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J. A. BECKER

2,414,792

BOLOMETRIC THERMISTOR

Filed June 29, 1945

FIG. 1

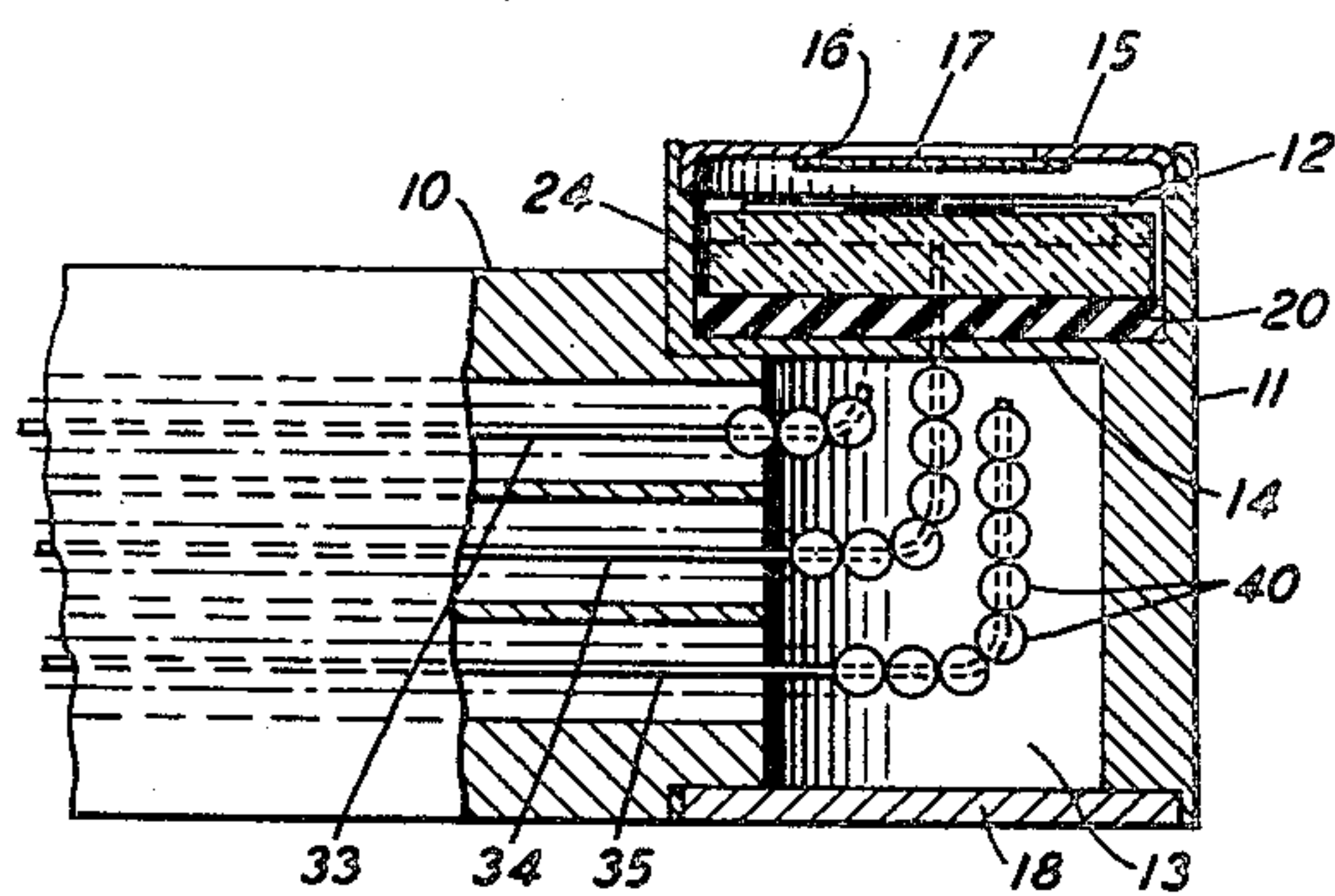


FIG. 2

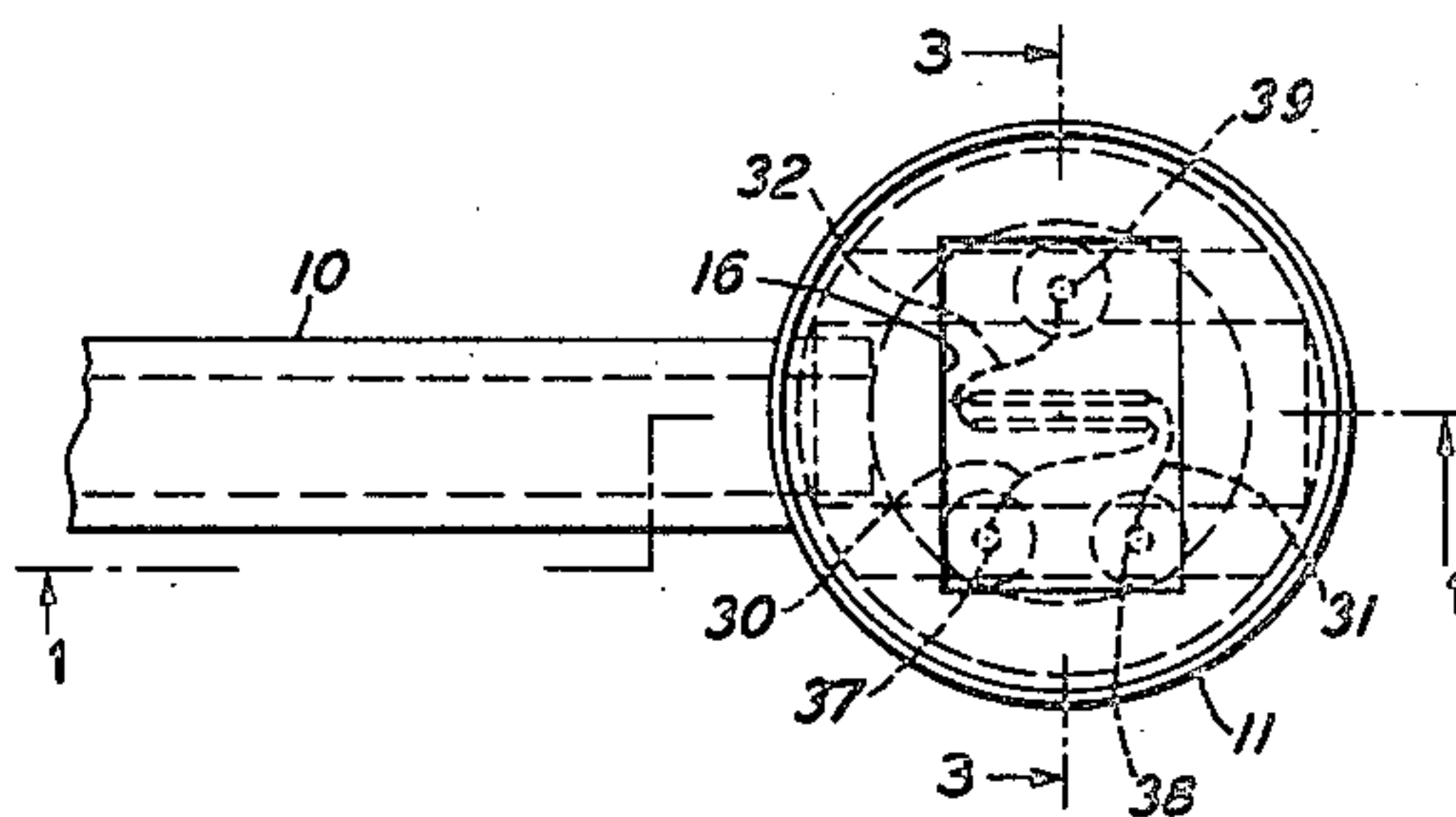


FIG. 3

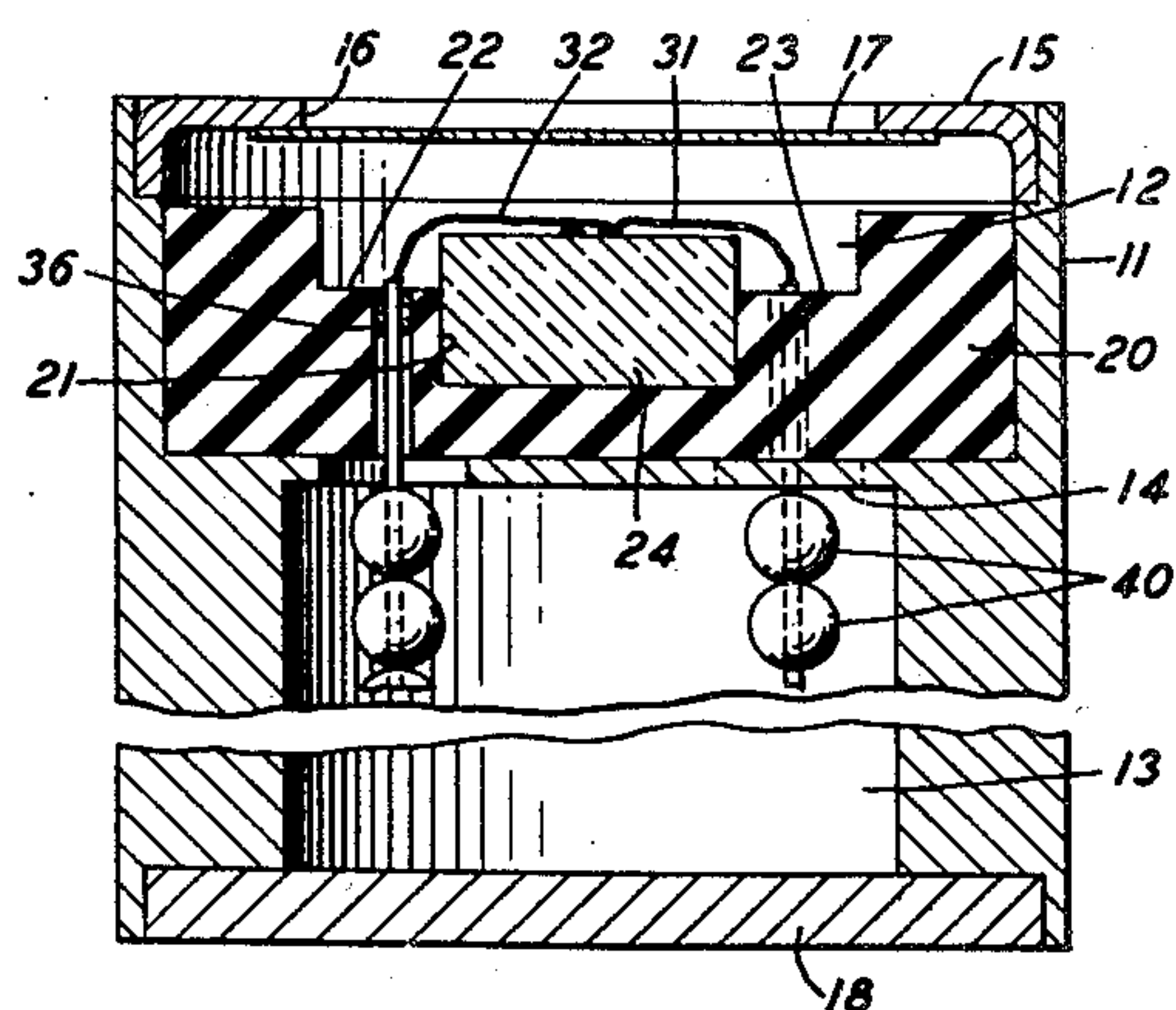


FIG. 4

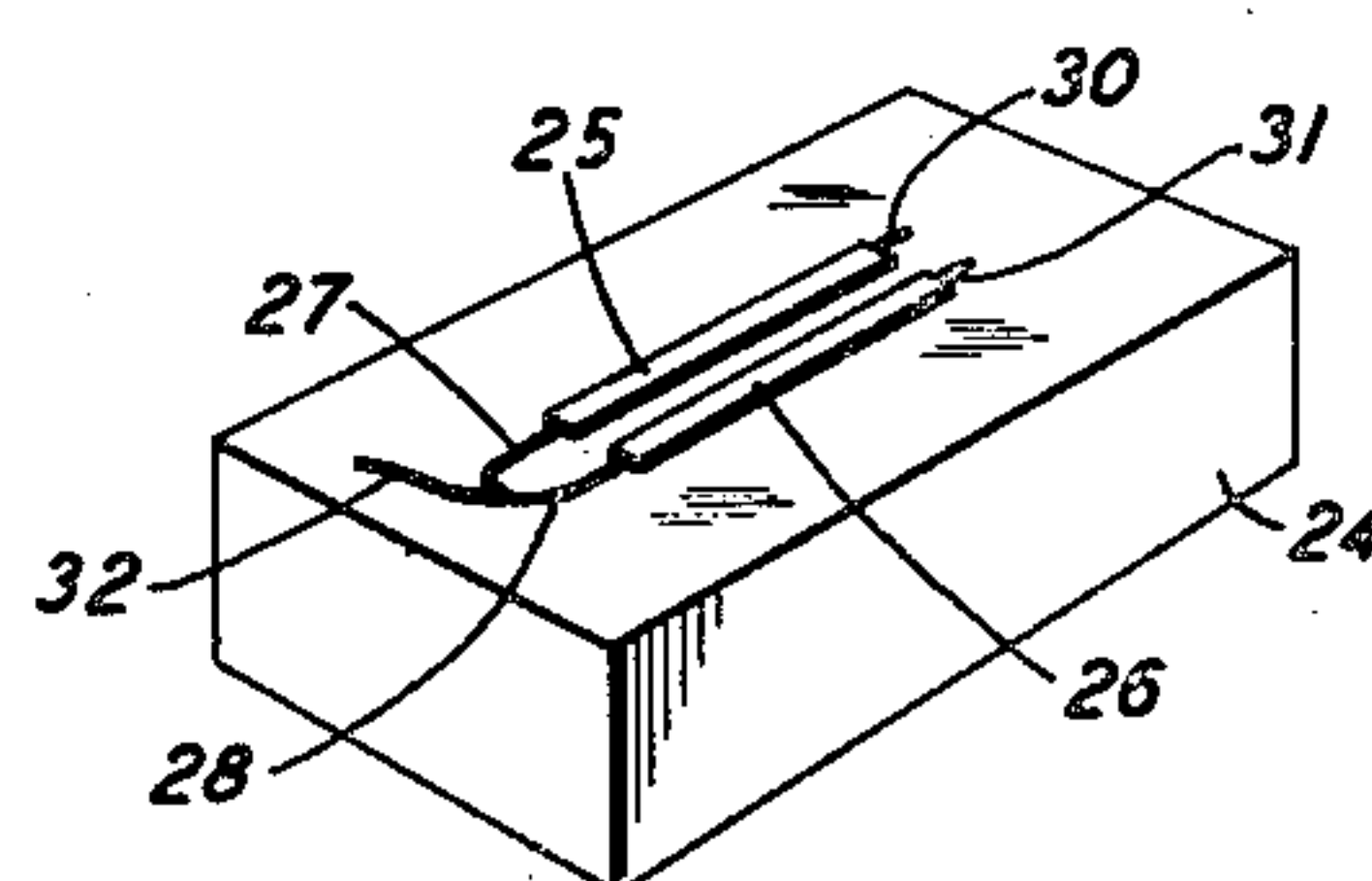
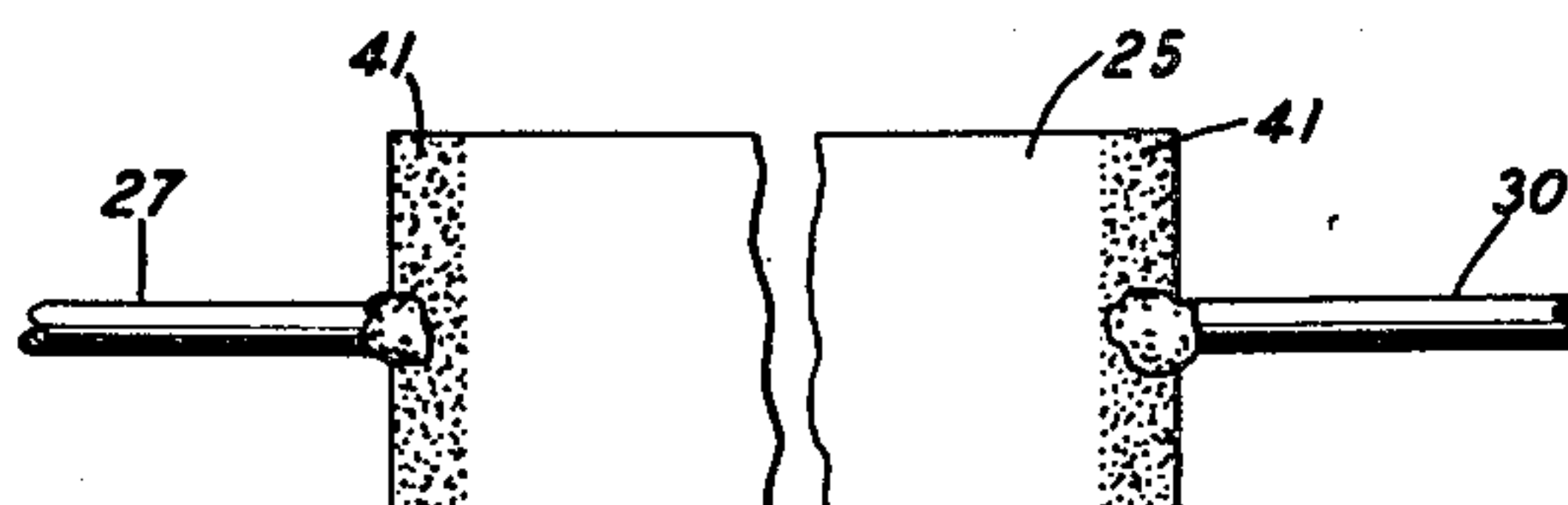


FIG. 5



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BOLOMETRIC THERMISTOR

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Application June 29, 1945, Serial No. 602,261

13 Claims. (Cl. 201—63)

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This invention relates to resistors and more particularly to small, thin film resistors made of material having a relatively high temperature coefficient of resistance.

Resistors, the resistance of which varies greatly with changes in temperature, have been called "thermistors" for convenience of terminology. The devices under consideration in this application by virtue of their high resistance-temperature coefficients belong to this class. In so far as the term "thermistor" is employed in this specification and the appended claims, a resistor of the type indicated is intended.

An object of this invention is the improvement of bolometric and like radiant energy sensitive devices.

A feature of this invention resides in a very thin, relatively small thermistor element in good thermal contact with a relatively large mass of substantially high heat capacity and high thermal conductivity, the thermal diffusivity of the mass being large compared to that of the thermistor element, whereby the heat capacity of the combined element and mass is substantially the same as that of the element alone.

A further feature of this invention lies in so proportioning the thermistor element and its mounting that the time constant of the combination is short. This is done by keeping the heat capacity of the combination small while making the dissipation constant relatively large.

Another feature of the invention lies in a small, self-sustaining thermistor body, that is sufficiently rugged to avoid damage by vibration or shock.

A further feature of the invention resides in a radiant energy sensitive element having a temperature coefficient of resistance of the order of ten times higher than that of metals.

An additional feature of this invention resides in a resistor having a resistance range at room temperature of .5 to 5.0×10^6 ohms.

Another feature of the invention lies in an energy responsive unit, that is a high absorber of practically all radiant energy from .5 to 20 μ or more.

A still further feature lies in the high electrical and chemical stability of the thermistor material, whereby the change of resistance or chemical composition with time is extremely small.

Other and further objects and features of this invention will appear more fully and clearly from the following description of exemplary embodiments thereof taken in connection with the appended drawing in which:

Fig. 1 is a side elevation partly in section of a

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mounting including thermistors of the type contemplated by this invention;

Fig. 2 is a top plan view of the device shown in Fig. 1;

Fig. 3 is an enlarged sectional view taken on line 3—3 of Fig. 2;

Fig. 4 is a perspective view of a pair of thermistor elements on their immediate supporting means; and

Fig. 5 is an enlarged view of a thermistor element showing small portions of its connecting leads.

Although the thermistor of this invention may be used in other ways, it has for illustrative purposes been shown in a bolometer mount for the detection of infra red rays. In view of the smallness of the thermistor elements employed, it has been necessary to exaggerate some proportions in the drawing in order to adequately illustrate the invention.

Referring to Figs. 1, 2 and 3 of the drawing, the mounting comprises an arm 10 the end portion only of which is shown and a housing 11 secured to the end of the arm 10. The housing 11 is provided with front and back cavities 12 and 13, respectively, separated by a partition or wall member 14. The front cavity 12 is provided with a cover 15 having an opening 16 therein.

The back cavity 13 may have a simple cover such as 18. The opening 16 is covered by a window member 17 of a material capable of transmitting the rays of interest in the particular application involved. In the device illustrated, the member 15 is of silver and the window element 17 is of silver chloride. The silver chloride window transmits infra red rays to the thermistor elements.

A stage 20 of a phenol condensation product or other suitable insulating material is secured in the bottom of the front cavity 12. The stage 20 is provided with a diametral shallow groove 21, which in the present instance is parallel to the axis of the arm 10. Flanking the groove 21 are ledges 22 and 23, respectively.

A backing member or slab 24 supports the thermistor element or elements, two in this case, 25 and 26, respectively. The backing member or slab 24 may be made of various different materials depending on the time constant desired for a particular application. The slab illustrated is of quartz, which gives a relatively short time constant, as will be more fully pointed out in a later discussion of other suitable materials.

The thermistor elements 25 and 26 which are tiny flakes of suitable thermistor material are cemented or otherwise secured to the center of

the slab 24. The thermistor elements are provided with suitable leads 27, 30 and 28, 31, respectively. As indicated in Fig. 4, two of the leads, for example 27 and 28, may be connected together near the thermistor element and to a common lead 32. If desired each of the leads may be brought out separately where a common lead is not wanted.

External connections are made by means of conductors 33, 34 and 35 which extend through channel sections of the arm 10. The ends of the conductors are cemented, as illustrated at 36 in Fig. 3, in orifices in the stage 20. In the illustrative embodiment there are two orifices 37 and 38 in the ledge 23 and one orifice 39 in the ledge 22. The common thermistor lead 32 is secured, as by soldering or welding to the single terminal at 39, and the other two leads 30 and 31 to the terminals at 37 and 38, respectively.

The leads 33, 34 and 35 may be insulated, for example by means of glass beads, a few of which are illustrated at 40 in Figs. 1 and 3.

As illustrated in Fig. 5, the thermistor element or flake 25 is provided at each end with a metallic coating 41 to which are secured leads, for example 27 and 30, by any suitable means. A satisfactory method of attachment comprises providing the ends of the thermistor flake with metallic films and securing the ends of the leads to these films by a suitable metallic paste or composition that may be "cured" as by heating, to form a substantially metallic bond between the thermistor element and the leads.

In order to give a better idea of the proportions of this device, which are somewhat distorted by the necessities of illustration, a thermistor element such as 25 may be from 0.3 to 7 millimeters long, 0.1 to 2 millimeters wide and from 10 to 40 microns thick, (1 millimeter equals 1000 microns). The particular thermistor elements shown are about 0.2 millimeter wide, 3.0 millimeters long and about 15 microns thick. The leads such as 27 and 30 are approximately 1 mil (.0254 millimeter) in diameter. The mounting slab 24 is about 3 millimeters wide, 8.5 millimeters long and 1.6 millimeters thick.

The tiny flakes of thermistor material may be made by any suitable process, for example, the one set forth in the application of J. A. Becker and H. Christensen, Serial No. 602,260, filed June 29, 1945. Suitable materials are one or more of the oxides of manganese, nickel, cobalt, copper, iron, zinc, and uranium. Good results have been obtained with a thermistor material comprising the combined oxides of manganese, nickel and cobalt.

The time constant of the thermistor unit, i. e., thermistor flake or element and the slab or backing, being dependent upon the relative characteristics of the flake and backing, with a given flake, the selection of the backing is governed by the time constant desired. In considering the characteristics of the backing those of the cement used to attach the flake to the backing must also be taken into account. The backing material must be of electrical insulation or be insulated from the thermistor flake in order that the electrical current in or voltage across the flake may be restricted thereto.

A relatively short time constant may be obtained by employing a backing member of crystalline quartz such as the one shown in the illustrative embodiment of the invention. Other materials giving a relatively short time constant are various metal slabs or plates having an insulating

coating on the surface to which the thermistor element is attached. For example, aluminum with an anodized surface; silver or copper with thin films or layers of glass, quartz, or mica may be used. The flake may be cemented directly to the metal with an insulating cement if this cement meets the dielectric requirements of the particular application.

Due to the necessity of using a layer of electrical insulation, which in most cases has low thermal conductivity, on the metal backing, a quartz backing, which requires no such insulating layer, may give a time constant comparable to that of the metal backing notwithstanding its lower thermal conductivity. A unit comprising a slab of glass with a thermistor element cemented to one surface will have a relatively long time constant.

A glass back unit may also be made by selecting a glass having a thermal expansion coefficient near enough to that of the thermistor material and by sticking the flake directly to the glass by local heating. Such a unit would have a shorter time constant than one with the flake cemented to the glass and with proper selection of materials might have as short a constant as the quartz or metal unit.

A relatively long time constant may be obtained by employing a plurality of layers of insulating material such as a phenol condensation product for the backing. Such a backing may be made up on a metal base where desirable. If the thermistor element or plate is mounted in air or in a vacuum without a solid backing, the time constant will be quite long.

In those applications in which radiant energy impinges on the thermistor element in successive pulses at short time intervals, the time constant must be short. For this reason thermistor units with a solid backing are used for such applications. The solid-backed thermistor elements are also much more sturdy and robust than those simply mounted in air or in a vacuum. Since considerable shock and vibration may be encountered in some applications or in shipment, the more rugged, solid-backed elements are superior to those having no backing. It is therefore preferable to use a solid-backed element when possible even when a long time constant is required.

For some applications in which radiant energy falls on the thermistor element for a short period of time, it is possible to obtain a greater response from a solid-backed element than from one simply suspended in air.

It is believed obvious that the mounting described in the foregoing is but one form of mounting suitable for the resistor device of this invention. Furthermore, the unit comprising a thermistor or thermistors and a backing element, such as is shown in Fig. 4, is not limited to the size and shape illustrated and described nor even to the range of dimensions suggested in this specification. However, in general, the thermistor element will be small and the backing element or slab relatively large with respect thereto.

When radiant energy impinges upon the thermistor element or flake, it is rapidly heated and when the radiant energy is removed the backing carries the heat away rapidly and quick cooling results. The speed of heat removal from the resistor element depends upon the material employed for the backing as previously indicated. In order that the thermistor element shall

heat rapidly when energy falls on it, its heat capacity should be small; hence its dimensions should be small. To make the cooling rate high, the thermal conductivity of the backing should be high. In order that the heat capacity of the system be practically that of the thermistor element or flake, it is necessary that the thermal diffusivity of the backing be large compared to the thermal diffusivity of the thermistor flake material. Thermal diffusivity may be defined as thermal conductivity divided by heat capacity per centimeter cube. To obtain a bolometer with a short time constant, it is necessary to keep the heat capacity small and make the dissipation constant large. This dissipation constant is the watts which must be supplied to the thermistor to maintain its temperature 1° C. above its surroundings. Good thermal contact between the thermistor element or flake and its backing is essential to a large dissipation constant.

Although this invention has been described by means of a specific illustrative embodiment thereof, it should be understood that it is not limited thereby, but by the scope of the appended claims only.

What is claimed is:

1. A bolometer thermistor element adapted for short exposure to radiant energy and comprising a relatively small area, thin flake of thermistor material secured in thermally conductive relation to a relatively large area, thick, heat absorbing backing member in which the time constant of the thermistor element is controlled by the relative thermal diffusivities of the flake and backing member, and means for passing electric current through the flake only.

2. A bolometer thermistor comprising a small, thin flake of metal oxide thermistor material secured in good thermal contact with a relatively large, thick backing member, and electrical conductors connected to spaced portions of said flake, the backing member being in electrically insulating relation to said flake, the thermal diffusivity of said backing member being high with respect to that of said flake.

3. A thermally sensitive resistor comprising a flake of high resistance-temperature coefficient material of the order of 1 to 6 millimeters long, 0.2 to 2 millimeters wide, and 10 to 40 microns thick, secured to a surface of a backing member of the order of 8.5 millimeters long, 3.0 millimeters wide and 1.6 millimeters thick, the thermal diffusivity of the backing member being greater than that of said flake.

4. A thermally sensitive resistor comprising a relatively small, thin body of high resistance-temperature coefficient material having relatively low heat capacity, and a relatively large, thick mass of relatively high heat capacity and high thermal conductivity in good thermal contact with said body, the thermal diffusivity of said mass being large compared to that of said body.

5. A thermally sensitive resistor comprising a relatively small, thin body of high resistance-temperature coefficient material having relatively low heat capacity, and a relatively large, thick mass of substantially high heat capacity and high thermal conductivity in good thermal contact with said body, the thermal diffusivity of said mass being equal to or greater than that of said body.

6. A thermally sensitive resistor comprising a small, thin, self-sustaining flake of high resistance-temperature coefficient metal oxide material secured in good thermal contact to a relatively

large block of quartz, which is in intimate thermal contact with a larger massive metal housing.

7. A thermally sensitive resistor device comprising a relatively small, thin, self-sustaining flake of sintered thermistor material, a relatively large, thick backing member, and means for securing said flake to a portion of a surface of said member, the member and securing means having thermal conductivity and heat capacity characteristics so correlated with those of the flake that the effective over-all heat capacity of the device for short heating and cooling periods is little higher than the heat capacity of the flake alone.

8. A thermally sensitive resistor comprising a small, thin flake of thermistor material, a relatively large, thick backing member, and means for securing the flake in good thermal contact with, but electrically insulated from the member, said flake being self-sustaining, whereby the thermal conductivity and heat capacity characteristics of said member and securing means are correlated with the thermal characteristics of the flake on a use basis with minimum limitation from assembly requirements.

9. A bolometer resistor adapted for short period intermittent exposure to radiant energy, and comprising a small, thin flake of thermistor material secured in good thermal contact with, but electrically insulated from a relatively large area surface of a relatively thick backing member, the thermal diffusivity of the flake being low relative to that of the member whereby the effective heat capacity of the assembly for said short period exposure is comparable to that of the flake alone.

10. A thermally sensitive resistor comprising a small, thin flake of thermistor material, a body which is large relative to said flake, and a means for securing the flake in good thermally conductive relation to a portion of a surface of the body, but electrically insulated from the body, said flake being self-sustaining, whereby the thermal conductivity and heat capacity characteristics of said body are functionally adapted to those of the flake free from limitations of flake manufacture.

11. A thermally sensitive resistor comprising an independently sintered, small, thin flake of thermistor material secured in electrically insulated relation to, but in good thermal contact with a portion of a surface of a relatively large thick body, whereby the thermal characteristics of the body are correlated with those of the flake free from flake sintering limitations.

12. A thermally sensitive resistor comprising a small thin, low heat capacity flake of thermistor material secured centrally of and in good thermal contact with an electrically insulating surface of a relatively large, thick body of heat absorbing material, the thermal diffusivity of the body being of a sufficiently high value that the effective over-all heat capacity of the assembly for relatively short heating periods is substantially the same as that of the flake alone.

13. A thermally sensitive resistor comprising a small, low heat capacity body of thermistor material in good thermally conductive relation to, but electrically insulated from, a relatively large mass having thermal conductivity and heat capacity characteristics selected so that the over-all heat capacity of the combined body and mass is little higher for short heating and cooling cycles than the heat capacity of the body alone.

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