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APPARATUS FOR REDUCING SPURIOUS SIGNALS IN THERMAL IMAGE CONVERTERS

Max Garbuny, Pittsburgh, Pa., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Air Force

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4 Claims. (Cl. 178—7.2)

This invention relates to image converters, especially of the photothermionic type, and has as its principal object the preservation of the contrast in the original image.

The photothermionic image converter consists of means for forming a thermal image on a surface of photoemissive material the photoemissivity of which is a function of temperature. When such a surface having a thermal image thereon is scanned by a spot of light, the temperature variations in the thermal image are reproduced as variations in the photo-current. These variations may, however, be so small as to be masked partly or wholly by inherent fluctuations in the photocurrent due to non-uniformities in the photoemissive material. The result is a reduction in the signal-to-noise ratio of the signal currents and a corresponding reduction in resolution and contrast in the visual image produced therefrom.

It has been found that the response of the photoemissive surface is a continuous function of position on the surface, i.e., no sudden local discontinuities of emission appear. Hence, in accordance with the invention, if the emissive surface is subdivided into two groups of interlaced elements, such that one group receives the thermal image while the other is shielded from it, a comparison of response to a uniformly scanning light spot will result in a signal that is independent of emitter nonuniformities to the extent of the degree of subdivision.

A more detailed description of the invention will be given in connection with the specific embodiment thereof shown in the accompanying drawing, in which

Fig. 1 is a cross section of an image converter tube in accordance with the invention;

Fig. 2 illustrates the construction of the interlaced grid, and

Fig. 3 is a schematic diagram of the complete image converter.

Referring to Fig. 1, evacuated envelope 1 has an electron gun structure 2 which directs a beam of electrons 3 toward a layer 4 of a phosphorescent material of short persistence. The phosphor is supported on a transparent substrate 5. The beam is caused to line scan the phosphor 4 by a suitably energized deflection yoke 6 in accordance with conventional television practice. Situated parallel to substrate 5 and only slightly spaced therefrom is a semipermeable layer of photothermionic material 7. An infrared transparent window 8 closes the end of the envelope 1 with its inner surface in close proximity to the surface of photothermionic layer 7. The inner surface of window 8 supports an interlaced grating 9 composed, as seen in Fig. 2, of one set of opaque conductive bars 10, connected to terminal B, and a similar set of transparent conductive bars 11, connected to terminal A, interlaced with the first set and electrically separate therefrom. These bars may be applied to the inner surface of the window by evaporative techniques. A suitable lens system 12 forms an infrared image of the field of view on the surface of photothermionic layer 7, the rays passing through grating 9.

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As the electron beam scans the short persisting phosphor 4, light from the resulting light spot passes through transparent substrate 5 and strikes the surface of the photothermionic layer 7. Because of the close spacings this results in a scanning spot of light on the surface of layer 7. The substrate 5 may also have the properties of an optical filter rejecting all wavelengths of light except those for which the particular material of layer 7 exhibits its photothermionic effect. The effect of the scanning light spot on semipermeable layer 7 is to cause the emission of photoelectrons which are attracted to grating 9 as a result of its being maintained at a slightly positive potential relative to layer 7, as will be seen later.

Those surface areas of photothermionic layer 7 lying beneath opaque bars 10 of the grating 9 are shielded from the infrared image and, assuming a scanning spot of constant intensity, variations in the photoelectron current from these areas are a function of variations in the photothermionic layer 7 only. On the other hand, variations in the photoelectric current from those surface areas of layer 7 lying beneath the transparent bars 11 are functions of both the heat image and nonuniformities in the photothermionic material. Since, as already stated, the nonuniformities of the photothermionic material are gradual and continuous, the characteristics of the material are very nearly the same in adjacent shielded and unshielded strips, and the finer the grating the more nearly alike adjacent strips become. Consequently, very nearly identical "noise" currents flow to grids 10 and 11 during the scanning process and subtracting the grid 10 current from the grid 11 current resulting in a high degree of cancellation of the "noise" currents, leaving only the signal due to the thermal image.

A schematic diagram of a complete system for converting an infrared image into a visible image of equal contrast is shown in Fig. 3. The converter tube within envelope 1 is a schematic representation of the tube of Fig. 1. Cathode-ray tube 13 is a conventional kinescope for converting a video signal into a visual image. Sweep generators 14 produce appropriate horizontal and vertical deflection voltages which are applied to deflection yokes 6 and 6' for synchronizing the scanning operations in the two cathode ray tubes. In tube 1, the grids 10 and 11 are held slightly positive with respect to the photoemissive layer 7 in order to attract the emitted photoelectrons.

The signal at grid 11, appearing at terminal A, is integrated by circuit R_1-C_1 and applied between the grid and cathode of inverter tube 15. The signal at grid 10, which appears at terminal B, is integrated by circuit R_2-C_2 with the integrated signal appearing across resistor 16. The integration of the grid signals extends at least over the period of time required by the scanning spot to traverse adjacent shielded and unshielded strips of the photoemitter. The leakage time provided by resistors 16 and 17 is made such that the signal across these resistors is able to follow the variations in photoemission due to the thermal image.

The signal appearing at terminal A and derived from grid 11 is a series of negative pulses having a pulse repetition frequency proportional to the scanning speed and the number of grid elements and amplitude modulated in accordance with the photoemission to grid 11 as the photocathode 7 is scanned. Similarly, the signal derived from grid 10 and appearing at terminal B is a series of negative pulses, of the same repetition frequency, amplitude modulated in accordance with the photoemission to grid 10. The envelope of each of these two pulse series therefore represents the manner in which the photoemission to the corresponding grid varies during the scanning process. The integrating circuits R_1-C_1 and R_2-C_2 serve to smooth the pulse signals

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at terminals A and B and produce across resistors 17 and 16 continuous negative voltages which follow the envelopes of these pulse signals.

In the absence of a thermal image on the photocathode 7, the only variations in photoemission that occur during the scanning process are those due to non-uniformities of the photocathode. As stated above, non-uniformities in the photocathode are of a gradual and continuous nature without abrupt changes. Therefore, if the elements of grids 10 and 11 are made sufficiently fine and closely spaced the photocathode will be substantially uniform within the small distance covered by an element of one grid and the adjacent element of the other grid. As a result, the pulse produced at terminal B when the scanning spot passes beneath any element of grid 10 will be substantially the same as the pulse produced at terminal A when the scanning spot passes beneath the adjacent element of grid 11. Consequently, the pulse trains at terminals A and B, and the corresponding continuous signals across resistors 16 and 17, are substantially identical in the absence of a thermal image on the photocathode. Due to the phase reversal produced by tube 15, the output of this stage, when properly adjusted in amplitude by resistor 21, cancels the signal across resistor 16 so that no signal appears on the grid of tube 18 as a result of nonuniformities in the photocathode.

The presence of a thermal image on the photocathode 7 does not alter the above cancellation process. In this case the signal across resistor 17 is the sum of two components, one representing nonuniformities in the cathode as described above and the other representing the detail of the thermal image. Due to the shielding provided by opaque grid 10, the image produces no signal across resistor 16 so that the signal across this resistor is representative of cathode nonuniformities only. The signals due to cathode nonuniformities cancel as before, leaving only the image signal at the grid of tube 18. The output of this tube, after further amplification in video amplifier 19, is applied to the beam intensity control electrode 20 of kinescope 13. The ability of the device to resolve the detail in the thermal image is, of course, determined by the fineness of the grids, the limit of resolution being roughly twice the width of a grid element. The grids are shown disproportionately large in the drawing for practical illustrative purposes. With present photoetching and evaporative techniques, grids of great fineness permitting comparatively high resolution are possible. The output of this tube, after further amplification in video amplifier 19, is applied to the beam intensity control electrode 20 of kinescope 13.

The circuit is initially adjusted by shielding the face of image converter tube 1 from any infrared radiation and adjusting resistor 21 for a minimum background or "noise" signal on the screen of the kinescope.

While the invention has been described in connection with image converters of the photothermionic type it is not limited thereto and may be used with image converters operating in the visible spectrum, such as television transmitting tubes, where it is desired to transmit an image of such low contrast that the resolution is reduced by nonuniformities of the light sensitive element.

I claim:

1. Apparatus for converting an image into a representative video signal comprising: an image converter tube containing a photosensitive element having an image receiving surface; means for scanning said element with a small spot, said element having the property of emitting electrons from its image receiving surface when scanned, the number of which varies in accordance with the variations in any image on said surface and also in accordance with nonuniformities in the electron emitting properties of said element; radiant energy focusing means for forming an image on said image receiving

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surface; an opaque shield situated between said focusing means and said surface and in close proximity to said surface for dividing said surface into alternate shaded and unshaded elemental areas, said areas being arranged relative to the scanning pattern of said scanning spot so that said spot scans alternate shaded and unshaded areas; means for integrating the signal resulting from electrons emitted from shaded areas; means for integrating the signal resulting from electrons emitted from unshaded areas; and means for producing a video signal proportional to the difference in said integrated signals.

2. Apparatus for converting a thermal image into a representative video signal comprising: an image converter tube containing a photoemissive element of the type in which the photoemissivity is a function of temperature, said element having an image receiving surface; means for scanning said photoemissive element with a small constant intensity spot of light, said element having the property of emitting electrons from its image receiving surface when scanned the number of which varies in accordance with the temperature variations in any thermal image on said surface and also in accordance with nonuniformities in the electron emitting properties of said element; infrared energy focusing means for forming an image on said image receiving surface; an opaque shield situated between said focusing means and said surface and in close proximity to said surface for dividing said surface into alternate shaded and unshaded elemental areas, said areas being arranged relative to the scanning pattern so that said spot of light scans alternate shaded and unshaded areas; means for integrating the signal resulting from electrons emitted from shaded areas; means for integrating the signal resulting from electrons emitted from unshaded areas; and means for producing a video signal proportional to the difference in said integrated signals.

3. Apparatus for converting an image into a representative video signal comprising: an image converter tube containing a photosensitive element having an image receiving surface; means for line scanning said element with a small spot, said element having the property of emitting electrons from its image receiving surface when scanned the number of which varies in accordance with the variations in any image on said surface and also in accordance with nonuniformities in the electron emitting properties of said element; radiant energy focusing means for forming an image on said image receiving surface; an opaque shield consisting of a plurality of parallel equally spaced opaque conductive bars situated between said focusing means and said surface and parallel to and in close proximity to said surface, the direction of said bars being transverse to the scanning lines; means maintaining said bars at a small positive potential relative to said image receiving surface, whereby electrons emitted from those parts of said surface beneath said bars flow to said bars; means for integrating the signal resulting from electron flow to said bars; means for collecting the electrons emitted from those parts of said surface not beneath said bars; means for integrating the signal resulting from said collected electrons; and means for producing a video signal proportional to the difference in said integrated signals.

4. Apparatus for converting a thermal image into a representative video signal comprising: an image converter tube containing a photoemissive element of the type in which the photoemissivity is a function of temperature, said element having an image receiving surface; means for line scanning said photoemissive element with a small constant intensity spot of light, said element having the property of emitting electrons from its image receiving surface when scanned the number of which varies in accordance with the temperature variations in any thermal image on said surface and also in accordance with nonuniformities in the electron emitting properties of said element; infrared image focusing

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means for forming an image on said image receiving surface; an opaque shield consisting of a plurality of parallel equally spaced opaque conductive bars situated between said focusing means and said surface and parallel to and in close proximity to said surface, the direction of said bars being transverse to the scanning lines; means maintaining said bars at a small positive potential relative to said image receiving surface, whereby electrons emitted from those parts of said surface beneath said bars flow to said bars; means for integrating the signal resulting from electron flow to said bars;

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means for collecting the electrons emitted from those parts of said surface not beneath said bars; means for integrating the signal resulting from said collected electrons; means for producing a video signal proportional to the difference in said integrated signals; and means for adjusting the amplitude of one of said integrated signals for reducing said video signal to zero in the absence of an image on said image receiving surface.

No references cited.