The invention described herein may be manufactured and used by or for the Government for governmental purposes and there­after to the extent切入点 private royalty thereon.

This invention relates to a heat-sensitive mosaic such as may be enclosed within the nose of a missile serving to guide the missile toward a military target that emits heat, and more particularly to an improved form of such mosaic.

This invention is a continuation-in-part of our co-pending application Serial No. 691,647, filed August 19, 1946, for Infra-Red Television Detector and Controller, now U.S. Patent No. 2,955,777, granted October 11, 1960, in which the mosaic as here described and claimed is shown in an illustrative circuit installation.

In the past, mosaics embodying thermocouples, bolometers, photo-electric cells and the like, have been used to guide military missiles toward heat emitting targets with varying degrees of success. Previously developed heat seeking devices that depended upon the use of photo-electric cells, had the limitation of not distinguishing with a sufficiently high degree of precision, military targets from other sources of radiation. Infra-red sensitive cells, such as form part of the present mosaic, have the characteristic of selectively distinguishing sources of maximum heat radiation, such as that given off by an operating steel works, oil cracking plants and the like, as distinguished from lesser sources of heat in the background. Previously produced infra-red sensitive cells have very largely lacked sufficient sensitivity when mounted in the nose of a missile, to direct the flight course of the missile with satisfactory accuracy toward the target that is farther away than five miles from the missile and have lacked a desirable degree of accuracy and clarity when used for the purpose of presenting on a television screen the observations gathered by the cells.

The mosaic type infra-red heat detector that forms the subject matter of the present invention, when subjected to the type of scanning that is indicated in the description of the mosaic that is presented hereby has the important advantage over scanning systems using a single cell in that energy from an infra-red target image is stored throughout the period between electron scans of adjacent condenser plates. In the present types of scanning, the current path is only completed during the time in which the scanning beam is passing over a mosaic element. The sensitivity of a mosaic made of photo-conductive material is limited by the smallest change in pick-up currents that can be detected above the noise level as the electron beam passes over a mosaic element. The mosaic that is described herein is not dependent upon the electron scanning beam to produce current flow through the photo-conductive material, but has an auxiliary circuit which discharges condenser elements by amounts depending upon the infra-red radiation that is received from the target image. This provides, as an object of the present invention, a storage principle that is analogous to that in an iconoscope as used in television if the time of scanning a mosaic element by the cathode ray beam is 10^-4 seconds and the time interval between scans is .10 of a second, the mosaic that is disclosed herein would be of the order of possibly 1000 fold more sensitive than pre-existing types of mosaics, assuming that the target image stays in one spot for .10 of one second. This illustration of increased mosaic senci-
mosaic. The insulation sheet 27 preferably is a thin sheet of mica suitably cemented to the metal back plate 24.

In the making of the mosaic, there is disposed upon the insulation plate 27 through a mica stencil, not shown, by any suitable process of evaporation, a desired plurality of strip layers of photo-sensitive material 33 which preferably is lead sulphide, which has been activated by exposure to oxygen gas.

This photo-sensitive material has the property of changing its resistance upon exposure to intermediate wave lengths in the infra-red. The lead sulphide deposit of photo-sensitive material 33 is disposed in strip form vertically or longitudinally of the insulation material 27; the individual strips terminating inwardly from the margins of the insulation material 27 so that the lead sulphide is insulated from the back plate 24. Above each strip of photo-sensitive material 33, there is disposed a positive grid strip 28 of gold or platinum deposited upon the insulation material 27 by evaporation, sputtering or the like. Below each strip of photo-sensitive material 33, there is a horizontally disposed row of spaced small substantially square condenser plates 30 that are applied to the insulation material 27 by the evaporation or sputtering of gold or platinum. Air gaps separate the condenser plates 30 from each other.

Electrical contact is made between the positive grid strips 28 and the condenser plates 30 by the highly resistant photo-sensitive material 33 throughout the face of the mosaic, which is exposed to electromagnetic bombardment. Below the row of condenser plates 30, there is another deposit or strip of lead sulphide material 33 and below that another positive grid strip 28 of gold. This structure is repeated until there are preferably not less than four hundred combinations of elements 28, 30 and 33 each one covered by a backplate 24 with the mica insulation 27 therebetween. As a practical matter, it is equivalent to saying that there should be at least 400 condenser plates 30. For the proper guidance of a missile, the seeker should be large enough to cover 20° of the field of view, both vertically and horizontally.

The function of the three-element combination just described is as follows:

A condenser plate 30 upon receiving heat signal, loses electrons (negative charges) thereby acquiring a positive proportionate charge. An electrical picture of a heat signal is therefore formed on some of the gold plates 30 which serve as condenser plates. Backplate 24 forms the other plate of the condenser and the mica sheet 27 the dielectric.

The condenser plates 30 may be scanned by an electron beam 22 (see FIG. 4) without injury. To scan the lead sulphide material 33 directly would cause loss of sensitivity. The bombarding electrons can easily destroy the disturbance centers set up by the incident infra-red radiation conductivity of a semi-conductor due to incident radiation. These disturbance centers can exist only as long as electrons are removed from filled levels to conducting levels, which leaves a conducting positive hole in the formerly filled levels. These levels are either in the crystal lattice or impurities held in the lattice. The conduction due to the radiation can only continue until electrons recombine with the positive holes. Electron bombardment can free electrons in the vicinity of the positive holes to recombine with them, or can rephrase ejected electrons from impurity centers, allowing them to recombine with the positive holes and stop the conduction caused by the radiation. Thus, electron bombardment can readily destroy the lead sulphide sensitivity by causing the recombination of the electrons and positive holes produced by the radiation.

The beam 22 in scanning the rows of condenser plates 30 brings the potential of each one in turn, toward that of the cathode 23 from which the scanning beam originates.

Electrons are reflected from the plates 30 and these must be caught before they drift to as yet undischarged condenser plates 30 and partially discharge them before the cathode ray (scanning beam 22) discharges them. The reflecting screen 19 behind a small positive charge is provided for this purpose. The screen 19 is disposed over the face of the whole mosaic 20 and is penetrated by the scanning beam 22. It should not be so fine as to interfere with the action of the beam. The distance between the screen 19 and the mosaic 20 is only a few millimeters. A second function of the screen 19 is to assist in keeping the face of the mosaic cool. The lead sulphide photosensitive material 33 is sensitive at the temperature of Dry Ice. The slight decrease in the electron bombardment effect on the grid and the lowering of electron collisions between condenser plates 30 will be of value in helping to keep the temperature low.

A preferred source of cooling the mosaic 20 is a filling of Dry Ice (not shown) contained in a pan 37 mounted upon the rear side of the backplate 24 (see FIG. 2). The pan 37 is attached by any suitable mechanical fastener to one or more bus bars 36 which extend from the backplate 24 of the mosaic 20 through a glass envelope 39 which houses the mosaic and which is identical with the tube envelope. Any other provision for cooling the mosaic may be substituted if it is reasonably compact and can keep the mosaic at least as cold as —70° C.

A scanning circuit is shown in FIG. 4. V1 to V4 inclusive, shown as resistances, are successive rows of lead sulphide photosensitive material 33 on the mosaic. A pair of deflection plates 25 and 26 is paired with the scanning operation. Reversal of polarity on plates 38 accomplishes the scanning motion of the beam in the usual manner. The beam 22 is shown passing through the screen grid 19 which is charged positively by being connected to the positive terminal of a battery 21. A second battery 26 is provided to render positive the grid strips 28. The positive terminal of the battery 26 is connected by lead 34 to the positive grid strips 29 in parallel; its negative terminal together with the positive terminal of battery 21 is led to ground 35. A third battery 40 provides focussing for the electron beam 22 from the cathode 31 within the tube 32. A lead 41 grounds the negative side of battery 40 at ground 35.

A pickoff resistor 25 is connected to the mosaic 20 by its backplate 24. A lead 42 grounds the resistor at ground 35. A circuit is therefore completed from battery 26 through the mosaic 20 and resistor 25 to ground 35; and another circuit from battery 21 to collector screen 19 to beam 22 to ground 35. The current of battery 26 is available to form signal taken from the end of resistor 25 as indicated by a pair of arrows extending therefrom. The mosaic acts as a condenser to block the passage of direct current through it.

Upon incidence of heat on the photosensitive material 33, its conductivity is increased sufficiently to allow positive potential from battery 26 to flow to the condenser plates 30.

The electrical action may be described as follows: When the most effective infra-red energy strikes one of the photo-sensitive material resistances such as V1, then that condenser plate 30 to which resistance V1 is connected, is charged more than the others during the interval between scans. When the scanning beam 22 passes over the highly charged plate 30, the largest pickoff voltage is obtained across resistor 25. At each passage of the electron beam 22 over a condenser plate 30, that plate is discharged and brought essentially to the potential of the cathode 31. It is important that a small, sharply focussed scanning spot be applied to the condenser plates 30 so that bombardment of the photo-sensitive material 33 is minimized. Aligning tabs for this purpose are shown in operation with the present mosaic 20. In our above-mentioned scanning, the mosaic 20 may be about one millimeter square. The other elements may be of proportionate size as indicated on the drawings. The various elements of the
mosaic may be provided with electrical connections as will be seen from FIG. 4. It will be noted in FIG. 1 that the positive grid strips 28 are connected in parallel.

The invention claimed is:

1. A mosaic, comprising a backplate made of an electrically conductive metal, a sheet of insulating material substantially covering one side of said backplate, a strip of infra-red-sensitive material on said insulating material, a strip of thin gold bordering one side of said infra-red-sensitive strip and in contact therewith, and a plurality of small plates of thin gold on the other side of said infra-red-sensitive strip, said plates being of substantially equal area and in contact with the infra-red-sensitive strip.

2. A mosaic according to claim 1 in which the infra-red-sensitive strip is composed of lead sulfide which has been activated by exposure to oxygen.

3. A mosaic according to claim 1 in which the mosaic comprises not less than 400 cells comprising infra-red-sensitive material bordered on one side by a gold strip and on the other by a separate area of thin gold.

4. A mosaic comprising a backplate made of a metal which is a good conductor of electricity, a thin sheet of insulating material covering one side of said backplate except the margins thereof, a plurality of strips of a material having the property of becoming positively charged on exposure to infra-red light, on said sheet of insulation, a strip of thin gold bordering one side of each of said infra-red sensitive strips and in contact therewith, and a multiplicity of small deposits of thin gold on the other side of said infra-red-sensitive strips, said deposits being of substantially equal area and also in contact with the infra-red-sensitive strips.

5. A mosaic according to claim 4 in which the infra-red-sensitive strips are composed of lead sulfide which has been activated by exposure to oxygen.

6. A mosaic according to claim 4 in which the first-mentioned gold strip is provided with an electrical connection for maintaining a charge thereon.

7. A mosaic according to claim 4 which comprises not less than 400 small deposits of thin gold.

8. A mosaic intended to be scanned by an electron beam, comprising a backplate of a metal which is a good electrical conductor, a sheet of insulating material covering one side of said plate except the margins thereof, a sensitive element comprising lead sulfide activated by oxygen, said sensitive element being closely adherent to said sheet of insulating material, a positive grid of a noble metal, said grid being adherent to said sheet of insulation and in electrical contact with said sensitive element, and a multiplicity of condenser plates, not less than 400, said condenser plates being also made of noble metal and adhering to said sheet of insulating material and in electrical contact with said sensitive element, said condenser plates being arranged in rows adapted to be scanned by the electron beam having a small focal spot.

9. In combination, a mosaic comprising a backplate of a metal which is a good electrical conductor, a sheet of insulating material covering one side of said plate except the margins thereof, infra-red sensitive material disposed in strips on said insulating material, an electrically conductive grid on said insulating material and making electrical contact with said infra-red sensitive material and to which grid a source of positive charge may be connected, and a multiplicity of small condenser plates attached to said sheet of insulating material for receiving positive electrical charges from said grid upon increasing the temperature of said sensitive material and said condenser plates being mounted in superposed rows to be scanned by an electron beam and thereby discharged to provide an electrical signal.

10. In combination, a mosaic, comprising a heat-sensitive element which is most sensitive when extremely cold, said mosaic having a backplate of a metal which is a good electrical conductor, means attached to said backplate for the conduction of heat therefrom, and a pan mechanically attached to said means, said pan being adapted to contain a filling of Dry Ice, said mosaic including also a sheet of insulation between the heat-sensitive element and the backplate, a grid on the insulation for supplying potential to the heat sensitive element and a multiplicity of condenser elements on the insulation for collecting potential from said heat sensitive element.

11. A combination according to claim 10 having in addition a glass envelope enclosing the mosaic and in which the heat-conducting means is a plurality of heavy bus bars, said bus bars extending through said envelope, and said pan being outside the envelope.

12. In combination, a mosaic in part sensitive to infra-red radiation, a back plate of conductive metal for said mosaic, a source of an electron beam, means attached to said beam source for focussing the beam issuing therefrom to a small scanning spot, means for oscillating said beam, a screen before said mosaic for capturing electrons reflected from said mosaic, means for keeping said screen charged positively, a circuit including a source of direct current and connecting the infra-red sensitive part of said mosaic through said source of current to said backplate, and a pickoff resistor in said circuit.

13. An infra-red sensitive mosaic comprising an electrically conductive backplate, insulation covering a substantial part of said backplate, an electrically conductive grid attached to said insulation, a strip of electrically resistive infra-red-sensitive material of increasing electrical conductivity with increase in temperature and attached to said conductive grid, and a plurality of condenser plates attached to said insulation and making electrical contact with the infra-red-sensitive material by one of their edges, by which arrangement said condenser plates are disposed in parallel rows on the insulation.

14. In a device for detecting heat signals, a backplate made of a highly electrically conductive metal of substantial thickness, a covering of electrical insulation over a substantial area of one side of said plate, strips of infra-red-sensitive material laid on said insulated surface, said infra-red-sensitive material being of a material which has a high electrical resistance when extremely cold and a lower resistance when exposed to faint infra-red radiation, said means for supplying positive electrical potential to said infra-red-sensitive material mounted adjacent thereto, and collecting means also mounted adjacent to the infra-red-sensitive material for removing and holding discrete electrical charges from said infra-red-sensitive material whenever incidence of infra-red radiation lowers the electrical resistance of the infra-red-sensitive material to an extent permitting leakage of potential across said infra-red-sensitive means to said collecting means.

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