

July 5, 1960

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2,944,155

TELEVISION PICKUP TUBE

Filed Jan. 30, 1957

2 Sheets-Sheet 1

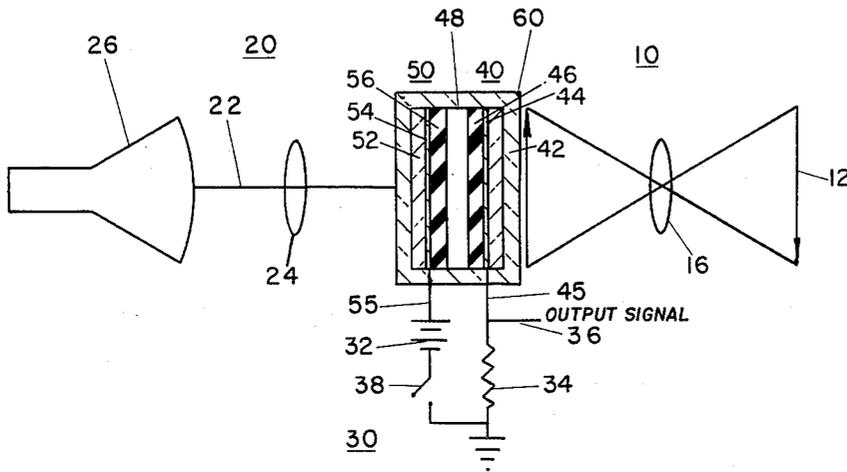


FIG. 1

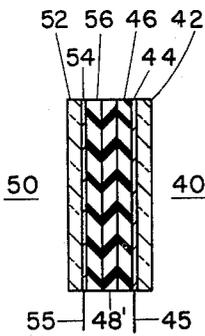


FIG. 2

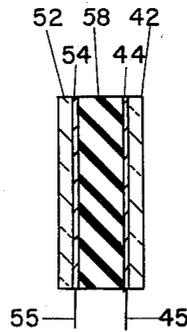


FIG. 3

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2 Sheets-Sheet 2

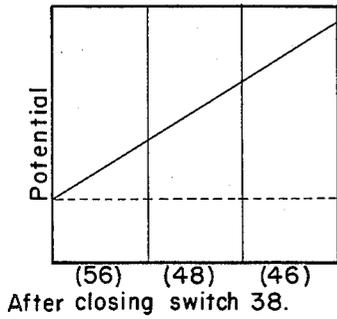


FIG. 4a

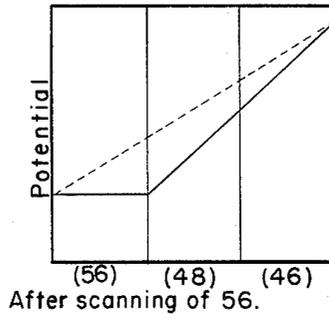


FIG. 4b

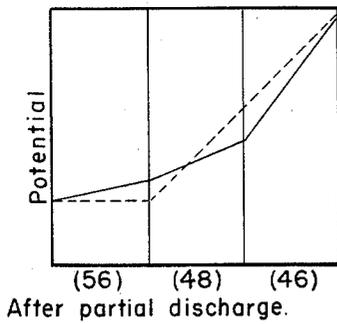


FIG. 4c

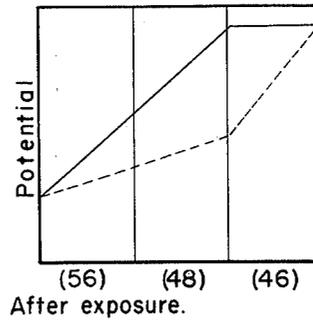


FIG. 4d

----- before
——— after

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TELEVISION PICKUP TUBE

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1 Claim. (Cl. 250—213)

This invention relates to an image transducer. More particularly, it relates to a device in which a light image is converted into an electrical signal which can be transmitted to a location remote from that at which the light image is produced and converted, in turn, into the desired intelligence at a point of reception. One practical use of a device of this type is as a television pickup tube.

In the prior art many devices are known for accomplishing the same objective, but such devices are characterized by the presence of complex components which must be accurately dimensioned and precisely controlled in order to achieve the desired result. One such device is commonly known as a Vidicon, described in an article beginning on page 70 of the May 1950 issue of Electronics Magazine.

In the Vidicon, a stream of electrons is employed to scan one face of a photoconductive target, the other face of which receives information in the form of illumination falling thereon. The result is an output in the form of an electrical signal which reproduces electrically the information received on the photoconductive target.

In accordance with the system invented by me, the target is scanned by means of a light beam instead of an electron beam, and the target itself is modified. Thus my invention differs from prior art pickup devices in the scanning and in the means provided for converting light into charge.

The following description, taken with the drawings, will serve to explain the device constituting my invention.

In the drawings:

Figure 1 is a diagrammatic sketch showing one overall system contemplated by me;

Figure 2 is a diagrammatic representation of a solid state modification of the pickup device of Figure 1, in which the liquid or gaseous dielectric is replaced by a solid dielectric material;

Figure 3 is a further modification of the device of Figure 2; and

Figures 4(a)—4(d) illustrate schematically the voltage gradients across the transducer at various stages of the process.

As may be seen in Figure 1, the device comprises an input optical system 10 which is merely a means for introducing a light image 12 or an X-ray image onto a suitable receiving surface, either continuously or intermittently. With an X-ray source, the lens 16 shown would, of course, be unnecessary. The information fed into the system may take the form of a film projected onto the detecting surface, or as slides projected thereon, or merely as a spotlight beam moving in a controlled path, or any other illuminated scene.

The second portion of my novel image transducer is a scanning system 20. Essentially, the scanning system comprises a controlled spot of light 22 which can be focused, for example, by a lens system 24 onto a surface of the pickup unit. In Figure 1 the scanning spot is shown as produced by a cathode ray tube 26. It will be

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understood, however, that any beam of light or light spot may be used for scanning.

The third essential portion in the system devised by me is an output circuit 30. Essentially, this comprises a source of potential 32 and a load resistor 34, together with suitable amplifiers (not shown) and a conductor 36, to conduct the output signal from the device to a receiver (not shown). The circuit is completed through a switch 38 and through the novel pickup device constituting my invention.

The pickup device shown in Figures 1 and 2 consists of two units 40 and 50 arranged in a specific fashion and connected in a suitable circuit so that potential 32 is applied across them. Unit 40, shown in greater detail in Figure 2, is composed of a backing layer of a transparent material, such as glass 42, on which there is provided a thin transparent conductive coating 44 of tin oxide, for example, which is shown with a greatly exaggerated thickness. On this there is supported a photoconductive layer 46. Unit 50 is similarly constructed, 52 representing a transparent support of glass with an electrically conductive film 54 supported thereon, and 56 representing another photoconductive coating supported on the electrically conductive film. In the modification shown in Figure 1, members 40 and 50 are disposed with the photoconductors facing each other and are spaced less than about $\frac{1}{4000}$ of an inch apart. Photoconductive targets 40 and 50 may be manufactured in the same manner as conventional Vidicon targets, for example, in the manner described in United States Patents 2,654,852; 2,687,484; 2,710,813 or 2,744,837, or in any known fashion. Manufacturing these targets forms no part of the present invention.

As shown in Figure 1, the conductive films 44 and 54 of targets 40 and 50 are electrically connected by leads 45 and 55 in a circuit in which potential 32 may be impressed across the capacitor formed by the photoconductive elements 46 and 56 and the gap 48 between them. Between the two photoconductive surfaces the dielectric may be air or other gas, or a suitable liquid, preferably an oil, disposed between the two photoconductive surfaces. To permit operation under subatmospheric pressure and to avoid the disturbing influence of dirt or dust, or to minimize evaporation of any liquid in gap 48, it may be preferable to provide a glass or other protective envelope about the transducer. Conventional methods are known for forming such envelopes and of constructing them so that leads 45 and 55 may be suitably connected to the output circuit 30. The envelope 60 is shown in Figure 1 in close proximity to the elements 40 and 50. Obviously the envelope may be enlarged so that the targets are spaced an appreciable distance from the walls of the envelope, or the transparent supports 42 and 52 may consist of the end walls of the envelope itself without departing from my inventive concept.

In Figures 2 and 3 there are diagrammatically shown two other embodiments of the transducer of Figure 1. The solid state pickup device of Figure 2 is similar to that shown in Figure 1 in all respects except that the dielectric between the two photoconductive elements is an insulator 48'. In the somewhat simpler form shown in Figure 3, a single photoconductive layer 58 is disposed between the two conductive films 44 and 54.

In order that the invention may be better understood, the operation of the device of Figures 1 and 2 will next be described.

Considering the system before any information is received by the input portion of the system, the two photoconductive members, together with the gap between them, form in effect a condenser across which a potential is impressed when the switch is closed. When the scanning spot of light illuminates each small incremental area of

the surface of photoconductor 56 in turn, the photoconductor of each incremental area experiences an increase in conductivity and permits a partial discharge across layer 56. This causes the rear surface of the layer to attain a potential approximately that of the electrode. This increases the field gradient across the gap to a value above that at which discharge will occur across the gap. This discharge causes transferral of charge to the rear surface of photoconductor 46. Without information in the form of a light signal falling upon surface target 40, the output signal will fall, after the first scan, to a negligible value since the rear of layer 46 will charge up to a potential sufficient to prevent further discharge across gap 48. Now when a light image or an X-ray image is received on the surface of target 40 to the photoconductor 46 will be partially discharged and the charge pattern produced will correspond in intensity to the information imaged onto the target. As a result, when the light beam 22 scans target 50 in a repetition of the scanning cycle, it will effect a discharge across the gap separating the photoconductors wherever the charge on the photoconductor has been sufficiently altered by the light to which it has been exposed. This discharge will be detected as a measurable difference in the output signal which will then represent the light received on target 40.

Figures 4(a)-(d) illustrated in diagrammatic form the potential gradient across the system consisting of photoconductor 46 and photoconductor 56 and the dielectric or gap 48 between them. In these figures the ordinates represent potential and the abscissae represent the distance through the photoconductor 46, the gap 48 and the photoconductor 56.

Figure 4(a) shows the system diagrammatically before any light is put into the system. When switch 38 is closed the potential difference that exists across gap 48 as a result of the battery 32 is insufficient to cause breakdown or discharge across the gap. The potential drop across this gap is dependent upon the dielectric constant of the photoconductor, the material in the gap and the battery potential 32. These are maintained so that the condition of no discharge occurs without the application of light. When light in the form of the scanning spot strikes photoconductor 56, because of the change in conductivity which this produces, the potential drop across the photoconductor is greatly diminished and may be reduced to almost zero, as shown in Figure 4(b). The gradient across the dielectric or gap is, therefore, increased to maintain the over-all potential drop between leads 45 and 55. Breakdown and discharge across the dielectric occur to produce the condition shown diagrammatically in Figure 4(c). When light or X-rays are imaged onto the photoconductor material of target 40 to the photoconductive material experiences a reduction in resistance sufficient to permit partial discharge across this photoconductive material and produces the condition shown in Figure 4(d), which is similar to that shown in 4(b).

As the scanning spot passes each point on the complementary photoconductive member, it causes the photoconductor to experience an increase in photoconductivity which will be sufficient to cause discharge to occur across the gap whenever it is focused on an area directly opposite that which possesses a diminished potential because of the light imaged on it. As a result, whenever the flying spot impinges on an area opposite that at which the photoconductor has recently been altered by virtue of exposure to light, or is presently being subjected to exposure to light, discharge will occur and an output signal will be produced which corresponds in magnitude to the amount of illumination imaged on the photoconductor target. Once the scanning spot passes on to an area opposite that which is unilluminated or which has not recently received any illumination, the charge on the photoconductive surface is just below that at which discharge will occur and the output signal will reflect this

difference. As the information projected as a changing pattern of illumination is altered, the signals produced by repeated traverses of the scanning light beam will indicate the nature of these changes.

In operation, the modification in Figure 2 is virtually identical with the modification of Figure 1 except that the insulator 48' must be thin enough so that transport of charge through it occurs at extremely low potential. During the time between repeated scans the charge on target 40 decays by virtue of the light or X-ray image being projected onto its outer surface. When the scanning spot passes each point on target 50 opposite target 40, sufficient charge is placed on the surface of target 40 to restore it to the potential of Figure 4(b). This causes a voltage to appear across the output resistor 34 which will be proportional to the amount of discharge of the photoconductor 46 and hence will be proportional to the light imaged on the photoconductor. When the scan passes areas which have not been illuminated no potential change is experienced and the output signal produced indicates this.

In the modification shown in Figure 3 only a single photoconductor 58 is employed, and the pickup device comprises two transparent supports 42 and 52 on which thin conductive films 44 and 54 are present between the photoconductor 58 and the supports 42 and 52. The range of the hole or electron carriers in the photoconductor determines the thickness of layer 58. In general, the thickness of the photoconductor provided is between 1.25 and 1.75 times the average carrier range, which is on the order of 1 to 10 microns. This would mean that the light or X-ray imaged on the one surface of the photoconductor could move charges from about $\frac{1}{4}$ to $\frac{1}{5}$ of the distance through the layer 58 in which zone a large percentage would be trapped. The trapped charges are freed by scanning the opposite side of the photoconductor and transported through layer 58 to appear as an output signal. In this embodiment and in each of the previously described modifications, the photoconductor preferred by me is amorphous selenium, but it will be understood by others skilled in the art that other photoconductors having a suitable combination of properties may be employed without departing from the spirit of my invention. I prefer photoconductors possessing a high resistivity, e.g., amorphous selenium or antimony trisulfide, but any other suitable photoconductor may be used.

Each of the pickup devices described above may be employed in color television.

The devices described above are comparatively simple and inexpensive to construct. Unlike prior art pickup devices, they are adapted to be used at higher potentials than conventional Vidicons, with consequent increased sensitivity and to be used in sizes which are greatly enlarged as compared with prior art pickup tubes. Indeed, the size of the camera is limited only by the ability to project the scanning light spot accurately.

Having now described my invention in accordance with the patent statutes;

I claim:

1. A device for converting a light image into an electrical signal corresponding to said light image which comprises: a unitary assembly consisting essentially of a thin phototconductive wafer consisting of a photoconductive core having on each of two of the larger opposed faces respectively a transparent layer and an electrically conductive layer, the thickness of the photoconductive core of said wafer being between 1.25 and 1.75 times the average carrier range for the specific photoconductive material; means to impinge a light image through one of said transparent layers and onto one surface of the photoconductive core and to thereby move electrical charges through the major portion of the thickness of said photoconductive core; and means to scan the opposed surface of the photoconductive wafer by means of a light beam projected through the second of said transparent

layers and onto the second of the larger opposed surfaces of said photoconductive core; means for electrically connecting a source of D.C. potential to each of said electrically conductive layers and thereby impressing said D.C. potential across said photoconductive wafer while it is being illuminated and while it is being scanned and means to conduct an output signal from the device.

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