DEVICE FOR SENSING THERMAL GRADIENTS

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6 Claims. (Cl. 73—339)

This invention herein described and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of royalties thereon or therefor.

This invention concerns heat sensing instruments which are operative to indicate and measure relevant characteristics of thermal gradients, and heat sensitive control devices adapted to function in response to variations in such characteristics of thermal gradients. Unlike temperatures at spaced apart points in a substance give rise to a thermal gradient whose representation as a vector is derived from the temperature difference which defines a magnitude therefrom, and the path of the heat flow between the points of higher and lower temperatures manifesting its direction. Therefore, instrumentation according to the invention is advantageously applicable to heat conditioned environments for obtaining an accurate analysis of significant heating effects. The invention would facilitate a rapid identification of the disposition and distribution of the relative heat intensities or temperature in such environments. When devices according to the invention are applied to exercise control, they function positively and efficiently to direct the functions of mechanisms adapted to be operationally responsive to a wide variation in heating conditions.

A structural component basic to all forms of the invention comprises a sealed enclosure containing a liquid having occluded therein a gaseous element capable of manifesting the existence and direction of a thermal gradient. A phenomenon of nature which predisposes this capability is evidenced by an effect in which the gaseous occlusion darts through the liquid medium defining it, toward or away from a point of higher temperature when the sealed enclosure is situated in the path of a thermal gradient. Although not completely established, it has become evident from many experiments performed that this phenomenon follows from the relative thermal molecular impacts on the hotter and colder interfaces defining the gaseous occlusion. These forces are known to be temperature- and composition-dependent, but in a rather complex manner. It appears that the thermal expansion of the liquid in response to temperature rise results in a change in the net force exerted which acts in one or another direction to oppose the forces normally present on the aforesaid interfaces. Even though a proper selection of the particular liquid for use in the sealed enclosure would evidently allow the making of instruments according to the present invention which could have occlusions that move either toward or away from the higher temperature when placed in the path of a thermal gradient, for the purposes of the description herein reference is made to only liquids whose occlusions move toward the higher temperature. Ideally, the volume of liquid is enclosed by a thin-walled vessel such that thermal equilibrium with the surrounding environment will be rapidly established. Moreover, such enclosures are appropriately shaped to allow a suitable effective component of the force created by the temperature differential to move the occlusion against the normal buoyancy induced by gravity. The ostensible effects of gravity may be eliminated through the use of a horizontal upper confining wall for the enclosing vessel. However, general applications of the invention for control purposes, require that the effects of gravity be utilized to predetermine the sensitivity of responsiveness of the instrument or device made according to the invention.

As hereinabove indicated, the effect of gravity may be utilized as a constant control force, which is countered by the thermal gradient effect to provide a determinable force for operating the invention. To endow any particular form of the invention with a thermal gradient threshold and a range of sensitivity, consideration is given to a number of factors effectively constituting the basic parameters for the relationships upon which are founded the operational characteristics of such embodiment. Among such factors are the density of the liquid contained therein and the size of its gaseous occlusion. It is evident that a denser liquid or a larger occlusion would require the existence of a temperature differential providing a greater force for displacing the occlusion counter to the effects of gravity. Increasing the angular disposition of the channel in the enclosure constituting the confining path provided for the mobile occlusion, in respect to the horizontal, also makes necessary a greater thermally created force. Naturally, the pertinent effective component of the gravitational force, that is the one directed along the path of the occlusion's displacement, increases from a mere frictional force at a horizontal disposition to a maximum at a vertical one. Accordingly, it is seen that gravity will result in a displacement along a path situated at a uniform angular disposition, in response to a continuing thermal gradient equal to or greater than a given threshold, the effective gravitational force will maintain an unchanging resistance to the occlusion's movement which continues unchecked until prevented by the occlusion upon which it eventually becomes lodged. On the other hand, a path defined by a gradually changing angular disposition in respect to the horizontal, such as one substantially following an arc, will present a graduated effective gravitational force for resisting the movement of the occlusion occasioned by the thermal gradient force. Consequently, an instrument according to the invention, comprising a vessel formed to provide a gradually changing angle for the path along which the occlusion is confined to travel, may be furnished with suitable calibrations to indicate the relative or particular intensity of a thermal gradient. In addition, it is equally practicable to shape the enclosure vessel such that its plan view appears as a disk whereby the direction in which the occlusion moves along a horizontal radius thereof can be observed to aid in a direct determination of the direction along which the thermal gradient lies.

In the past, thermal gradients were detected, indicated and controlled by means of instruments using pairs of individual thermal sensors. These instruments generally comprised current generating differential thermal couples as their sensing structure. Nevertheless, instruments of this type are mainly useful for detecting and measuring small temperature differences between two more or less static environments. Examples of instrumentation fashioned in this manner are disclosed in Patent No. 2,964,946, issued Dec. 20, 1960, to Gillfillan, Jr., and Patent No. 3,024,657, issued Mar. 13, 1962, to Brown. Reference to these patents makes evident that such instruments comprise relatively complex structural arrangements. However, the heat responsive components disclosed herein for the present invention will be found to have structures that are inherently simple, but which are also compact and rugged, making them highly effective for use in test and control equipment for a wide range of industrial and research activities.

An object of the present invention is therefore to provide highly sensitive instruments for detecting the existence of thermal gradients.

Another object of the invention is to provide devices