Sept. 3, 1957 R. THEILE 2,805,359

TELEVISION PICK-UP TUBES AND TELEVISION APPARATUS INCORPORATING THE SAME

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Fig. 1.

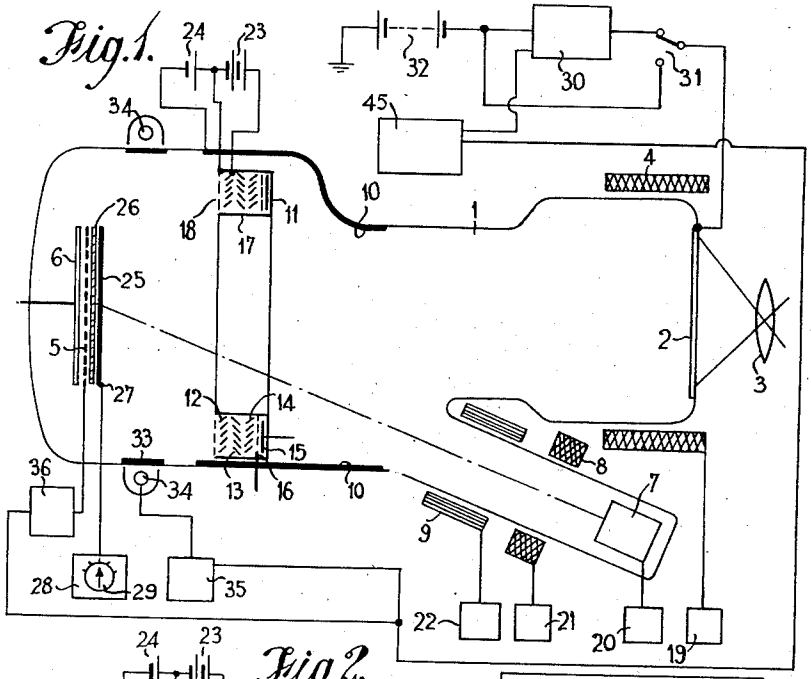
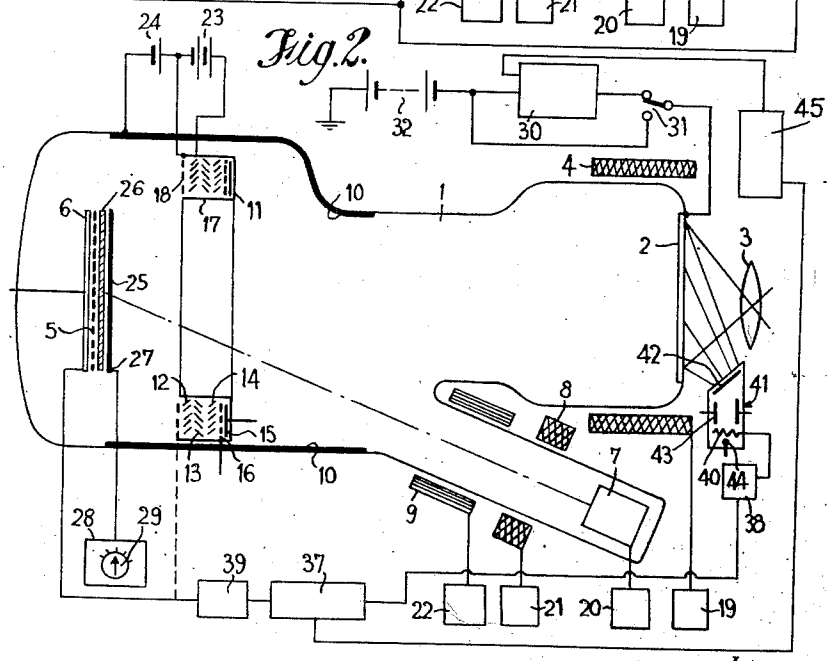


Fig. 2.



Inventor
Richard Theile,

By
Emery, Holcombe & Blair,
Attorneys

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TELEVISION PICK-UP TUBES AND TELEVISION APPARATUS INCORPORATING THE SAME

Richard Theile, Cambridge, England, assignor to Pye Limited, Cambridge, England, a British company

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13 Claims. (Cl. 315—11)

The present invention relates to television pick-up tubes of the storage type in which the scanning of the storage surface or target is effected by high velocity electrons, for example, of the order of 1000 volts, and in which the modulated signal current leaving the storage surface as a result of the scanning process is multiplied by means of a secondary emission multiplier. Examples of such pick-up tubes are described in the specifications of co-pending U. S. application Serial No. 286,069 filed May 5, 1952, for "Television Pick-Up Tubes" and which is now U. S. Patent No. 2,786,157, granted March 19, 1957.

It is known to bias the target in high velocity scanned pick-up tubes, such as iconoscopes and image iconoscopes, to a potential which is negative relative to the potential at which the target normally stabilises, by flooding the target with a stream of low velocity electrons. These electrons may be photoelectrons released from an appropriately positioned photo-cathode surface within the tube envelope and illuminated by an external light source. Arrangements for this purpose are described, for example, in the specifications of United States Patent No. 2,622,226 dated December 16, 1952 for "Television Pick-Up Tubes" and in the specification of copending application Serial No. 258,459 filed November 27, 1951 for "Television Pick-Up Tubes, and Television Transmitting Apparatus Incorporating the Same" and which is now U. S. Patent No. 2,738,440, granted March 13, 1956.

The present invention has for an object to adapt this target biassing technique to multiplier pick-up tubes of the kind first above referred to.

According to the present invention, a multiplier multiplier tube as above referred to is provided with a photo-cathode and associated light source for biassing the target negatively according to the above-mentioned technique, wherein the photo-cathode is illuminated only during a part or the whole of the line and/or frame blanking periods. This may be carried into effect by feeding current to the lamp or lamps constituting the light source in pulses timed with the line and/or frame blanking periods.

Since the photo-cathode producing the low velocity bias photo-electrons is located closely adjacent the multiplier, these slow electrons tend to be collected by the multiplier and would introduce noise in the output signal from the multiplier if the bias photo-electrons were produced during the actual picture scanning periods. By means of the present invention, deterioration of the signal-to-noise ratio due to bias photo-electrons being taken by the multiplier is reduced by illuminating the photo-cathode only during the line and/or frame blanking periods during which periods no actual picture signals are being collected by the multiplier.

If desired the target may be pulsed positively with respect to the photo-cathode during the intervals when the light source is illuminated. This, however, is not essential since the target is automatically maintained positive with respect to the photo-cathode by reason of the field penetration of the multiplier.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which show two embodiments thereof by way of example, and in which

Fig. 1 shows one form of the invention using a separate photo-cathode, and

Fig. 2 shows another form of the invention in which the photocathode of a tube the image iconoscope type is utilised for biassing the target negatively.

The pick-up tube shown in Figure 1 is of the image iconoscope type and comprises an evacuated envelope **1** formed in known manner at one end with a photo-cathode 2 on which the picture to be projected is focussed by a lens 3. The released photo-electrons are focussed by the focus coil 4 on to the storage plate **5** backed by the signal plate **6**, the focus coil **4** being energised from a suitable potential source **19**. The storage plate is arranged to be scanned by an electron gun **7** fed from a source **20** and located in a side tube of the envelope **1**, the scanning beam being focussed and deflected by the focus coil **8** energised from a potential source **21** and deflecting coils **9** fed with modulating waveforms from a source **22**. The internal surface of the envelope **1** is provided with a conductive wall coating **10** normally constituting the collector electrode of the tube. The tube construction as so far described is conventional and well-known in the art.

The tube also includes an electron multiplier which may be in the form of a ring structure generally indicated at **11**, the axis of which is slightly off-set from the tube axis, as shown, in order to minimise masking of electrons emanating from the gun **7**. However, in certain circumstances it may be coaxially mounted if desired. The multiplier electrodes constituted by the first, second, third and fourth dynodes **12**, **13**, **14** and **15** respectively and the collector **16** are enclosed in a screening box **17**, the end of which, facing the storage plate **5**, is covered by a screen **18** through which the secondary electrons released from the storage plate 5 pass to impinge upon the first dynode **12**. The screening box **17** and screen **18** may be held at approximately the same potential as the wall coating **10** and are held at a potential substantially less (of the order of 100 volts or more) than the potential of the first dynode **12**, as shown schematically by the interposition of a potential source **23**. The size of the aperture in the screen **18** and its spacing from the first dynode **12** are so determined that there is about 3% penetration of the positive field of the first dynode into the space near the storage plate. Such a low field penetration does not substantially increase the potential at which the surface of the storage plate stabilises whilst it is sufficient to accelerate and cause the secondary electrons to be collected by the multiplier. The field penetration should, furthermore, be such that the potential at which the surface of the storage plate stabilises is positive with respect to the wall coating **10** so that the latter produces a retarding field upon the secondary electrons and the latter are not lost to the surrounding electrons but are collected by the multiplier.

The ratio of the diameter of the annular multiplier structure to the distance between the screen **18** and the storage plate is made such as to produce a substantially uniform field over the surface of the storage plate. Since the insulating surface of the storage plate stabilises approximately to the adjacent space potential, any non-uniformity in the space potential produced from the field by the multiplier dynode would cause different portions of the plate to stabilise at different potentials thereby giving rise to spurious signals. The ratio of the said diameter and distance is so chosen that the storage plate is at a position where the field is of maximum flatness, the influence exerted by the signal plate and the wall coating on this field being taken into account.

The distance between the first dynode and the screen **18**, as well as the relative potentials therebetween have an effect upon this field. Further, by varying the relative potentials of the screening box and the wall coating, for example, by making the potential of the former slightly positive or negative with respect to the potential of the latter as shown schematically by the interposition of a potential source **24**, which makes the potential of the screening box slightly positive with respect to the coating **10**, slight correction may be effected in the field disposition in order to obtain field uniformity over the surface of the storage plate.

If desired, the geometric arrangements and the potentials applied to different parts thereof may be adjusted to produce a desired non-uniform field over the storage plate to compensate for "shading" or other spurious signals.

Preferably the surface of the storage plate **5** is arranged to have a small amount of surface leakage in order to equalise any residual unevenness of the storage plate without noticeable dilution of the charge pattern due to the picture storage. This may be achieved by providing the surface of the storage plate with a slightly conducting layer **25** which may, for instance, be of glass. An insulating layer **26** is interposed between the conductive layer **25** and the surface **5**, and the peripheral regions of the conducting layer **25** may be formed with conducting electrodes **27** which, if desired, may be connected to a source **28** of bias for biassing the surface of the conducting layer to improve the efficiency of operation and change the transfer characteristic. Preferably, the source **28** is adjustable under control of a control member **29**.

With a pick-up tube, such as so for described above, the noise level in the picture is produced by the shot noise of the scanning beam current and also of the photo-current itself. When operating under low light conditions for which the multiplier tube is most suitable, the average photo current is less than, or at the most equal to, the scanning beam current so that the noise due to the photo-current is not appreciable and only increase the general noise by about a few percent. However, under high light conditions, the lens adjustment, i. e., the aperture of the pick-up tube, is more critical in order to avoid noise as the increased light, which improves the picture, causes excessive noise. To overcome or reduce this difficulty, the tube is arranged to have its photo-cathode **2** operative only during the picture blanking intervals, which may be the frame blanking intervals and/or the like blanking intervals when the tube is operating under high light conditions or when the photo-current is interrupted during scanning of the tube.

To bring this about, the photo-cathode **2** may be biassed negatively by a series of pulses corresponding to the picture blanking pulses. In the embodiment illustrated, the biassing pulses are produced by a pulsing device **30**, although if desired they may be obtained by appropriate voltage amplification of the blanking pulses. A switch **31** may be incorporated to cut out the biassing pulses and to bias the photo-cathode **2** continuously for continuous photo-emission when the tube is operating under low light conditions. The pulsing device **30** is connected to a suitable source **32** for the production of the negative pulses. If desired, means may be provided for operating the switch **31** automatically in dependence upon the amount of average light in the scene or in the picture to be transmitted.

In accordance with the invention, the tube is provided with an additional photo-cathode and associated light source or sources for biassing the target **5** negatively and this photo-cathode is illuminated only during a part or the whole of the line and/or frame blanking periods. In this embodiment, the photo-cathode is shown at **33** in the form of an annular semi-transparent photo-cathode layer applied to the interior of that part of the tube envelope which lies between the multiplier **11** and the target **5** and the light source or sources **34** comprise a plurality of small electric lamps around the tube as shown, and current is fed to the lamps **34** in pulses timed with the line and/or frame blanking periods. Conveniently these pulses may be produced by a pulse generator **35** which is arranged to operate in conjunction with the means for producing the line and/or frame blanking periods in a manner which is well-known in the art.

For example, the generator **30** may be controlled by a master oscillation generator **45** that forms part of the means for producing the line and/or frame blanking periods. To obtain the synchronising relationship between the generators **30** and **35**, the generator **35** also is controlled from the generator **45**. It will be understood that other light sources may be provided for effecting the energisation of the photo-cathode **33**, for example, a continuous lamp in the form of an annular strip may be used.

If desired, the target **5** may be pulsed positively with respect to the photo-cathode **33** during the intervals when the light source or sources **34** is iluminated. This may be effected, for example, by means of the pulse generator shown schematically at **36**. To obtain synchronisation generators **36** and **45** are also connected together. This expedient, however, is not essential since the target **5** is automatically maintained positive with respect to the photo-cathode **33** by reason of the field penetration of the multiplier **11**.

Although this embodiment of the invention has been described in combination with a tube of the image iconoscope type, it will be appreciated that it could also be applied to a tube of the normal iconoscope type.

Referring now to Figure 2, the invention is here shown specifically in conjunction with a tube of the image iconoscope type and in which the ordinary photo-cathode **2** thereof is used for the negative biasing effect instead of providing an additional photo-cathode as in the arrangement of Fig. 1. Since the tube and its operating arrangements may be the same as described previously with respect to Figure 1, the same reference numerals are employed in Figure 2 for parts having the same function as those in Figure 1 and, therefore, the complete operation of the tube of Figure 1 need not be re-described. However, it will be observed that the collector wall coating **10** extends further along the interior wall surface of the tube towards the target than is the case in Figure 1.

In order to bias the storage surface **5** negatively, the photo-cathode **2** is flooded with light during at least part of the frame blanking intervals whilst simultaneously applying pulses a positive potential to the target, for example, to the signal plate thereof or negative pulses to the collector electrode or the electron multiplier. This may be effected by means of a sub-master oscillator **37** which is arranged to energise a pulse generator **38** in synchronism with a second pulse generator **39**. The pulse generator **38** is connected to the modulating electrode **40** of a cathode-ray tube **41** whose screen **42** is angularly placed so that it may illuminate the whole of the photo-cathode **2** of the tube **1**. In order to obtain the necessary synchonisation between the generators **30** and **38**, the master oscillation generator **45** is connected to the sub-master oscillator **37** and to the generator **30**. The cathode of the tube **41** is shown at **44** and conventional beam electrodes at **43**. The timing of the pulse generator **38** is such that it will apply pulses to the electrode **40** of the tube **41** to allow the screen **42** to be energised during at least part of the frame blanking intervals so that the photo-cathode **2** is illuminated by screen **42** only during that time. The pulse generator **39** is operated in synchronism with the pulse generator **38** so that simultaneously with the flooding of the photo-cathode **2** with light, positive pulses are applied to the signal plate **6** so that a field is provided for returning the secondary electrons emitted by the storage surface **5** over the surface thereof in proper time sequence. Alternatively, however, the pulse generator **39** may be arranged to feed negative pulses to the col-

lector electrode **10** or multiplier **11** (screen **18** and/or dynode **12**). The dotted line connection shows how negative pulses may be applied to the collector electrode **10**. If this dotted connection be employed, obviously the connection between the generator **39** and the signal plate **6** would not be used. It will also be obvious that the dotted line could connect the generator **39** and the electron multiplier.

If desired, the biassing pulses may be applied only during a fraction of the frame blanking periods, the picture to be transmitted being projected on to the target during the remaining portions of the frame blanking periods. With this arrangement, noise due to the photo-current is reduced since the photo-current is only produced during the frame blanking intervals, which is particularly advantageous when operating under high light conditions.

Arrangements for biassing the target surface in high-velocity pick-up tubes such as iconoscopes and image iconoscopes are described for example in the specification of United States Patent No. 2,733,292 dated January 31, 1956 and titled "System for Correcting the Equilibrium Potential of Storage Means" and in the specification of United States Letters Patent No. 2,651,674 dated September 8, 1953 for "Apparatus Incorporating a Video Storage Tube, and Method of Operating Same."

I claim:

1. A television pick-up system comprising a pick-up tube of the storage type having a target with a charge-storage surface, means for scanning the charge storage surface or target with a beam of high velocity electrons, comprising a secondary electron multiplier extending around the inside of the tube and facing said charge-storage surface and itself comprising a plurality of multiplying electrodes with an electrical screen electrode interposed between said electron multiplier and said storage surface or target, a photo-cathode in said tube, a light source located to illuminate said photo-cathode and means associated with said light source for supplying current to it only during the picture-blanking periods of operation of said tube.

2. A television pick-up system as claimed in claim 1, comprising a pulse generator operable in timed relation with said picture-blanking periods and connected to said light source.

3. A television pick-up system comprising a pick-up tube of the image iconoscope type having a target with a charge-storage surface, an electron multiplier extending around the inside of the tube and facing said charge-storage surface, a light source arranged to illuminate the photo-cathode of the tube, means for pulsing said light source in timed relation with the picture-blanking periods of operation of the tube, and means for simultaneously pulsing the target suface positively.

4. A television pick-up system comprising a pick-up tube of the image iconoscope type having a target with a charge-storage surface, an electron multiplier extending around the inside of the tube and facing said charge-storage surface, a light source arranged to illuminate the photo-cathode of the tube, means for pulsing said light source in timed relation with the picture-blanking periods of operation of the tube, and means for simultaneously pulsing the collector electrode negatively.

5. A television pick-up system comprising a pick-up tube of the image iconoscope type having a target with a charge-storage surface, an electron multiplier extending around the inside of the tube and facing said charge-storage surface, a light source arranged to illuminate the photo-cathode of the tube, means for pulsing said light source in timed relation with the picture-blanking periods of operation of the tube, and means for simultaneously pulsing the said electron multiplier negatively.

6. A television pick-up system comprising a television pick-up tube of the image iconoscope type having a target with a charge-storage surface, an electron multiplier extending around the inside of the tube and facing said charge-storage surface, means for pulsing said charge-storage surface positively, a cathode ray tube external of said pick-up tube and having a screen located to illuminate, when energised, the photo-cathode of the tube, a control electrode in said cathode ray tube, and means for applying pulsed modulation to said electrode in timed relation with the picture-blanking periods of said pick-up tube, and simultaneously with the pulsing of said charge-storage surface.

7. A television pick-up system as claimed in claim 6, comprising a pulse generator connected to said control electrode; said pulse generator being fed from a master oscillator which is also connected to a second pulse generator connected in turn to the signal plate of said tube to provide positive pulses thereto.

8. A television pick-up system as claimed in claim 6, comprising a pulse generator connected to said control electrode, said pulse generator being fed from a master oscillator which is also connected to a second pulse generator connected in turn to the collector electrode to supply negative pulses thereto.

9. A television pick-up system as claimed in claim 6, comprising a pulse generator connected to said control electrode, said pulse generator being fed from a master oscillator which is also connected to a second pulse generator connected in turn to the said electron multiplier to supply negative pulses thereto.

10. Television transmission apparatus, comprising a pick-up tube of the charge-storage type having a target with a charge-storage surface, means for scanning said charge-storage surface with a beam of high-velocity electrons, a secondary-electron multiplier extending around the inside of the tube and facing said charge-storage surface, a source of electrons in said tube, means for energising said source to spray the charge-storage surface with electrons, and means associated with said energising means to effect the electron spraying only during picture blanking periods of operation of the tube.

11. Television transmission apparatus comprising a pick-up tube of the charge-storage type having a target with a charge-storage surface, means for scanning said charge-storage surface with a beam of high-velocity electrons, a secondary-electron multiplier extending around the inside of the tube and facing said charge-storage surface, an electrical screen between said electron multiplier and said charge-storage surface, a source of electrons in said tube, means for energising said source to spray the charge-storage surface with electrons, and means associated with said energising means to effect the electron spraying only during picture blanking periods of operation of the tube.

12. In television transmitting apparatus the combination of a pick-up tube of the charge-storage type having a charge-storage target, means for scanning said target with a beam of high velocity electrons, a secondary-electron multiplier device located within said tube between said target and said scanning means offset from the tube axis to be out of the path of the scanning beam, a source of electrons in said tube, means for energising said source of electrons to spray said target with a rain of low-velocity electrons, and means for effecting operation of said energising means only during the picture blanking periods of operation of the tube.

13. In television transmitting apparatus the combination of a pick-up tube of the charge-storage type having a charge-storage target, means for scanning said target with a beam of high velocity electrons, a secondary-electron multiplier device located within said tube between said target and said scanning means offset from the tube axis to be out of the path of the scanning beam, an electron-permeable electrode between said multiplier device and said charge-storage target, a source of electrons in said tube, means for energising said source of electrons to spray said target with a rain of low-velocity electrons, and means for effecting operation of said energising means

only during the picture blanking periods of operation of the tube.

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