Dec. 27, 1960 R. A. FOTLAND 2,966,612

RADIATION DETECTION

Filed June 6, 1957

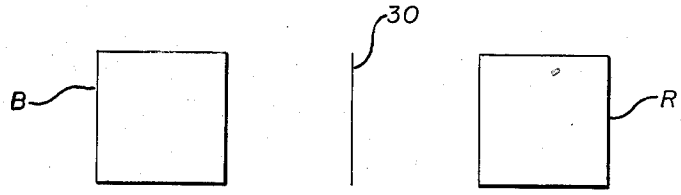


FIG 1

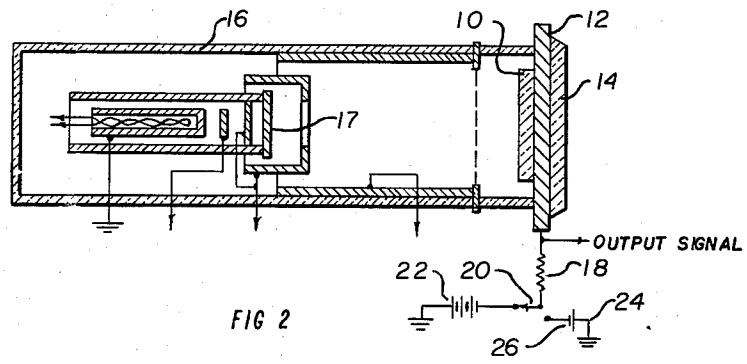


FIG 2

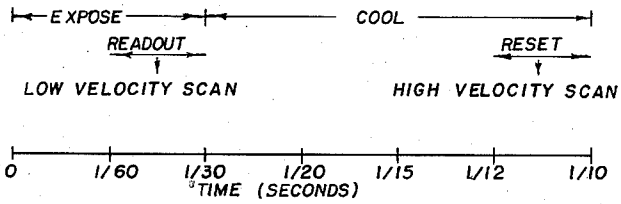


FIG 3

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# RADIATION DETECTION

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2 Claims. (Cl. 315—10)

This invention relates to the detection of objects by means of the infrared radiation generated by the objects and to an electrical system whereby the objects are detected. More particularly it relates to a system for the conversion of infrared images to visible images in which a television camera tube provided with a target which includes a pyroelectric material is operated in synchronism with a means for interrupting the reception of infrared radiation while the pyroelectric target is charged to a desired potential by means of the scanning electron beam and for permitting the infrared radiation to pass to the target during an interval in which the electron beam is not scanning the target. As a result, the infrared changes the polarization of the target material and hence the potential across the target, i.e., the charge on the surface, and this change is converted into a visible representation by suitable means.

The invention will be more fully understood by reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of the system forming the present invention;

Figure 2 is a more detailed view of the receiver in Figure 1; and

Figure 3 is a representation of the sequence of operation in a complete cycle.

As represented diagrammatically in Figure 1, infrared radiation generated by a body B is received by a receiver R which may consist of a Vidicon, or an iconoscope, or other device in which the scanning of a target by means of an electron beam produces an electrical signal output indicative of the extent to which any incremental area of the target has been exposed to infrared radiation, and which consequently has developed an electrical charge on said incremental area of the target.

In the embodiment illustrated in the drawings, the pick-up device comprises a receiver having a target consisting of a suitable pyroelectric material **10** supported in one surface of an electrically conductive film **12**, on the other surface of which there is disposed a window **14** which is transparent to infrared radiation. In an alternative construction, a single element (not shown) formed of an electrically conductive material which is transparent to infrared radiation may be substituted for film **12** and window **14**. As shown in Figure 2, the receiver consists of a conventional Vidicon or iconoscope, such as that shown in U.S. Patents 2,654,852 and 2,687,484 except that the tube face has been modified. It comprises an evacuated glass envelope **16** with an electron gun **17** for generating an electron beam and means (not shown) for focussing and for deflecting the beam so as to cause it to travel in any desired path. The electrically conductive film **12** is connected through an output load resistor **18** selectively by means of switch **20** either to a source of potential **22** or to a small reference potential **26**, connected by lead **24** to ground.

In the device illustrated the target may be formed of any suitable pyroelectric material. The term "pyroelectric" is intended to describe that class of materials which



experience a change of polarization charges when they undergo a change in temperature. Known pyroelectric materials include quartz, tourmaline, lithium sulfate, potassium sodium tartrate (Rochelle salt), and ferroelectric materials such as barium titanate, other titanates, stannates, zirconates, niobates, and the like. These pyroelectric materials may be used either in the form of single crystals or as polycrystalline masses and targets may be formed of a single compound or of mixtures of pyroelectric materials. When a polycrystalline ferroelectric target is employed, it should be polarized prior to operation of the detection system. A suitable means **30** interrupts the infrared signal periodically in order to provide an exposure period during which the target receives infrared radiation, and is thereby heated, and a second period during which the target is shielded from infrared radiation and during which the target is permitted to cool.

A specific example will serve to further illustrate the practice of the present invention. The apparatus illustrated in the drawings was constructed using a standard, commercially available RCA Vidicon No. 6198 as the receiver. The pyroelectric portion of target was formed of a layer approximately 0.001 cm. thick composed of a thin platelet of barium titanate. Electrode **12** comprised a thin layer of metallic aluminum, deposited on the thin platelet of barium titanate by vacuum coating techniques well known in the art. A suitable infrared transmitting material was then applied to the outer surface of the electrode **12**, a $CaF_2$ window having been found satisfactory. For the interrupting means **30**, a chopping wheel run at 10 cycles per second was placed between the target face and the source of infrared radiation.

Figure 3 shows a complete cycle of operation on a time scale in which, for purposes of illustration, each unit is one-sixtieth ($\frac{1}{60}$) of one second. In the system shown in Figure 1, at the start of a cycle, the switch is connected to the one volt source of potential and the shutter is open, thereby heating the target. As the target is heated, the polarization of the barium titanate film decreases (pyroelectric effect). The heat image is thereby converted to a polarization image; the "hot" areas having a lower polarization than the "cool" area of the target. One-sixtieth of a second later the electron beam is caused to scan the rear surface of the barium titanate film. This low velocity beam deposits (as it scans) a charge per unit area related to the polarization of the barium titanate. The charge deposited is capacitively coupled, through the capacity of the film, to the load resistor; hence the charge generates an output voltage across the load resistor. One-sixtieth of a second later, the scanning beam has completed its scan and the chopping wheel cuts off the incident infrared radiation from the target. The target is now allowed to cool for one-twentieth of a second. At the end of this time the target is returned to ground potential by scanning the target with a high velocity electron beam and allowing the resultant secondary emission to charge the target down to the potential of a collector held at ground potential. The high velocity is imparted to the scanning beam by connecting the target substrate to the 100 volt source of potential. One-sixtieth of a second later the whole target is returned to ground potential, the scanning beam has finished its scan, and the cycle is completed.

It will be readily appreciated that the sensitivity of the device described will depend in large measure on the relative change in polarization produced by a unit change in temperature and that it is particularly advantageous to operate with the target at temperatures at which the change in polarization is a maximum. For many ferroelectric materials this will be at temperatures approaching their Curie point.

In the above description, the term "infrared" radiation is intended to apply to electromagnetic radiation having a wavelength between 0.7–30 microns.

Having now described my invention in accordance with the patent statutes, I claim:

1. An apparatus for converting an infrared image into a visible image which comprises: an evacuated envelope, one end of which comprises a pyroelectric target material adapted to receive said infrared image; a layer of an infrared transparent material on the outer surface of said target and a transparent, electrically conductive layer between the pyroelectric target and the infrared transparent material; and an electron gun within said envelope for directing a stream of electrons onto said target material.

2. A system for producing an output signal representing the image produced by exposure of a material which experiences a change in polarization when exposed to infrared radiation which comprises: a television camera tube having a target composed of a pyroelectric material supported on an infrared transparent electrically conductive metal backing; electron gun means capable of generating a low-velocity electron beam and a high-velocity electron beam, wherein said electron gun high-velocity beam is adapted to return said target to ground potential during



an interval when said target is cut off from infrared radiation, and said electron gun low-velocity electron beam is adapted to scan said target during at least a portion of the interval during which the target is exposed to infrared radiation and thereby deposit a charge on said target varying with the polarization of each increment of said target; means for cutting off the infrared radiation during one portion of an operating cycle and for exposing said target to a pattern of infrared radiation during another portion of the cycle of operation, thereby producing a change in polarization of said target material; and a load resistor directly connected to said electrically conductive metal backing member of said target to generate an output signal representative of the charge deposited on said target during the low velocity scan.

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