Dec. 7, 1943. C. K. GRAVLEY ET AL 2,336,241

TRANSDUCER APPARATUS.

Filed June 6, 1941 2 Sheets-Sheet 1

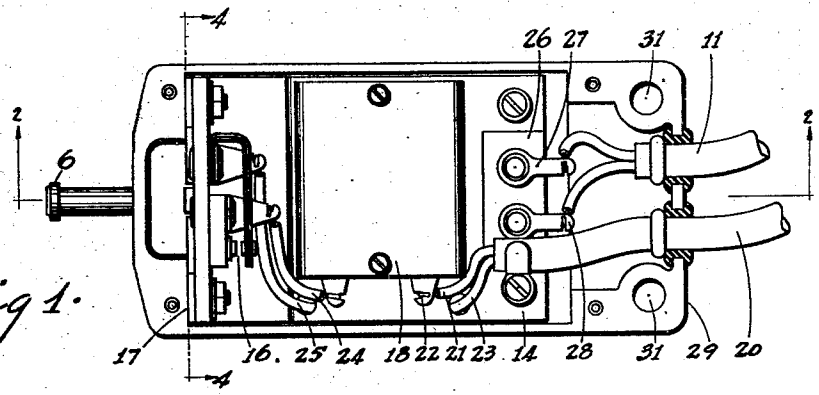


Fig 1.

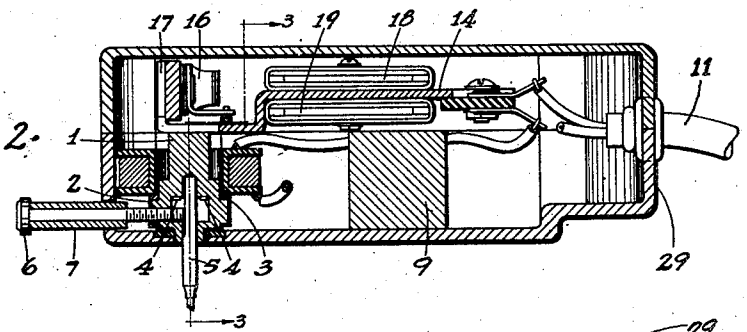


Fig 2.

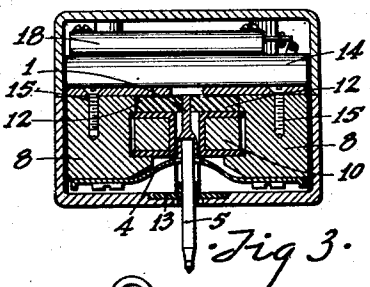


Fig 3.

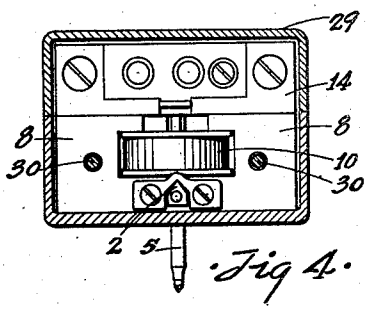


Fig 4.

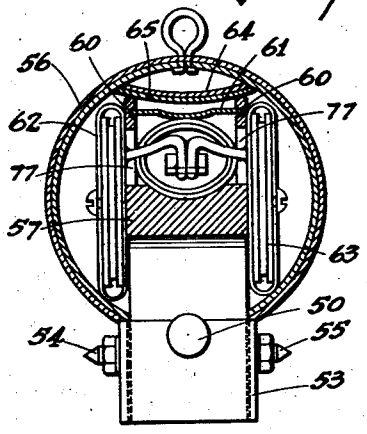


Fig 6.

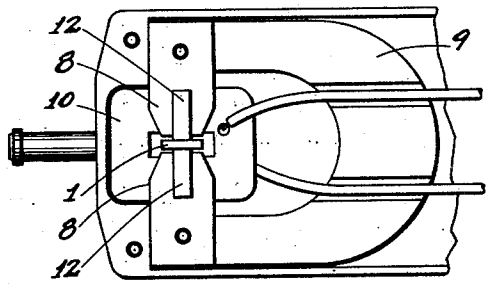


Fig 5.

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TRANSDUCER APPARATUS

Filed June 6, 1941 2 Sheets-Sheet 2

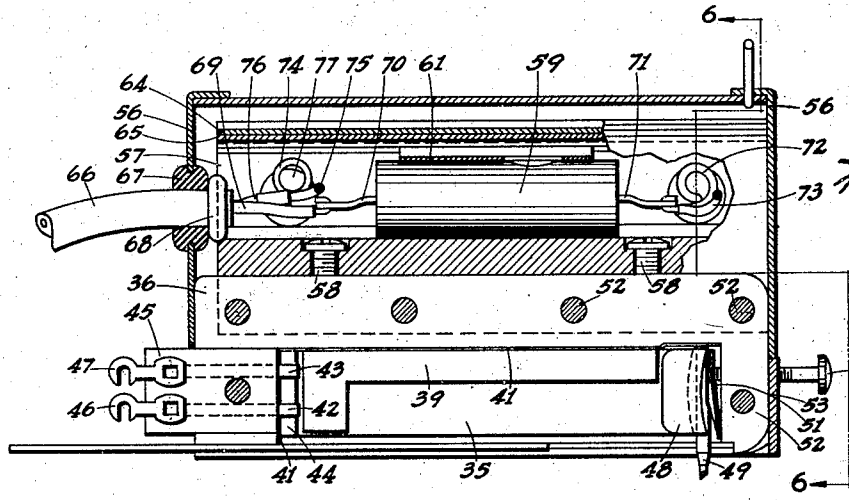


Fig. 7.

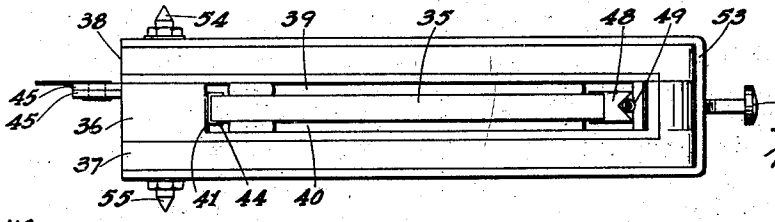


Fig. 8.

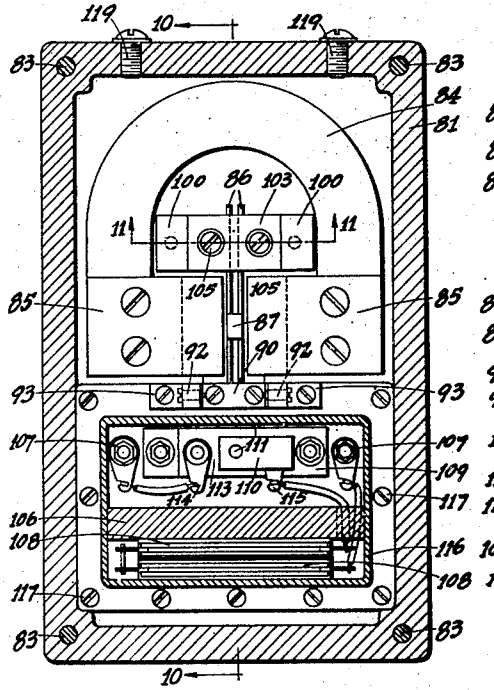


Fig. 9.

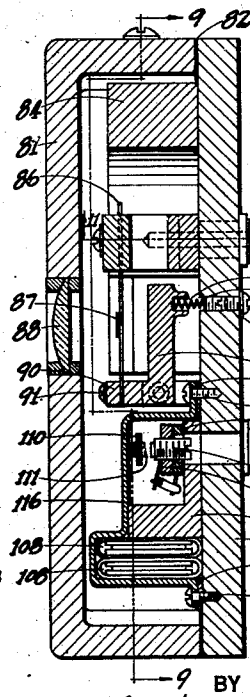


Fig. 10.

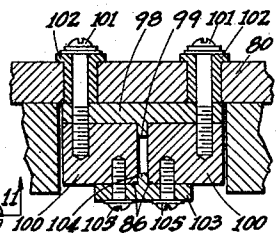


Fig. 11.

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2,336,241

UNITED STATES PATENT OFFICE

2,336,241

TRANSDUCER APPARATUS

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Application June 6, 1941, Serial No. 396,844

7 Claims. (Cl. 179—100.41)

This application is a continuation in part of United States patent application, Serial No. 294,237, filed September 11, 1939, which issued as Patent No. 2,244,690 on June 10, 1941.

This invention relates to electromechanical transducers which employ damping means to improve the performance thereof, and it relates more particularly to means for obviating the undesired results of temperature-induced variations in the characteristics of the damping material.

Transducer devices (that is, devices for converting electrical vibrations into mechanical or acoustic vibrations and vice versa) usually require the use of some form of mechanical damping if they are to exhibit reasonably uniform performance characteristics throughout a desired frequency range. Since the materials used to provide the damping usually are affected by changes in temperature, the performance of most types of vibratory electromechanical transducers is a function of temperature, whereas for most uniform results, it should be independent of temperature. While this difficulty can be minimized either by avoiding excessively large changes in temperature or by making the moving system of the device mass- or stiffness-controlled throughout the useful frequency range, neither of these expedients is completely satisfactory. If the transducer device is designed so that the moving system is mass- or stiffness-controlled (that is, if the resonant frequency is well outside the frequency range), the effects of temperature changes on the damping material are made less important, but the efficiency of the device is reduced so much, in many cases, as to make it impractical to obtain the desired level of output. Attempts have been made to avoid large changes in temperature by resorting to air conditioning in the room wherein the device is to be operated, this being primarily for the purpose of obtaining a fairly stable temperature in the atmosphere immediately surrounding the device. For the most part, this expedient has not given complete satisfaction for numerous reasons. The air conditioning equipment is expensive, takes considerable space, and each time the equipment is placed in operation, considerable time is required in order to establish a temperature equilibrium in the room.

From the foregoing introduction, it will be understood that the principal object of this invention is to provide means for reducing the effect of temperature changes on the performance of a vibratory electromechanical transducer.

It is also an object of this invention to reduce the non-linear distortion which results from the use of mechanical damping at ordinary temperatures.

Another object is to provide simple, convenient and economical means for obviating temperature-induced variations in the damping characteristics of damping materials.

It has been found that the objects of the invention can be achieved through the use of thermostatically controlled means for stabilizing the temperature of the damping material at temperatures sufficiently above or below room temperature to substantially eliminate the effects of changes in the temperature of the ambient atmosphere. When the temperature is stabilized above room temperature one effect is also to minimize non-linearity of the compliance and internal friction of the damping material. Either type of control over the temperature of the damping medium in a vibratory electromechanical transducer is applicable to both motor and generator devices, but it is most useful in motor devices since the latter must usually dissipate considerably more energy while in operation. The use of such temperature control means is particularly applicable to phonograph record cutters, oil-damped galvanometers and other devices of like nature in which considerable mechanical damping is used. In view thereof, the invention will be illustrated through reference to transducers of this type. For this purpose a magnetic type phonograph record cutter, a piezoelectric record cutter, and a magnetic galvanometer are shown in the accompanying drawings and are described hereafter.

In the drawings:

Fig. 1 is a top view of a magnetic type record cutter constructed in accordance with the invention, the top cover having been removed to expose the interior construction.

Fig. 2 is a sectional side view of the cutter taken along line 2—2 of Fig. 1.

Fig. 3 is a sectional view taken along line 3—3 of Fig. 2.

Fig. 4 is a sectional view taken along line 4—4 of Fig. 1.

Fig. 5 is a partial top view of the cutter with the top cover, heater and thermostat removed.

Fig. 6 is a front elevational view partly in section of a piezoelectric type record cutter which embodies the invention, the view being taken along the line 6—6 of Fig. 7.

Fig. 7 is a side elevational view of the piezo-

electric cutter with part of the case removed, and with other parts broken away or removed to better expose the inner construction.

Fig. 8 is a bottom view of the piezoelectric cutter with the bottom plate and the heater unit removed.

Fig. 9 is a front sectional view of an oil-damped magnetic galvanometer which embodies the invention, the section being taken along line 9—9 of Fig. 10.

Fig. 10 is a sectional view of the galvanometer taken along line 10—10 of Fig. 9.

Fig. 11 is a sectional view taken along the lines 11—11 of Figs. 9 and 10.

In the magnetic type record cutter shown in Figs. 1–5, a vibratory armature 1 is pivoted for vibration about an axis extending through a pair of knife edge bearings 2 and 3, and held in position by means of a curved spring metal strip 4 which extends through the armature. The armature drives a cutting stylus 5, which is held in place by means of a clamping screw 6. Excessive vibration of this screw is prevented by a rubber sleeve 7. The armature is positioned between a pair of magnetic pole pieces 8, 8 which are energized by a permanent magnet 9, and magnetic energizing of the armature is provided by a coil 10 which is connected through a cable 11 to the source of signal to be recorded. Two pads of damping material 12, 12 are disposed in notches in the top of the pole pieces 8, 8 and are arranged to engage the top portion of the armature 1. Additional damping is provided by a thin pad 13 of rubber which surrounds the lower part of the armature. The damping pads 12, 12 are preferably made sufficiently stiff to place the resonant frequency of the armature at the upper end of the useful frequency range of the cutter. A bent plate 14 of non-magnetic metal having good heat-conducting properties is fastened to the pole pieces by means of screws 15, 15 and serves to hold the damping pads 12, 12 in place. The temperature of the damping material is controlled by a thermostat 16 which is disposed directly above the damping pads and fastened to an upwardly bent front portion 17 of the metal plate 14. Two heater elements 18 and 19 are fastened to the rear portion of this plate which is offset so that they can be disposed on opposite sides thereof. Since the heating elements may be of any suitable construction, and their structure forms no part of this invention, they are not described in detail. However, a suitable form of heating unit is illustrated in the above-mentioned parent application, and reference is hereby made thereto. By arranging the heating elements and thermostat in the foregoing manner, good heat transfer can be obtained between the heater elements, the thermostat and the damping pads. Accurate control of temperature of the damping material is secured thereby. The heater elements and thermostat are connected by means of a cable 20 to a source of power such as an ordinary 110 volt alternating current or direct current line. One of the leads 21 from this cable is connected to one terminal 22 of the heater element 18 which is fastened to the top of the bent plate 14, while the other lead 23 is connected to one terminal of the lower heater element 19. The other terminals of the heater elements are connected to the thermostat 16 by means of leads 24 and 25. A terminal strip 26 having two connectors 27 and 28, is fastened to the rear portion of the plate in order to facilitate making the connections between the coil 10 and the cable 11. The entire assembly is enclosed in a case 29 and held in place by means of screws 30, 30 which extend through the bottom portion of the case and into the pole pieces 8, 8. Two holes 31, 31 are provided at the rear of the case so that the cutter can be mounted on a feed mechanism.

This type of record cutter construction effectively utilizes the various features of the invention, as will be pointed out subsequently.

A piezoelectric record cutter embodying the principles of the invention is illustrated in Figs. 6, 7 and 8. In this device a torque-type "Bimorph" piezoelectric unit 35 is clamped edgewise within a frame 36 between a side wall 37 of the frame and a cover plate 38. The clamping is effected between "L" shaped pads 39 and 40 of damping material which are in register with each other on opposite sides of the unit and which extend along the top edge and one end edge of the unit. The unit is disposed within the frame so that the edges which are clamped between the damping pads are buttressed against the adjacent walls of the frame. Thin sheets 41, 41 of damping material are disposed between the unit and the frame walls to prevent the unit from contacting these walls directly. The electric connecting leads 42 and 43 of the unit extend outwardly from the clamped end, being reinforced and protected by an elongated "U" shaped clip 44 of insulating material which is clamped over the leads and presses them flatwise against a portion of the end edge and an adjoining portion of a side face of the unit. The leads 42 and 43 are then doubled back over the clip 44 and extend outwardly through the frame through a pair of insulating plates 45, 45 and terminate in a pair of lugs 46 and 47. This construction will be understood more fully through reference to Kornei application, Serial No. 382,303, filed March 8, 1941, which issued as Patent No. 2,266,768 on Dec. 23, 1941. The free end of the piezoelectric unit carries a stylus holder 48 adapted to form a pair of spaced "V" notch seats for a stylus 49. The stylus is clamped into said seats by means of a set screw 50 disposed substantially on the longitudinal axis of vibration of the piezoelectric unit. The construction and operation of the record cutter thus described will be more fully understood through reference to the copending application of Otto Kornei, Serial No. 317,621, filed February 7, 1940. From the description there presented, it will be understood that clamping screw 50 may press directly against stylus 49. In the device illustrated in Figs. 6, 7 and 8, however, the clamping screw bears against a ribbed spring 51 which is secured within the frame in any suitable manner. The cover plate 38 is secured to the frame 36 by means of screws or rivets 52, 52, and the whole assembly is disposed within a "U" shaped strap of metal 53 which extends from one pivot 54 to the other pivot 55. The set screw 50 aids in retaining this strap in position at the stylus end of the cutter.

It will be observed that in this construction the damping material is in intimate contact with the side walls of the frame of the cutter and hence has substantially the same temperature as that of the metal of the frame. By reason of this relationship it becomes possible to make use of thermostatically controlled heating means for controlling the temperature of the damping material, and to place these means at quite some distance away from the damping material without introducing serious temperature differentials between the controlling thermostat and the

damping pads. The heating means and controlling thermostat are mounted in a casing 56 disposed above the cutter. The construction involves an elongated U shaped support 57 secured to the frame 36 by means of screws 58, 58. The U shaped cavity within this support is suitably dimensioned and contoured to receive a thermostat assembly 59 and is provided with a pair of registering grooves 60, 60 (Fig. 6) into which may be fitted a spring plate 61 for holding the thermostat assembly in position within said U shaped cavity. Adjacent the opposite outer side walls of the U shaped support is a pair of wire-wound heating units 62 and 63. Since the construction of these heater units does not form a part of this invention, a description thereof will be omitted, except for reference to the parent application identified above wherein the construction is shown in detail. The outer casing 56 is fitted around the whole thermostat and heater assembly and is held in alignment by a spring plate 64 which presses against the top edges of the support 57. The spring metal plate 64 is insulated from the support by an intervening layer 65 of insulating material. As shown in Fig. 7, a suitable power cable 66 extends through a flexible bushing 67 in the end wall of casing 56. The cable is encircled with any suitable clamping ring 68 applied thereto within the cover to prevent the power cable from being pulled out accidentally. The power cable may be connected to any suitable source of heating current, such as the local power line. One lead 69 of the power cable is connected to lug 70 of thermostat 59. The other lug 71 of the thermostat is connected to leads 72 and 73 of the heating units. The other leads 74 and 75 of the heating units are connected together and to the other lead 76 of the power cable. It will be understood, therefore, that the thermostat is in series with the heating units, but that the heating units are in parallel with each other. Clearance openings 77, 77 are provided in the side walls of support 57 to provide passageways for the leads of the heating units.

It will be understood from the construction of the device of Figs. 6, 7 and 8 that the heating units are effective in bringing the damping pads 39, 40 to a desired temperature above the temperature of ambient atmosphere, and that the physical disposition of the heating units relative to the damping pads and to the thermostat is such that the thermostat is effective in controlling the temperature of the damping material so as to stabilize this temperature and maintain it within a small temperature range. The range of temperature variations is, of course, dependent upon the sensitivity of the thermostat and to some extent upon the thermal lag which exists between the thermostat and the damping pads. This thermal lag may be reduced to a minimum by making the frame 36, cover plate 38, and support 57 of metal having high thermal conductivity. Since the total weight of the assembly is sometimes a matter for consideration, these parts could well be made of aluminum, or of aluminum alloys which possess the high thermal conductivity of aluminum. Where weight is not a consideration, then copper and copper alloys would be suitable. Other metals will, of course, suggest themselves to one skilled in the art.

A further embodiment of the invention is illustrated in Figs. 9 and 10. The device which is shown here is an oil-damped galvanometer which embodies means for heating and thermostatically controlling the temperature of the oil used in the device. The galvanometer consists of a base 80 which supports all of the elements of the structure. An outer case 81 is secured to the base and is so dimensioned that it may enclose the entire construction. A gasket 82 is disposed between the base and the cover so as to seal the joint therebetween. The cover is firmly secured to the base by means of screws 83. The galvanometer is of the magnetic type and comprises a horseshoe magnet 84 having suitable pole pieces 85, 85 secured in magnetic relation to its ends. Two metal ribbons 86, 86 of non-magnetic material are positioned between the pole pieces 85, 85, and they carry a mirror 87 which is suitably secured flatwise against their outer surfaces. The case 81 is provided with a suitable transparent window 88 disposed in front of the mirror. The ribbons 86, 86 are clamped at their lower ends to a fulcrumed lever 89 by means of a metal cap 90 and screws 91, 91. The lever pivots around two pivot screws 92, 92 which are threadably retained in brackets 93, 93. The lever is provided with a recess in which is disposed a spring 94. An adjusting screw 95 threaded in an opening in base 80 permits the compression of the spring to be adjusted. A screw 96 is threaded into the same opening and carries a fibre washer 97 which acts to seal the opening against the leakage of oil from the assembly. The upper ends of the ribbons 86, 86 are suitably clamped in a fixed support, the construction of which is shown in Fig. 11. It will be seen that the support consists of an insulating base plate 98 having a boss 99 provided centrally thereof. The boss is dimensioned to correspond to the spacing between the ribbons 86, 86. A pair pair of metal blocks 100, 100 are disposed on the base plate on opposite sides of the boss and are firmly secured to base plate 80 by means of screws 101, 101 which are insulated from the base 80 by the insulating bushings 102, 102. The ribbons 86, 86 are clamped against blocks 100, 100 by means of a cap 103 having a boss 104 which extends into the space between the two blocks 100, 100. The cap is secured to the blocks by means of screws 105, 105. It will thus be seen that the spacing of the ribbons is determined accurately by dimensions of the boss 104 of cap 103. A similar boss is provided on the cap 90 of lever 89 to fix the spacing of the ribbons at their lower ends, as will be understood.

The lower portion of the assembly is occupied by a pair of electric heating elements and a thermostat for controlling the heating action of said heating elements. The thermostat and heater assembly includes an L shaped base 106 of heat insulating material which is secured to base 80 of the device by means of terminal screws 107, 107. Wire-wound heating elements 108, 108 are disposed below the bottom wall of the L shaped base. A thermostat is disposed above the bottom wall. This thermostat is similar in construction to the thermostat shown in Fig. 1, and consists of an insulating base 109 to which is secured a temperature-responsive bimetallic element 110 carrying a contact 111. An adjustable contact 112 is threadably engaged in a metal plate 113 and is disposed so as to be in register with contact 111 of the bimetallic element. Electrical connections to the adjustable contact 112 is made through metal plate 113 and lug 114, while electrical connection with the bimetallic

element is made through lug 115. Heating current is made available at terminal screws 107, 107. One of the terminals 107 is connected through lug 114 and plate 113 to the adjustable contact 112. The heating elements 106, 106 are connected in series between the other terminal 107 and lug 115. The thermostat and heating element assembly is wholly enclosed within a suitable case 116 which is secured to base plate 80 by means of screws 117, 117. A suitable gasket 118 is interposed between the case and the base 80 to effectively seal the joint and to keep oil from entering the case 116. After the device has been assembled as shown, suitable damping oil or other liquid is poured into the case through one of the screw holes 119, 119. When the chamber has been suitably filled with oil, screws may then be threaded into the oil holes to effectively seal the assembly. These screws may be used for mounting the instrument.

It will be understood that signal currents are applied to the galvanometer by making connections to terminal screws 101, 101. Heating current is supplied to the heating elements by making suitable external connections to the terminals 107, 107. It will also be understood that when the device is in operation, the mirror 87 is constrained to undergo limited rotary motion. Being wholly surrounded by oil, the vibratory system may be suitably damped if oil of the proper viscosity is selected. It is usually preferable to provide critical damping in an instrument of this type. In order to maintain this critical damping when the device is in operation, it is expedient to heat the oil by means of the heating units 106, 106 to a temperature which is not substantially below the highest temperature which the device will attain when in normal operation, and then to control this temperature within a narrow temperature range so that the ability of the oil to dissipate energy from the rotating mirror becomes and remains stabilized. It will be observed that the heating units are disposed at the bottom of the assembly and hence are instrumental in creating convection currents within the oil soon after heating current is supplied to the heating elements. Heat is therefore transferred promptly from the heating elements to all parts of the device, and equilibrium conditions can be established within a relatively short period of time, and maintained with a minimum of temperature differentials throughout the device. It will also be noted that the thermostat is not in direct metallic contact with either the metal shell 116 or the metal base 80 and is effectively insulated from the heating elements by means of the bottom wall of the L shaped insulating plate 105. Accordingly, the thermostat is substantially more responsive to the temperature of the oil than to other parts of the assembly. It is therefore possible to adjust the thermostat so that it will maintain the temperature of the oil at a fairly constant value after equilibrium conditions have been reached. The damping effect of the oil may thereby be stabilized and made substantially independent of the temperature of the ambient atmosphere in which the galvanometer is used.

From the foregoing illustrations of the invention it will be understood that the invention contemplates the use of means for stabilizing the temperature of at least the damping medium in a transducer at temperatures which are not substantially within the temperature range usually encountered in the operation of such transducer. By doing this, it is possible to avoid most of the adverse effects resulting from temperature-induced variations in the damping properties of the damping medium. The practical value of the invention may become more apparent when the operation of a device which does not embody the invention is considered. For example, if a transducer is designed for use at the usual room temperatures (as is generally the case), it is apt to exhibit its best performance within a narrow range of temperatures within the usual room temperature range. If the device is of a portable nature, it is likely to be subjected to wide variations in temperature, and even if it is located indoors at all times, it is more frequently than not operated at temperatures lying either above or below the optimum range, or under conditions which cause its temperature to change almost incessantly while it is in operation. The result is that the temperature conditions which induce the most desirable operating performance can seldom be sustained for any prolonged period of time, even in an air conditioned room. Now, as will be understood from what has been said previously, these variations in performance are due in large measure to the effect of temperature on the properties of the damping elements which are embodied in the device. The optimum temperature range referred to above is the range in which the amount and/or kind of damping is most nearly correct. When the device becomes heated to a temperature above this optimum range, or is cooled to temperatures below it, the damping material undergoes changes in its various properties. The result is that the amount and/or kind of damping needed for best results is no longer available, and the performance is altered. The nature of the alteration which occurs depends largely upon whether the damping medium has been heated above the optimum range or cooled below it. If heated above this range, the damping medium is generally affected in such manner that the device is under-damped, and exhibits overshooting and other tendencies which are the result of insufficient damping. On the contrary, if the device is cooled to temperatures below the optimum range, the damping medium is so affected that it over-damps the device. This usually results in reduced sensitivity, sluggishness, poor high-frequency response and similar defects. The damping material may also exhibit temperature-induced variations in its stiffness, and these variations may be, and often are, of such a nature as to aggravate the defects just described by causing changes in the resonant frequency of the vibratory system.

In view of what has been said above, it will be apparent that when the invention is embodied in a transducer which contains damping elements, the foregoing defects and disadvantages are largely obviated since the invention provides simple yet effective means for avoiding the temperature variations which induce the defects. It will be understood that this result is achieved through the use of means which function to stabilize the temperature of the dominant damping elements of the device. While the invention contemplates the use of refrigerating means for stabilizing the temperature at relatively low temperatures, it is directed principally to the use of heating means for stabilizing the temperature at slightly elevated temperatures. For most purposes it is sufficient to heat the damping elements to a temperature which is substantially at or slightly above the highest temperature which the device

is apt to encounter when used for the purposes for which it is designed. The device will then accomplish its intended functions without exhibiting the temperature-induced variations described above. In this connection it should be noted especially that when the damping elements are maintained at the temperature noted above, the advantages that accompanying the use of a stabilized temperature may be obtained even though the optimum temperature range does not coincide substantially with the temperature to which the elements are heated. The invention may consequently be applied with advantage to a device which was not originally designed for use with the invention. It will be understood, of course, that the advantages may be secured to their fullest extent by designing the device originally so that its optimum temperature range is close to or coincides with the temperature at which the damping elements are to be stabilized. The constancy of performance which characterizes a device embodying the invention may then be combined with high efficiency and sensitivity.

It will be appreciated that a reliable constancy of performance is a highly desirable quality in many devices but that it is especially desirable in devices of the type which may be calibrated; that is, in devices of the type wherein a signal of given amplitude is expected to produce a deflection or vibration which is in close correspondence with it, or wherein a given deflection or amplitude of vibration is relied upon to indicate the amplitude of the signal. A record cutter is a device of the first type, and a galvanometer is a device of the second. It is obvious that when the performance is a function of temperature, the utility of such devices is greatly impaired. This invention makes it possible to avoid such temperature-induced variations in performance.

As pointed out above, it is the object of the invention to provide means for maintaining the temperature of the damping medium at a moderately constant value at or substantially above the highest temperature which the device would be expected to encounter when in use. That is, if the device is to be operated in a locality where a limited fluctuation in ambient temperatures is to be expected, the temperature-stabilizing means should be set to hold the temperature of the damping material constant at about the upper limit of this range of temperatures, or higher. When this is done, the damping material will not be affected by the fluctuations in temperatures of the ambient atmosphere. Where the damping medium is a fluid, such as the oil in the oil-damped galvanometer of Figs. 9, 10 and 11, it is a relatively simple matter to hold its temperature constant by means of thermostatically controlled heating or refrigerating means, since convection currents can be relied on in most instances to maintain a uniform temperature in the fluid, and since the thermostat can be placed in such relation to the oil that it will respond to the temperature of the latter. However, the problem is somewhat more difficult when the pliable solid damping materials are used because such materials are generally poor conductors of heat and hence may exhibit rather large temperature differentials throughout even a small mass of the material. In other words, it is more difficult to maintain a uniform temperature throughout such poor heat conducting materials. Of course, if the temperature cannot be held fairly uniform, the advantages of the invention will be largely lost. The problem is overcome in the devices of Figs. 1–5, by contacting the damping material with a relatively large mass of metal having relatively high heat conductivity, and by positioning the heating units so that they are effective in supplying heat to this metal. The thermostat may then be placed so that its response to the temperature of the metal mass may be effective to control the heat output of the heating units. The temperature of the metal is thereby effectively stabilized. Since the metal has relatively high thermal conductivity, it exhibits only slight to negligible temperature differentials. Accordingly, the portion of the metal mass which is in contact with the damping material has substantially the same temperature as the part to which the thermostat responds. As a result, the thermostat indirectly controls the temperature of the damping material even though it is responsive to the temperature of the metal mass. It will be recognized that if a part of the damping material may be held at a nearly constant temperature, the other parts will, in most devices, ultimately reach an equilibrium condition centered around that part, with the result that the various portions of the damping material do not undergo objectionable fluctuations in temperature.

Another way to avoid temperature fluctuations in the damping material without using a metal mass as above, is to embed a thermocouple in the material, and let the thermocouple control the means which are relied on to stabilize the temperature of the damping material. In such an arrangement, the control means respond directly to the temperature of the damping material instead of responding indirectly as in the case of the metal mass. Such an arrangement is apt to be particularly advantageous in a device wherein large amounts of energy must be dissipated during short periods of time rather than continuously, since in such a device the temperature of the damping material is apt to rise rapidly during one of these periods, and then fall gradually. Equilibrium is difficult to establish under such conditions, so that the metal mass arrangement is not apt to be satisfactory. The arrangement using a thermocouple will, however, respond quickly with the result that better control of the temperature-stabilizing means can be secured.

Having now described the invention through an explanation and description of several exemplary embodiments, what we claim is:

1. In combination, an electromechanical transducer; damping material associated with said transducer for dissipating excess energy therefrom, said damping material having damping properties which vary with temperature; metallic means in close heat conductive relationship with said damping material, said metallic means being composed of metal having high thermal conductivity; and means for maintaining the temperature of said metallic means substantially constant at values beyond the range of temperatures which would be encountered by the device when in operation if the said temperature stabilizing means were inoperative.

2. In combination, an electromechanical transducer; damping material associated with said transducer for dissipating excess energy therefrom, said damping material having damping properties which vary with temperature; metallic means in close heat conductive relationship with said damping material, said metallic means being composed of metal having high thermal conductivity; and heating means for maintain-

ing the temperature of said metallic mass substantially constant at values equal to and above the highest temperature which would be encountered by the device when in operation if the temperature stabilizing means were inoperative.

3. In combination, an electromechanical transducer; damping material associated with said transducer for dissipating energy therefrom, said damping material having damping properties which vary with temperature; metallic means in close heat conductive relationship with said damping material, said metallic means being composed of metal having high thermal conductivity; and means for stabilizing the temperature of said damping material at values above the highest temperature which would be attained by the material when the device is in operation if said temperature stabilizing means were inoperative, said means comprising means for heating said damping material, and thermostatic control means for controlling the heat output of said heating means in response to the temperature of said metallic means.

4. The combination as claimed in claim 3 wherein said electromechanical transducer is of the electromagnetic type.

5. The combination as claimed in claim 3 wherein said electromechanical transducer is of the piezoelectric type.

6. In combination, a piezoelectric transducer, damping means engaging and extending for a distance along said piezoelectric transducer for dissipating excess energy therefrom, said damping means having damping properties which vary with temperature, heat conductive means in close heat conductive relationship with said damping means and extending substantially the distance of the said damping means, and means for maintaining the temperature of said heat conductive means substantially constant.

7. A device as set forth in claim 6 in which said means for maintaining substantially constant the temperature of the heat conductive means is a thermostatic means adapted to supply heat to said heat conductive means, and includes a thermostatic control for regulating the supply of heat to said conductive means.

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