereoscopic pictures thus received side by side at the receiving station may be synthesized in known manner.

In Fig. 5 is exemplified on a larger scale the pliable device shown in Fig. 1 employed for shifting movable parts under a high vacuum. The device here serves for the adjustment of the electrostatic deflector-plate 8, by means of the pliable metal body 9 actuated by nut 107, pressing upon the carrier-bush 24. This is joined by means of three screws 25, sliding in slots of the jacket 26, with the guide-ring 27, into which, by means of an insulating washer 29, e. g. of Bakelite, is fixed the supporting rod 28 of the deflector plate 8. The pliable body 9 is joined in a vacuum-tight manner at both ends with its guide-rings, and likewise the insulating washer 29 with guide-ring 27; furthermore, the supporting rod 28 is guided by another perforated insulating washer 30. The ring 31 carrying washer 30 is fixed directly into the jacket 7 of the cathode-ray tube.

The tube 32 for auto-electronic discharge shown in Fig. 6 contains an anode 33 and an intercepting electrode (auxiliary anode) 34 which during the release of the beam functions as an anode. The release is effected by two spark gaps or glow-lamps 35 and 36 connected by way of windings 37, 38 with the perforated intercepting electrode 34 and by way of a high resistance element 39 with the cold cathode 40. The high-tension continuous current required for feeding the tube is generated in the known manner by means of transformer 41, valve 42, and condenser 43, the valve 42 acting in known manner as a rectifier permitting current to pass only downwardly therethrough, thus maintaining the condenser 43 charged with the lower plate positive and the upper plate negative. If the gaps 35 and 36 are properly adjusted, any sudden surge of voltage arising from the transmission line or antenna 44 and inducted from the winding 45 according to the polarity of the surge, either onto the winding 37 or 38, causes a sparking of the

gap 35 or 36, the duration of which depends upon the value of the capacity 46 and the resistance 47. By this the electrode 34, which has hitherto intercepted the beam, becomes an anode, and the extremely sharp point of the cathode 40 ejects an electronic beam through the perforations in the electrodes 34 and 33, the intensity of the beam can further be varied by means of the controlling electrode 33 by varying the angle of the cone-shaped electronic beam.

In the lower part of Fig. 6 is shown schematically an electrostatic device for concentrating the electronic beam. It consists of cylindrical metal tubes 48, sustained by supports 49 in such a position as to allow of the electronic beam passing freely through it, and of the metal ring washers 50 between the tubes 48. If the washers 50 are charged negatively to the tubes 48, divergent electric fields are formed, which exercise a force concentrating radially the beam. Thus an exceptionally minute focal spot is obtained. Adjustment of the voltage applied to the tube and washer elements at the polarity indicated in the diagram, and according to the spacing of the electron-permeable window will bring the rays to a focus at the window, as will be understood by those skilled in the art.

The thermionic cathode-ray tube 51 shown in Fig. 7, is provided with the hot cathode 52, anode 53, and control-grid 54 controlling the intensity of the electrons in the beam while the latter is working. In order to prevent the fusing of the window during periods when the focal spot is at rest, an intercepting electrode 55 is provided, actuated by a tip-action electron-tube device. This device consists of the electron-tubes 56, 57, and 58, the anodes of which are connected on the one hand by way of resistances 59 and 60 with the positive pole of a storage battery, and on the other hand crosswise by way of condensers 61, 62 with the grids of the tubes 56 and 57. Thus far the circuit arrangement is quite similar to the well known multivibrator circuit. However, in the present system the circuit is intended to function not as a multivibrator, but as a trigger or tip-acting device for releasing the blocking charge on the intercepting electrode 55. This change in the function is accomplished by substituting for the usual grid leak between grid and cathode, a battery 63, which by way of the high resistances 64, 65 keeps the condenser 61 charged to the potential of the battery 63 and the grid potential of the tube 56 at a lower level than the anode potential of tube 57, the amount of the diminution being about the same as the anode potential itself so as to bring the said grid potential to zero or negative. The potential between the grid and filament of tube 56 will be the algebraic sum of the potential of the anode of the tube 57 and the battery 63. If the grid of the tube 57, which tube is fully emitting during the interception of the cathode-ray beam, is affected by a surge of negative voltage issuing from the antenna or transmission line 66 by way of the resistances 67 or 68, and by way of the condenser 69, the arrangement tips over into its other position of stable equilibrium. In that case tube 57 is blocked. The grid potential of tube 56 and therewith that of the intercepting electrode, hitherto negative, now receive the same potential as hot cathode 52, or a potential positive to it due to the rise in potential across the terminals of tube 57, and the cathode-ray beam is released. If the surges issuing from the antenna or line 66 are positive, the tube 58 acts in the same manner.

By means of resistance 70, the time of the tipping-over of the device back into the position of equilibrium corresponding to the period of interception of the cathode-ray beam may be adjusted at will, thus enabling the release to be maintained for any length of time desired.

Fig. 8 refers to a device suitable for the production of oscillations with linear variation of voltage, such as is provided for the oscillators 104' and 105' in Fig. 4. In Fig. 8, 71 and 71' are triode valves, fed by the batteries 72 and 72'. By the saturation-current of these valves, the condenser 73 is alternately charged and discharged by way of the resistances 74 and 74'. The charging and discharging is automatically controlled by the grids 76 and 76', the potential of which is maintained at a suitable level by means of batteries 75 and 75'. By varying the capacity of the condenser 73, the required frequency may easily and swiftly be obtained when working.

If the saturation-currents of the valves 71 and 71' are selected at various values, or the resistances 74 and 74' are given different resistivities, the upward branches 77 of the oscillations taking place proportionally with the time (see Fig. 9) become less steep than the downward branches 78, whereby both in the transmitter and in the receiver the effect of the downward branches is diminished in comparison with that of the upward branches.

If the batteries 75 and 75' shown in the connection-scheme Fig. 8 and their connections are omitted, the grid 76' joined with the hot cathode of its tube, and the grid 76 effected by the voltage of a control of the cathode-ray oscillograph, e. g. by the voltage of the oscillator 105' shown in Fig. 4, then to accumulate a definite charge after a given number of impulses from the oscillator 105', a positive dependence is obtained of the control voltage 104' upon the voltage of the control 105'. That is to say, the lengthwise return of the focal spot occurs always after a definite number of transverse oscillations.

What I claim is:

1. A transmission system comprising a cathode ray oscillograph having means to produce a beam of electrons, means to deflect the beam of electrons, an electron permeable window lying in the path of said beam of electrons, means to direct the beam of electrons through said window, a picture area electrode behind said window outside of said oscillograph and immediately adjacent thereto, said electrode being adapted to be scanned by electrons passing through said window, means for deriving from said electrode electric potentials produced by the scanning electrons which vary in accordance with the light and shades of the elemental areas of the picture area, a second cathode ray oscillograph having a focused beam of electrons, means to deflect the focused beam of electrons of said second oscillograph synchronously with the deflections of the beam of electrons of the first named oscillograph, and means to vary the intensity of the focused beam of electrons of said second oscillograph in accordance with the derived potentials from said picture area electrode.

2. A transmission system comprising a cathode ray oscilloscope having means to produce a beam of electrons, means to deflect the beam of electrons, an electron permeable window lying in the path of said beam of electrons, means to direct the beam of electrons through said window, a light sensitive electrode behind said window outside of said oscilloscope and immediately adja-

cent thereto, said electrode having a picture area and being adapted to be scanned by electrons passing through said window, and means for deriving from said electrode electric potentials produced by the scanning electrons which vary in accordance with the lights and shades of the elemental areas of the picture area.

3. A transmission system comprising a cathode ray oscillograph having means to produce a beam of electrons, means to deflect the beam of electrons, an electron permeable window lying in the path of said beam of electrons, means to direct the beam of electrons through said window, a metal plate electrode having different conductivity values at different points corresponding to the varying lights and shades of a picture, said electrode being positioned behind said window outside of said oscillograph and immediately adjacent thereto and adapted to be scanned by electrons passing through said window, means for deriving from said electrode electric potentials produced by the scanning electrons which vary in accordance with the lights and shades of the points of the picture, a second cathode ray oscillograph having a focused beam of electrons, means to deflect the focused beam of electrons of said second oscillograph synchronously with the deflections of the beam of electrons of the first named oscillograph, and means to vary the intensity of the focused beam of electrons of said second oscillograph in accordance with the derived potentials of said metal plate electrode.

4. A transmission system comprising a cathode ray oscillograph, means to produce a beam of electrons, an electron permeable window lying in the path of said beam of electrons, means to direct the beam of electrons through said window, means to deflect the beam of electrons over the area of said window, a plate having a picture formed of electrical responsive material on one surface of said electrode, said electrode being positioned behind said window outside of said oscillograph and immediately adjacent thereto with the picture facing said window, said picture being adapted to be scanned by electrons passing through said window, means for deriving from said plate electric potentials produced by

the scanning electrons which vary in accordance with the lights and shades of the elemental areas of the picture, and an output circuit to receive the derived potentials.

5. A transmission system comprising a cathode ray oscillograph, means to produce a beam of electrons, an electron permeable window lying in the path of said beam of electrons, means to direct the beam of electrons through said window, means to deflect the beam of electrons over the area of said window, a plate having a permanent image formed of electrical responsive material on one surface of said electrode, said electrode being positioned behind said window outside of said oscillograph and immediately adjacent thereto with the permanent image facing said window, said permanent image being adapted to be scanned by electrons passing through said window, means for deriving from said plate electric potentials produced by the scanning electrons which vary in accordance with the lights and shades of the elemental areas of the permanent image, and an output circuit to receive the derived potentials.

6. A transmission system comprising a cathode ray oscillograph, means to produce a beam of electrons, an electron permeable window lying in the path of said beam of electrons, means to direct the beam of electrons through said window, means to deflect the beam of electrons over the area of said window, a plate having a predetermined optical image formed of electrical responsive material on one surface of said electrode, said electrode being positioned behind said window outside of said oscillograph and immediately adjacent thereto with the predetermined optical image facing said window, said predetermined optical image being adapted to be scanned by electrons passing through said window, means for deriving from said plate electric potentials produced by the scanning electrons which vary in accordance with the lights and shades of the elemental areas of the predetermined optical image, and an output circuit to receive the derived potentials.

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