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S. YANDO

3,202,824

PICKUP DEVICE

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Fig. 1

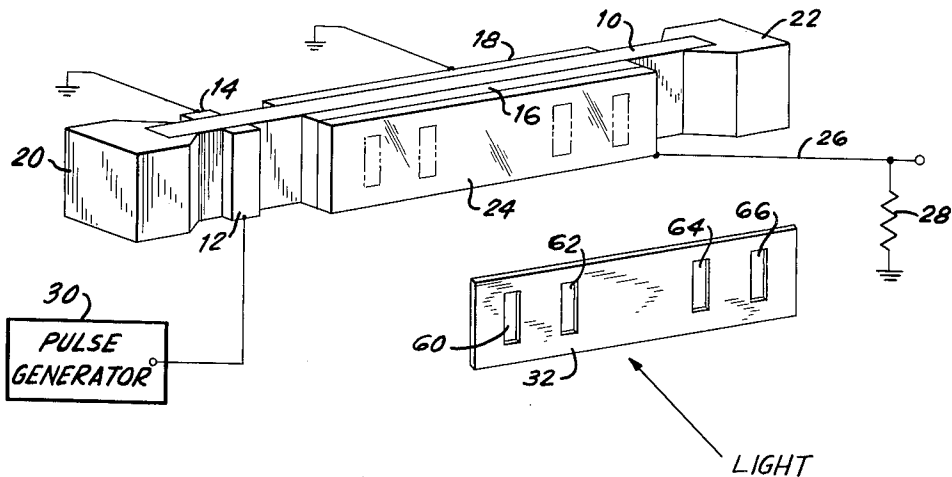


Fig. 2

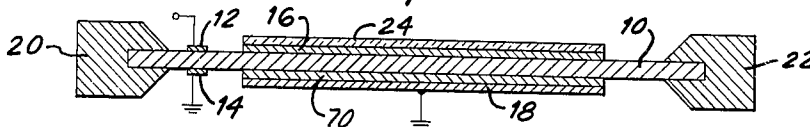
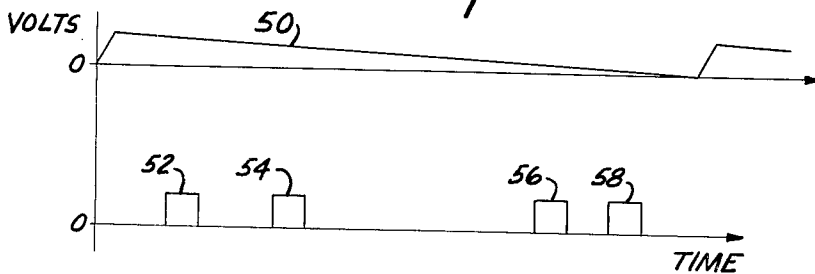


Fig. 3



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3,202,824

PICKUP DEVICE

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This invention relates to pickup devices and in particular to pickup devices of the type employing photoconductive materials.

Photoconductors are composed of materials which exhibit a change in resistance when exposed to light. When light is directed upon a photoconductor, its electrical resistance is sharply reduced. Upon interruption of the incident light, the resistance of the photoconductor increases to its original high value. As a result, the application of a voltage across an illuminated photoconductor produces a relatively high photocurrent through a connected load while, with the incident light removed, a much smaller current (defined as the dark current) is obtained.

I have invented a new type of pickup device employing a photoconductive layer in which a light pattern projected on the layer is transformed into a series of output voltage pulses. These output pulses are produced by propagating an elastic wave, accompanied by an electric field, along the surface of the photoconductive layer. When the elastic wave sweeps past an illuminated area on the layer a high photocurrent flows into the connected load; when the elastic wave sweeps past darkened areas of the photoconductive layer, the current flow is negligible.

Accordingly it is an object of my invention to produce an improved pickup device employing photoconductive material which is capable of scanning a light pattern and producing an output voltage corresponding to this pattern.

Another object of the invention is to produce a solid state pickup device suitable for sequentially scanning a plurality of light sources and producing a corresponding train of voltage pulses.

Still another object is to provide a solid state pickup device which does not excessively load the excitation voltage source.

In accordance with my invention, a pickup device is provided in which first and second contacts are respectively secured to opposite front and rear surfaces of a strip of piezoelectric material adjacent one end thereof. A piezoelectric material is defined as one which exhibits the piezoelectric effect; i.e. there is an interaction between the electrical and mechanical stress-strain variables in the medium. When a piezoelectric material is compressed, an electrostatic voltage is generated across it, and conversely, application of an electric field may cause the material to expand or contract in certain directions. The magnitude of the piezoelectric polarization is proportional to the strain and to the corresponding stress, and its direction is reversed when the strain changes from compression to tension. A photoconductive layer is placed in intimate engagement with the front surface of the strip in a position intermediate the first contact and the other end of the strip. A transparent electrode is affixed to the front surface of the photoconductive layer and a backing electrode is secured to the rear surface of the piezoelectric strip.

A voltage pulse applied between the first and second contacts produces, in the region of the strip intermediate the contacts, a localized mechanical strain proportional to the amplitude of the pulse. As this strain changes, a disturbance, in the form of an elastic wave accompanied by an electric field, propagates along the strip from the contacts toward the other end of the strip. That is,

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a mechanical wave in which the disturbance is a change in the strain of the elastic piezoelectric material travels along the strip. The intensity of the electric field is proportional to the time rate of change of strain and hence is proportional to the first time derivative of the voltage pulse. The elastic waves incident upon the ends of the strip are absorbed, without reflection, by suitable terminations.

Since the piezoelectric strip is in intimate contact with the photoconductive layer, the electric field sweeps along the surface of the photoconductive layer. If a load impedance is connected between the transparent and backing electrodes, current is caused to flow in the load impedance by the propagated electric field. When the photoconductive layer is darkened, its resistance is high, and the current flow through the load is negligible. However, when selected areas of the surface of the photoconductor layer are illuminated, the resistance of these areas becomes quite low. As a result, a pulse of current flows in the load impedance as the electric field sweeps through each illuminated area.

In another embodiment of my invention, a non-linear resistance layer is interposed between the backing electrode and the piezoelectric strip. The non-linear resistance layer is of the type wherein the impedance decreases as the voltage applied across the layer increases. Thus, in those portions of the device which are not being scanned at a particular instant by the elastic wave and accompanying electric field, the impedance of the non-linear resistance layer is high and loading of the pulse source is minimized. In the area of the device which is being scanned by the traveling electric field, the impedance of the non-linear resistance layer is low and the magnitude of the current flow through the load impedance is determined only by the pattern of illumination on the surface of the photoconductive layer.

In another embodiment of my invention, electrodes are attached to each end of the piezoelectric strip in order to control the scanning velocity of the elastic wave in the manner disclosed in my Patent No. 2,917,669, issued December 15, 1959. Also, an area type pickup device may be constructed by affixing a rectangular photoconductive layer on a sheet of piezoelectric material and attaching electrodes to the piezoelectric sheet adjacent at least two of the edges of the photoconductive sheet. The relationship between the electrodes and the photoconductive layer is similar to that shown between the electrodes and the electroluminescent layer in my copending patent application Serial No. 36,665 filed June 16, 1960, now Patent No. 3,132,276, and in my U.S. Patent 3,035,200, granted May 15, 1962.

The above objects of and the brief introduction to the present invention will be more fully understood and further objects and advantages will become apparent from a study of the following description in connection with the drawings, wherein:

FIG. 1 is a perspective view of one embodiment of the invention;

FIG. 2 is a plan view of another embodiment of the invention; and,

FIG. 3 depicts the input and output voltage waveforms of the devices of FIGS. 1 and 2.

Referring to FIG. 1, there is shown a thin strip 10 of polycrystalline piezoelectric material having contacts 12 and 14 attached to one end. A photoconductive layer 16 is placed in intimate engagement with the front surface of the piezoelectric strip 10 and a backing electrode 18 is affixed to the rear surface of the strip. Photoconductive layer 16 may be secured to piezoelectric strip 10 by mixing it with a suitable binder such as an epoxy resin and spraying it on to the surface of strip 10. Piezoelectric strip 10 consists of polarized lead titanate-lead zirconate

while photoconductive layer 16 is composed of polycrystalline cadmium sulphide activated with copper. Each end of the piezoelectric strip 10 is terminated in such manner as to absorb substantially without reflection any incident elastic wave propagated in piezoelectric strip 10. This is accomplished by coating the edges and immediately adjacent portions of strip 10 with lead to provide terminations 20 and 22. A transparent conductive electrode 24 is secured to the surface of the photoconductive layer 16 and connected by means of a lead 26 to a load resistor 28.

The application of a voltage pulse 50 (FIG. 3) by pulse generator 30 across contacts 12 and 14 causes an elastic wave to be propagated down the piezoelectric strip 10 at constant speed toward absorbing termination 22. This wave is accompanied by an electric field with an intensity proportional to the time rate of change of the pulse applied across contacts 12 and 14. A reverse wave also emanates from electrodes 12 and 14 but is absorbed by termination 20.

In one application of the invention, light is projected through prelocated slots in a punch card 32 on to the surface of photoconductive layer 16. In this way, a pattern of light is applied to the surface of the photoconductive layer causing its impedance to decrease in the illuminated areas. After the light pattern has been impressed on the photoconductive layer, sawtooth voltage pulse 50 is applied across contacts 12 and 14 causing an elastic wave to be propagated down piezoelectric strip 10 toward termination 22. When this wave is travelling in the space between contact 12 and layer 16, no current flows in load resistor 28. When the wave (accompanied by its electric field) reaches the edge of layer 16, a small current flows through the load resistor. The magnitude of this current is negligible since the dark impedance of photoconductive layer 16 is very high.

When the traveling electric wave reaches the area of layer 16 which is illuminated through slot 60 of punch card 32, the current in load resistor 28 increases sharply due to the low impedance of this portion of the photoconductive layer and a voltage pulse 52 is produced across the resistor 28. As the electric wave proceeds down the piezoelectric strip 10, pulses 54, 56 and 58 are generated each time the wave passes the portions of layer 16 illuminated through slots 62, 64 and 66 respectively of punch card 32. Since the velocity of propagation of the elastic wave in the piezoelectric strip 10 is constant, the time between output pulses gives an accurate measure of the location of the slot in punch card 32 and, therefore, the information contained on the card may be read out by any suitable voltage sensing device. It is believed apparent that other light patterns may also be converted to voltage outputs in this way, a punch card being utilized only to illustrate one particular application of my invention.

It shall be noted that the pulse 50 has a steep leading edge and a gradual trailing edge. Since the intensity of the electric field is proportional to the first time derivative of the applied voltage, this assures that an electric field of maximum intensity will be propagated down the length of the piezoelectric strip 10.

In the circuit of FIG. 1, the output load resistor 28 is effectively shunted by the summation of the portion of photoconductive layer 16 not under the scanning pulse. This shunting effect tends to limit the output voltage that can be obtained from the device. If a greater output voltage is desired, it can be obtained by interposing a non-linear resistance layer 70 between the rear surface of the piezoelectric strip 10 and the backing electrode 18, as shown in FIG. 2. The non-linear resistance layer may be of the type disclosed in my copending patent application Serial No. 72,789, filed November 30, 1960, which consists of an essentially non-photoconductive cadmium sulphide powder embedded in an epoxy resin. As explained in greater detail in this application, the non-linear

resistance layer is formed by suspending cadmium sulphide powder in a fluid of relatively high viscosity, such as diacetone alcohol, and then pouring the mixture over a substrate which has been placed in a suitable container. After the cadmium sulphide particles have settled on to the substrate, the diacetone alcohol is replaced by acetone which has a lower viscosity and a much higher evaporation rate than diacetone alcohol. A small amount of an epoxy resin containing a curing agent is dissolved in the acetone and the acetone allowed to evaporate at room temperature. The substrate and settled layer are then subjected to pressure to increase the conductivity of the layer.

When a voltage is applied across such a layer, a high initial current flows through it. This current remains relatively constant or increases during the interval that the voltage is applied. When the magnitude of the voltage is increased, the current magnitude increases in a non-linear manner. In particular, a small increase in voltage results in a relatively large increase in current and consequently a sharp decrease in resistance. Stated another way, the current through the layers equals KV^n where V is the applied voltage, n is a number greater than 1, and K is a constant of proportionality.

With this embodiment of the device the resistance of the non-linear resistance layer is connected effectively in series with the impedance of photoconductive layer 16. Since the impedance of non-linear resistance layer 70 is quite high when it is not subjected to an electric field, the output voltage across load resistor 28 is essentially unaffected by the shunting impedance. On the other hand, the resistance of the portion of non-linear resistance layer 70 which is subjected to the travelling electric field is quite low. Therefore the magnitude of the current pulse through load resistor 28 is determined almost entirely by the impedance of the photoconductive layer.

As many changes could be made in the above construction and many different embodiments could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A light sensitive pickup device comprising a strip of piezoelectric material having first and second opposite surfaces; a photoconductive layer placed in intimate engagement with the first surface of said strip intermediate the ends thereof; a backing electrode affixed to the second surface of said strip; a contact secured to the first surface of said strip adjacent one end thereof; said contact being spaced from said photoconductive layer, means for applying a voltage between said contact and said backing electrode, said voltage producing an elastic wave and an accompanying electric field propagating from said contact to the other end of said strip; and a transparent conductive layer affixed to the surface of said photoconductive layer, an output voltage pulse being produced between said transparent electrode and said backing electrode when the position of said elastic wave coincides with an illuminated portion of said photoconductive layer.

2. A light sensitive pickup device comprising a strip of piezoelectric material having first and second surfaces; a photoconductive layer placed in intimate engagement with the first surface of said strip intermediate the ends thereof; a backing electrode affixed to the second surface of said strip; a contact secured to the first surface of said strip adjacent one end thereof, said contact being spaced from said photoconductive layers, means for applying a voltage between said contact and said backing electrode, said voltage producing an elastic wave and an accompanying electric field propagating from said contact to the other end of said strip; a transparent conductive layer affixed to the surface of said photoconductive layer; and means for selectively illuminating portions of said photoconductive layer, an output voltage pulse being produced between

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said transparent electrode and said backing electrode when the position of said elastic wave coincides with said illuminated portion of said photoconductive layer.

3. A light sensitive pickup device comprising a strip of piezoelectric material; first and second contacts secured to opposite surfaces of said strip adjacent one end thereof, said first and second contacts being positioned opposite each other; a photoconductive layer placed in intimate engagement with one surface of said strip intermediate the ends thereof, said photoconductive layer being spaced apart from said contacts; a non-linear resistance layer affixed to the other surface of said strip, a transparent conductive layer affixed to said photoconductive layer; a backing electrode affixed to said non-linear resistance layer; and first and second terminations affixed to corresponding ends of said strip, said terminations absorbing substantially without reflection any incident elastic wave supplied thereto from said strip.

4. A light sensitive pickup device comprising a strip of piezoelectric material having first and second opposite surfaces; a photoconductive layer placed in intimate engagement with the first surface of said strip intermediate the ends thereof; a backing electrode; a non-linear resistance layer interposed between said piezoelectric strip and said backing electrode; a contact secured to the first surface of said strip adjacent one end thereof; said first surface of

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said strip adjacent one end thereof; said contact being spaced apart from said photoconductive layer, means for applying a voltage between said contact and said backing electrode, said voltage producing an elastic wave and an accompanying electric field propagating from said contact to the other end of said strip; and a transparent conductive layer affixed to the surface of said photoconductive layer, an output voltage pulse being produced between said transparent electrode and said backing electrode when the position of said elastic wave coincides with an illuminated portion of said photoconductive layer.

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