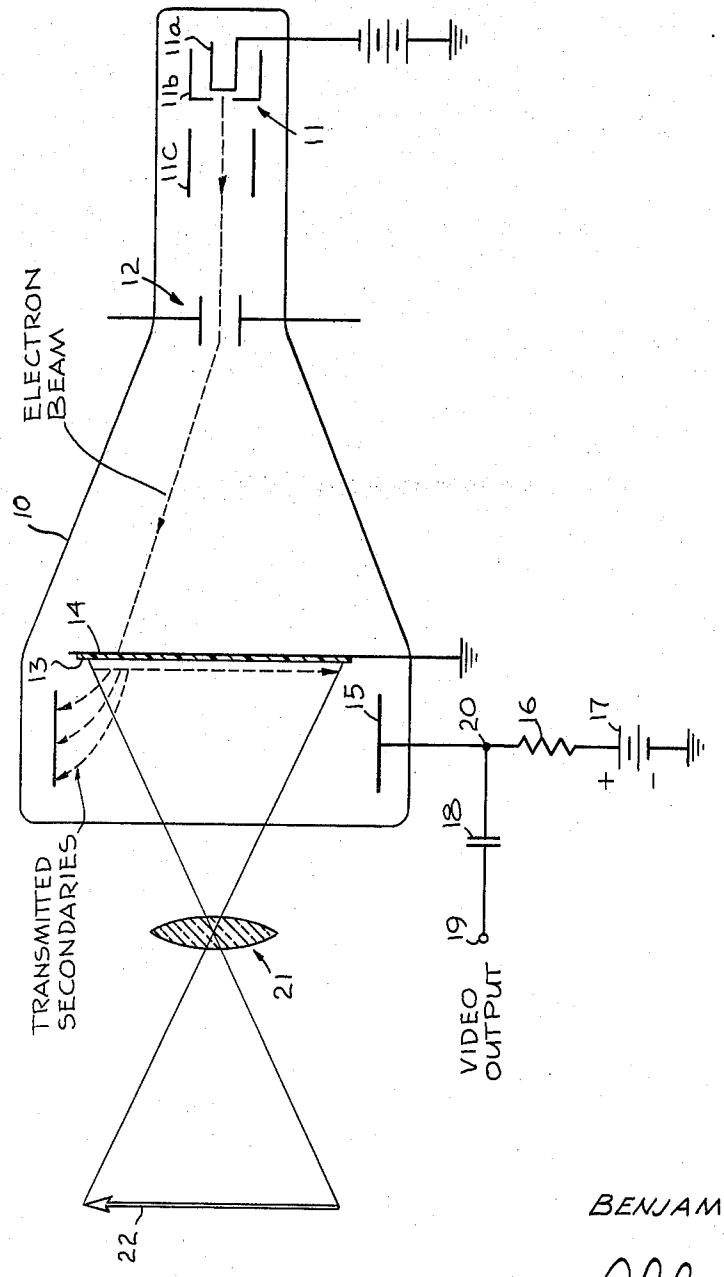
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THERMAL IMAGING DEVICE

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THERMAL IMAGING DEVICE

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The present invention relates in general to image converters and more particularly relates to a thermal image converter device that makes use of a special property of insulating materials, namely, the change of their secondary emission properties with temperature.

The problem of detecting low-level long-wavelength infrared images and converting them to high resolution electrical or visual output signals has already been the object of considerable research effort. Although a number of schemes have been developed demonstrating varying degrees of success, they all have important limitations. In all cases they cause a degradation of the original image as, for example, by the addition of noise or loss of resolution. In many cases they also cause practical difficulties due to the physical construction of the device and the critical factors involved in their operation. Accordingly, a need has existed for a new imaging technique which would avoid the restrictions inherent in the present schemes.

The present invention supplies this need by providing an infrared imaging device that makes use of a special property of insulating materials, namely, the change of their secondary emission properties with temperature. Stated differently, the essence of the present invention is in the use of a specially treated layer of insulating material which, in response to a given primary beam current striking it, emits a secondary electron current that varies as the temperature on the surface of the layer. More specifically, to make use of this effect for imaging purposes, a vacuum tube device is proposed in which is mounted a target consisting of a thin layer of insulating material that is coated on one side with a thin conductive black layer. In its operation, a thermal scene is imaged onto the target, producing a corresponding heat pattern due to the absorption of energy on the above said black layer. To obtain the desired output signal, the target is scanned on the opposite surface by a low-current cathode-ray beam which can partially penetrate the target. Internal secondary electrons are thus generated within the insulating layer and some of these electrons will emerge from the opposite side of the target. Since the emergence of the secondary electrons is temperature dependent as mentioned above, the number of secondaries leaving individual areas of the insulator surface will vary in accordance with the temperature pattern on the target. By means of a collector electrode which is maintained sufficiently positive with respect to the target, all of the secondaries are collected. Consequently, a time-varying collector current is obtained which, in turn, produces a corresponding output signal voltage across a load resistor.

It is, therefore, an object of the present invention to provide a thermal imaging device that is relatively simple in its construction and noise-free.

It is another object of the present invention to provide thermal imaging apparatus based on the phenomena of temperature-dependent secondary emission.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing in which an embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawing is for

the purpose of illustration and description only and is not intended as a definition of the limits of the invention.

Accordingly, the drawing illustrates only a preferred embodiment of an infrared imaging device according to the present invention.

For a consideration of the invention in detail, reference is now made to the drawing wherein the embodiment is shown to include a cathode-ray tube whose envelope **10** contains an electron gun arrangement, generally designated **11**, for producing and focusing a beam of electrons. Arrangement **11** is conventional and, therefore, its details are not shown. Suffice it to mention, therefore, that arrangement **11** includes the usual cathode **11***a*, control electrode **11***b*, as well as accelerating and focusing electrode **11***c*. In addition, the cathode-ray tube includes the usual beam deflection system, generally designated **12**, made up of a pair of vertical plates connected to a horizontal sweep generator and a pair of horizontal plates connected to a vertical sweep generator. For sake of simplicity which is made possible by the fact that beam-deflection systems are so well known, the sweep generators are not shown and the deflection plates mentioned are only representatively illustrated.

At the other end of the tube, in the proximity of its faceplate, is mounted a sandwich arrangement of two layers, one a thin layer of insulating material **13**, such as aluminum oxide (Al_2O_3), and the other a thin conductive black layer **14** that may, for example, be gold or aluminum. By way of example, the conductive layer may be about 400 Angstroms thick and the insulating layer about 500 Angstroms thick, the former layer being grounded as shown in the figure. As is also shown, the above said sandwich arrangement is mounted so that layer **14** faces deflection system **12** while layer **13** faces the faceplate of the cathode-ray tube. Finally, between the tube faceplate and insulating layer **13**, is mounted a collector electrode **15** which is connected through a load resistor **16** to a positive source of voltage **17** whose magnitude may, for example, be in the order of 100 volts. Completing the output circuit is a coupling capacitor **18** connected between output terminal **19** and junction **20** between the collector electrode and the load resistor.

Mounted in front of the faceplate of the cathode-ray tube is an optical system, generally designated **21**, by means of which infrared radiation from distant objects, such as object **22**, may be focused upon the surface of insulating layer **13**. Optical systems for collecting and focusing infrared radiation are well known in the art and may be, for example, a suitable lens assembly. Accordingly, optical system **21** used herein is merely represented by a lens.

In operation, the infrared rays from an infrared emitting object are focused or imaged by lens system **21** onto the target comprising insulating film **13** and black layer **14**. As a result, a corresponding heat pattern is produced due to the absorption of energy on the black layer. (The insulating layer is essentially transparent to the incoming radiation and does not cause significant loss of radiation by reflection.) At the same time that a heat pattern is formed on the black layer, the same black layer is scanned by a low-current cathode-ray beam which can penetrate the black layer to insulating layer **13**. As a consequence internal secondary electrons are thus generated within the insulating layer and some of these electrons will emerge from the surface of the insulating layer, the number of electrons emerging at any one point depending on the temperature at that point. Stated differently, the emergence of secondary electrons is temperature dependent so that the number of secondary electrons leaving individual areas on the insulator surface will vary in accordance with the aforesaid temperature pattern on the

target. The collector electrode being positive with respect to the target, the secondary electrons are collected by it, thereby producing a time-varying collector current which, in turn, causes a time-varying output voltage to be produced across load resistor **16**. It is thus seen that each scan of the target area results in the appearance of a video signal at output terminal **19**, the aggregate output at terminal **19** constituting the ultimate conversion of the image of an object to a waveform which may then be transmitted or otherwise used in some utilization device, such as a television receiver.

Although a particular arrangement of the invention has been illustrated herein by way of example, it will be recognized by those skilled in the art that various modifications, alterations, substitutions, additions, etc., can be made with respect to some parts of it. Thus, although not indicated in the figure, the collected secondary electrons may also be amplified by a secondary-emission multiplier section as used in the image orthicon if higher output signals are desired to avoid noise contributions from the output load resistor and input circuit of the first amplifier stage. For providing a visual display, the amplified video signal can be fed to a conventional TV type monitor synchronized with the scanning beam of the image tube.

It should also be noted that the black layer of the target should not only absorb the input radiation but should be slightly electrically conducting since this will prevent the insulating portion of the target from charging either positive or negative because of net loss of gain of electrons during secondary emission. If necessary, however, other measures may be adopted for preventing the target from charging such as by flooding the surface with an auxiliary electron beam of correctly chosen primary energy. Accordingly, the invention should be considered to include any and all modifications, alterations or equivalent arrangements falling within the scope of the annexed claims.

Having thus described the invention, what is claimed is:

1. Apparatus for converting a thermal image into a representative video signal, said apparatus comprising: an image converter tube including a target element made up of insulating and heat-absorbing layers back-to-back, and means for scanning said insulating layer through said heat-absorbing layer with a beam of electrons; infrared energy focusing means for forming a thermal image on said heat absorbing layer through said insulating layer;

and a collector electrode mounted between said target element and said focusing means.

2. Apparatus for converting a thermal image into a representative video signal, said apparatus comprising: a vacuum tube including means for providing a low-current cathode-ray beam; a target element mounted in said tube in the path of said beam, said target element including insulating and heat-absorbing layers back-to-back with the heat-absorbing layer facing said beam, said heat-absorbing layer being thin enough to permit said beams to penetrate through to said insulating layer and said insulating layer being thin enough to be substantially transparent to infrared radiation incident thereon; additional means for focusing infrared patterns onto said target element; and output means mounted between said target element and said additional means for collecting electrons emitted from said insulating layer to produce the video signal.

3. Apparatus for converting a thermal image into a representative video signal, said apparatus comprising: a vacuum tube having a target element capable of emitting secondary electrons mounted therein at one end thereof, said element being of a type in which the number of electrons emitted from a spot thereon is a function of the temperature of the spot; means mounted at the other end of said tube for line scanning said target element with a thin beam of electrons to produce secondary emission therefrom; additional means for focusing a thermal image on said target element; and output means for collecting the secondary electrons emitted from said target element which comprises two flat films of material, one material being an insulating material whose secondary-emission properties varies as does the temperature and the other material being a conductive black material that readily absorbs heat, said two films of material being back-to-back with the film of insulating material facing toward said additional means and the film of conductive black material facing toward said means.

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