March 29, 1955 W. E. BUCK 2,705,274

BOLOMETER AND METHOD OF MAKING

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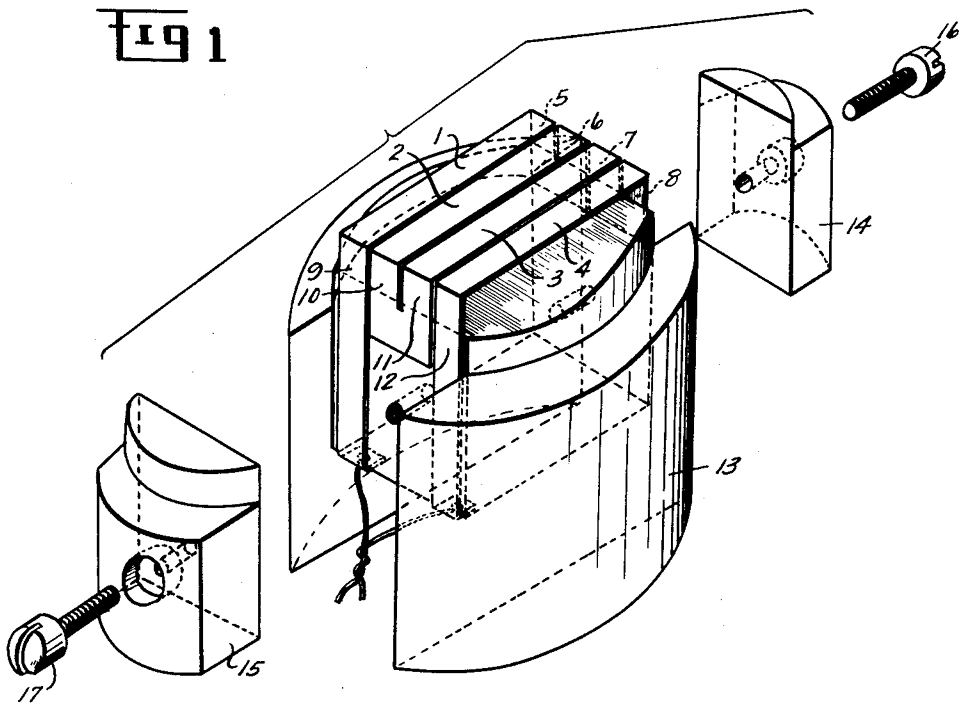
FIG 1



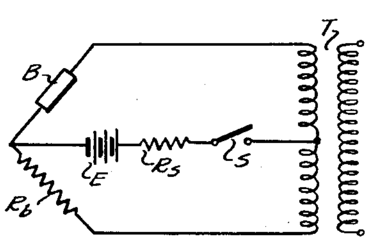


FIG 3

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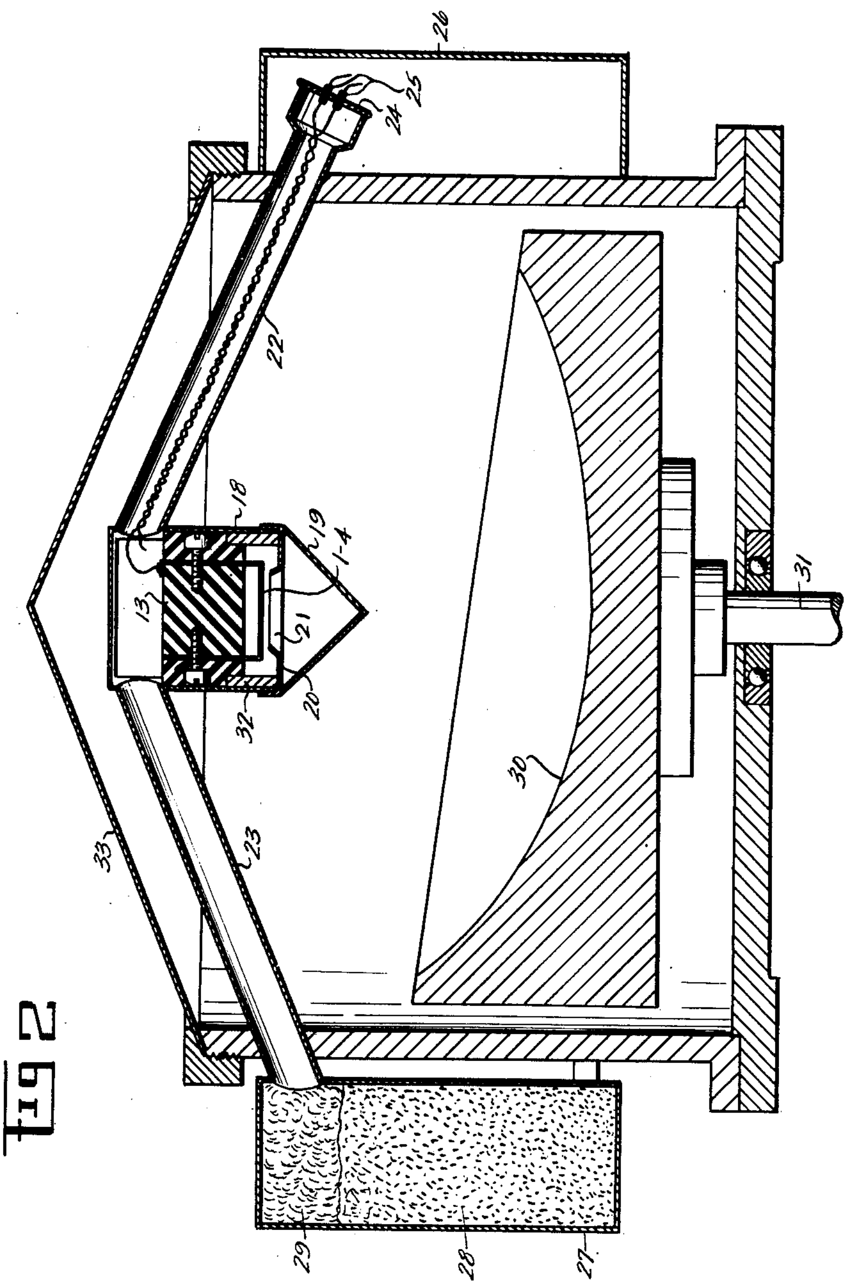

Fig 2

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BOLOMETER AND METHOD OF MAKING

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6 Claims. (Cl. 201—63)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to a device sensitive to long wavelength infrared radiation and particularly to such a device for use in the control system of a heat-homing bomb of the high-angle type. Such bombs may be carried in the bomb bays of standard bombers and are usually dropped with the use of a bombsight in the same manner as a freely falling bomb. The control system is usually operative only during the last fifteen seconds or so of the bomb's fall and serves to steer the bomb toward the strongest source of infrared radiation in the field of view of the bomb's "eye."

The "eye" is located in the nose of the bomb and comprises an infrared sensitive receiver and a suitable scanning device which enables the receiver to scan an area of a size consistent with the maneuverability of the bomb. The bomb is steered by angularly displacing its axis with respect to its velocity vector, the resulting "lift" produced by the body of the bomb being sufficient to change its direction of travel. The displacement of the bomb's axis is accomplished by rudder and elevator surfaces located in the tail of the bomb and controlled by means of servomotors, which are in turn controlled by an electronic unit capable of interpreting the information received from the "eye." The bomb is stabilized with respect to roll by gyroscopically controlled aileron surfaces also located in the tail.

Due to the weak signal likely to be encountered, the heat responsive element used in a bomb of the above-described type must be highly sensitive; however, it must also be sufficiently rugged to withstand the severe shocks probable in the handling of such a heavy object as a bomb. A short time constant is required in order to give sufficient corrections to the bomb's travel during the brief fifteen seconds or so of controlled flight. Also the element must be free from serious microphonic effects even under considerable vibration. It is therefore the object of this invention to provide a bolometer that satisfactorily meets these requirements.

The details of the invention will be described in connection with the accompanying drawing in which:

Fig. 1 shows the arrangement and mounting of the sensitive elements of the bolometer;

Fig. 2 shows the complete bolometer unit and its relationship to other parts of the bomb's optical system; and

Fig. 3 shows a typical circuit in which the bolometer may be used.

It has been found that the above requirements are most successfully met by a metal strip bolometer with a sensitive area 0.2" in diameter. In the illustrated embodiment, the bolometer is made up of four thin strips of nickel, **1**, **2**, **3** and **4** in Fig. 1. These strips are held in position by Phosphor bronze springs **5** through **12**, to the top ends of which the strips are soldered with high-melting-point solder, using the minimum amount necessary to get a solid non-microphonic joint. The strips and springs are positioned as shown on the body **13** of a mounting made of plastic or other suitable insulating material and held in place by means of clamping blocks **14** and **15** and screws **16** and **17**. The Phosphor bronze springs serve the functions of electrically connecting the nickel strips in series and of keeping the strips tight in spite of differential thermal expansion.

Nickel was chosen as the material with which to make the sensitive strips because of its high temperature coefficient of resistance, which for thin strips of the type used is about 0.0040, and for its good mechanical strength. The rate at which the "eye" scans the target area is about 32 scanning cycles per second. In order to obtain good sensitivity at this frequency, the time constant of the bolometer must be less than 0.03 second which requires that the strips be very thin, approximately 0.00001" thick. Strips of this thinness are made by electroplating on aluminum using a hot saturated bath of nickel ammonium sulphate and a rather high current density. The nickel plating is first sliced into strips 0.045" wide by light cuts with a sharp blade and then the aluminum is dissolved in sodium hydroxide, leaving the strips suspended in the solution. The size of the strips when mounted as shown in Fig. 1 is 0.26" x 0.045" x 0.00001". Finally a very thin coat of aluminum black is deposited on the front surface of the strips by evaporation at about 4 mm. of hydrogen. The best thickness about doubles the sensitivity of the bolometer; thicker coats will absorb more energy, but the gain at 32 C. P. S. is more than offset by the increase in time constant. In order to reduce microphonics, the strips should be under sufficient tension from the Phosphor bronze springs to raise their natural period well above the 32 C. P. S. scanning frequency. This requires a pull of 2 to 3 grams per strip.

The bolometer element of Fig. 1 is housed in a cylindrical steel case **18**, Fig. 2, which also serves to magnetically shield the bolometer loop. A conical window of silver chloride **19** is fused to a silver cap or diaphragm **20**, the latter being placed over the end of cylinder **18** and soldered thereto to make an airtight seal. A circular ring **32** of metal or plastic may be used to hold the mounting **13** in place. The diaphragm has a circular aperture **21** having a diameter of 0.2" and serves to mask the sensitive strips 1–4 of the bolometer so that the area on which infrared radiation may fall is limited to a circle 0.2" in diameter. Metallic tubes **22** and **23** are fitted into the top of case **18** as shown and soldered thereto to produce an airtight seal. The end of tube **22** is flared and a plate **24** soldered thereto through which the leads of the bolometer are brought by means of insulating and sealing beads **25**. A junction box **26** is provided in which connection to an external circuit may be made. The tube **23** terminates in an airtight metallic container **27** to which it is soldered and which contains charcoal **28** held in place by a small amount of glass wool **29**. The two tubes **22** and **23** and cases **18** and **27** form an fairtight container which is evacuated and then filled with hydrogen at a pressure of about 4 mm. of mercury. The hydrogen increases the speed of response of the bolometer without producing microphonics, which are very bad for a bolometer in air at atmospheric pressure. The charcoal trap removes any extraneous gases other than hydrogen.

Scanning of the target area is produced by the parabolic mirror **30** which is mounted on shaft **31** and rotated at about 32 revolutions per second. Infrared radiations are admitted to the mirror through conical window **33** of silver chloride. The mirror is positioned so that its optical axis is at an angle of 5 degrees to the axis of rotation and its primary focus falls on the axis of rotation. The bolometer is supported by means of tubes **22** and **23** so that the primary focus falls on the sensitive strips 1–4 and in the center of the circular area under aperture **21**. This area, as stated above, has a diameter of 0.2" which is sufficient to subtend an angle at the optical center of the mirror that is twice the angle between the optical axis and the axis of rotation, or 10 degrees. With this arrangement, the instantaneous scanning area on a plane perpendicular to the axis of rotation is a circle 10 degrees in diameter which revolves about the axis of rotation so that the total area scanned is a circle 20 degrees in diameter centered about the axis of rotation.

Fig. 3 shows an external circuit in which the bolometer may be used. It consists of a Wheatstone bridge in which two adjacent arms are formed by the two balanced halves of the primary winding of transformer T and the other two adjacent arms are formed by the bolometer B and balancing resistor R_b. The balancing resistor must match the resistance of the bolometer at its operating temperature as closely as possible. Operating current for the bolometer is supplied by battery E through current limiting resistance R_s. When no heat waves are falling on bolometer B, the currents in the two halves of the primary are equal and the flux in the transformer core substantially zero. A change in the resistance of the bolometer produced by the heating effect of infrared rays causes the primary currents to become unbalanced and a voltage to be induced in the secondary winding of transformer T.

Tests on bolometers of the type described show that the sensitivity at the bolometer terminals runs from 0.0015 to 0.0045 volt per watt per square centimeter radiation density. Time constants range from 0.020 to 0.006 second, depending on thickness of strips, weight of blackening, cleanliness, etc. A bridge current of about 0.15 amp. through the bolometer heats the strips to approximately 100° C. above ambient temperature. Higher currents increase the sensitivity but cause a decrease in the signal-to-noise ratio. With the above value of current, the noise of the bolometer is only 0.015 to 0.03 microvolt, even with considerable vibration.

What I claim is:

1. A bolometer comprising a plurality of thin strips of nickel, a plurality of spring strips of conductive material, a mounting of insulating material, means for clamping said spring strips to said mounting so as to form two oppositely disposed rows of the free ends of said spring strips with all free ends in the same plane, means conductively connecting said nickel strips between pairs of opposite spring strip free ends, and means including said spring strips for electrically connecting said nickel strips in series.

2. Apparatus as claimed in claim 1 in which the nickel strips are coated on one side with a black substance.

3. Apparatus as claimed in claim 1 in which the nickel strips are coated on one side with a black substance and in which the spring strips are adjusted so as to produce a tension in the nickel strips sufficient to raise the natural frequency thereof well above the frequency of vibrations to which the bolometer may be subjected in use.

4. A bolometer comprising a plurality of resistive strips of a material having a high temperature coefficient of resistance, a plurality of spring strips of conductive material, a mounting of insulating material, means for clamping said spring strips to said mounting so as to form two oppositely disposed rows of the free ends of said spring strips with all free ends in the same plane, means conductively connecting said resistive strips between pairs of opposite spring strip free ends, means including said spring strips for electrically connecting said resistive strips in series, a gas-tight container for said resistive strips and mounting, said container having a masking device and a window transparent to long wavelength infrared radiation so positioned as to admit radiations to a restricted area of said resistive strips.

5. Apparatus as claimed in claim 4 in which said container is filled with hydrogen at low pressure and in which a trap is provided to absorb gases other than hydrogen.

6. Apparatus as claimed in claim 4 in which said window is made of fused silver chloride.

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