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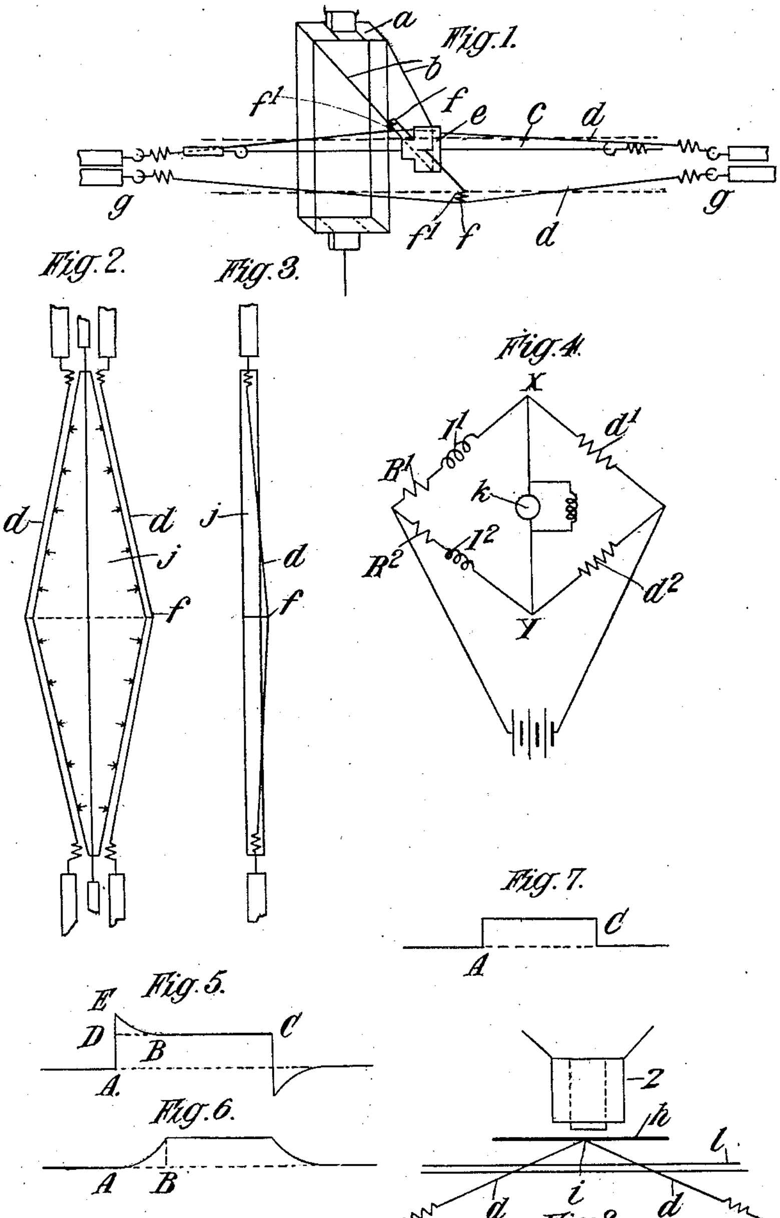
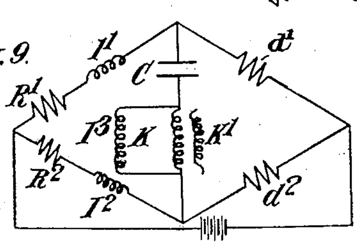
ELECTRICAL MEANS FOR MAGNIFYING SMALL MECHANICAL EFFECTS.

APPLICATION FILED JUNE 29, 1910.

1,029,123. Patented June 11, 1912.





Witnesses

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ELECTRICAL MEANS FOR MAGNIFYING SMALL MECHANICAL EFFECTS.

1,029,123. Specification of Letters Patent. Patented June 11, 1912.

Application filed June 29, 1910. Serial No. 569,499.

To all whom it may concern:

Be it known that I, Ernest Sydney Heurtley, a subject of His Majesty the King of England, residing at 193 Woodstock road, in the city and county of Oxford, Kingdom of England, gentleman, have invented certain new and useful Electrical Means for Magnifying Small Mechanical Effects, of which the following is a specification.

This invention relates to improved means whereby any small mechanical movement, such as that made by an electrical or other recording, signaling or measuring instrument, may be magnified; the magnified movement being more or less identical or altered in a definite form relatively to the primary movement.

This invention is especially applicable to the magnification of the mechanical effect of the weak electric currents at the receiving end of submarine cables, and the apparatus will be hereinafter described, with reference to the accompany drawings, to illustrate the application of my invention for this particular purpose; though it will be obvious that it may be applied to any form of measuring or recording instrument or the like of feeble mechanical effects.

The invention is based on the following facts (1) that the heat abstracted by the atmosphere or any gas from a heated filament, or wire, has different values depending upon the rate of movement of the gas past the heated substance and also on the temperature of the gas. (2) That the heat conductivity of any gas or the atmosphere, or combination of gases is less than that of the majority of liquids. (3) The variation in the electrical resistance of a conductor of electricity with change of temperature. (4). The variations in the dimensions of a wire or filament with change of temperature. (5) The effect of inductance, capacity and resistance or combinations of these to compensate for any lag in a thermal change.

In the accompanying drawings:—Figure 1 is a diagrammatic perspective view illustrating an arrangement for magnifying signals in accordance with this invention. Figs. 2 and 3 are diagrammatic views taken at right angles to one another of a slightly modified arrangement; Fig. 4 is a diagram illustrating the arrangement of induction, capacity and resistance, or combination thereof for rectifying a time lag in a local hot wire circuit. Figs. 5, 6 and 7 are diagrams illustrative of the operation of the device. Fig. 8 is a diagram showing the adaptability of the mechanism in conjunction with telephonic apparatus. Fig. 9 is a diagram showing a different arrangement from Fig. 4.

Referring more particularly to Fig. 1 of the drawings *a* denotes a coil that is suspended in a magnetic field under the influence of the current from a cable. A mechanical connection is made from the coil *a* to the upper and lower portions of an aluminium cradle *e* suspended on a wire *c*, by means of a pair of fibers *b*. Attached to the cradle *e* is an arm carrying insulated supports *f* for a pair of fine hot wires or filaments *d* of platinum or other suitable material. These wires *d* are supported at their ends by suitable means as shown at *g* and they are so arranged that the wires *d* are slightly inclined to the horizontal when the supports *f* are in their zero position.

It will be seen that upon the cradle *e* and supports *f* being turned about their axis *c* the inclination of the wires *d* to the horizontal will be increased or reduced and these wires *d* are normally partially immersed in a liquid such as water and partially in the atmosphere, or wholly in one or other of these mediums, but in close proximity to the other. Thus when the suspended coil changes its relative position it changes the position of the suspended wires or filaments *d*, in such a way as to change the relative amount of any particular wire immersed in the liquid. The conductors *d* have sufficient electric current passing through them continuously, to raise their temperature greatly above that of the surrounding atmosphere when they are exposed to the latter, and this alteration in the amount of any particular wire or filament immersed in the liquid will by changing its temperature have the effect of altering the average conductivity of the whole wire, on account of the greater cooling effect of the liquid in comparison to the atmosphere. This alteration in resistance may be employed in any suitable way to affect an electrical instrument such as a coil suspended in a magnetic field on the principle of the differential galvanometer, the Wheatstone bridge or any other of the known methods of registering change of resistance, thus magnifying the movements of the prime mover.

The variation in resistance for any given movement of the prime mover may be still further increased by arranging a spring connection such as at f' between the moving part c and the moving wires or filaments d; this spring connection keeps the wires or filaments under tension, and as these wires or filaments lengthen with heat it draws them up and consequently out of the liquid.

In the place of a liquid to reduce the temperature of the wire or filament d, this temperature may be reduced by the wire or filament being more or less immersed in a current of air or gas, by the prime mover; in the same way in which the prime mover immerses the wire or filament in the liquid. Or the wire or filament may by the same means be immersed more or less in a flame or current of hot air or gas which may thus vary its temperature. Such an arrangement as the latter is shown in Figs. 2 and 3 of the drawings in which j indicates a suitably shaped piece of wood or other material adjustable in size or otherwise. A blast of air or other gas is blown by any suitable means as indicated by the arrows along the surface of the wood on to the hot wires d. These wires d are movably connected up as in the previously described arrangement by an insulated arm f so that any movement of such arm will shield from or immerse the wire more in the blast which cools the wires and thus causes a variation which is controlled by the movement of the coil a. The recording instrument in the local circuit may be a telephone, hot wire operated device on the principle of the Cardew voltmeter, or any of the known electrical registering instruments.

Referring to Fig. 4 of the drawings let d' d^2 be the hot wires of the invention, and let the other two arms be made up of an inductive resistance *i. e.* an ohmic resistance R', R^2 with magnetic induction I', I^2 and let k be the recording instrument. Suppose a balance to be maintained and d' d^2 to be at their zero position. Next suppose that owing to a movement of the prime mover d' is immersed more in the cooling medium while d^2 is immersed less. This will result in the ohmic resistance of d' being reduced, while that of d^2 is increased, and thus there will be a tendency for the current to increase in d' and R' while the tendency will be for the current to be reduced in R^2 and d^2. The inductance in I', and I^2 will tend to stop these changes in current passing through them. That is the effective resistance of I' will be higher for the first instant than justified by its ohmic resistance, and will mean that the balance will be thrown out more in the first instant than the actual change in d' would cause if inductance were not present. And the effect of inductance I^2 will be exactly similar except in the reverse direction, thus still further momentarily putting out the balance. When, however, the currents through I' and I^2 have assumed their steady values I' and I^2 will have only their ohmic values and at that time the alterations in resistance of d' d^2 will be the only cause of alteration in balance. Now if d' and d^2 were to change completely instantaneously the current passing k for a steady deflection of the prime mover might be represented by the curve in Fig. 5, where A is the point where the prime mover is deflected, D E the momentary increase in the change of balance due to the inductance in the arms which is reduced to zero at B after which the change of balance is due solely to the change in resistance in the hot wires.

In Fig. 6 is shown the shape of the disturbance in balance curve if no inductance I', I^2, but only ohmic resistance is present and the hot wires take an appreciable time to change their temperature completely and therefore their resistance. In this case it is seen that whereas the change of balance commences at the same time, it never overshoots its mark but rises slowly to its maximum. And if the curve in Fig. 6 be superimposed upon the curve in Fig. 5 a practically straight line will be the result as in Fig. 7. This can be obtained in practice by so adjusting the electrical time constants of the inductances I' and I^2 so as to agree with the thermal time constants of d' and d^2; and by similar adjustments in these inductances the distortion in the signals due to the capacity and resistance of the cable through which the primary current has passed can in part be rectified. A similar effect might be produced by placing an inductive shunt straight across the recorder coil k its shunting effect being negligible for the first instant of any change in current thus forcing all the current through the coil; while it would be appreciable after an interval depending upon its inductance, and in this way it could be made to square up the signals, or these two methods might be used in conjunction as shown in diagram. In place of inductance in series or parallel, capacity, or capacity and resistance, may be used in parallel or series respectively to produce a similar effect, or a combination of all these methods may be used.

In addition to the inductances fine wires or filaments kept hot by the constant current, but unmovable, may be placed in the arms of the bridge at R' and R^2 as shown in diagram in Fig. 4, and thus if the current is increased through R' owing to d' being cooled, R' will increase in temperature and in resistance and will thus augment the effect of d'. The electrical time constant of this local circuit may be varied by the usual methods of combinations of inductances resistance and capacities.

Although only two methods are shown for arranging the hot wires, inductances, etc., it is obvious that there are many other ways of arranging them involving the invention suitable for various instruments. For instance the hot wires of the invention might be made to act as a telephone relay or in place of the instrument known as the microphone. In this case the hot wire would be mechanically connected to the diaphragm of a telephone receiver, or to a diaphragm actuated by vibrations of the air or the like, similar to a microphone diaphragm. In Fig. 8 *h* is the telephone or microphone diaphragm *d d* the hot wires of the invention rigidly connected to the diaphragm at *i*. These wires may be connected in various ways to the diaphragm; for instance as shown in Fig. 8. Any movement of the diaphragm *i* causes a variation of the amount of the wire above or below the dividing line *l*. This dividing line is either the surface of a liquid or a partition of suitable material such as wood or ebonite upon one side of which a blast of air gas or vapor is caused to blow and the other side of which the medium surrounding the wire is comparatively at rest or in a different state; thus causing a change of temperature in the wire which will result in a change of resistance which may be arranged as described already to alter the current in a local circuit. Fig. 9 shows a particular method of obtaining this end. d' d^2 are the heated movable wires I' I^2 I^3 suitable inductances and C a suitable capacity as before described. R' R^2 are suitable resistances for minor adjustments etc., and K is the primary of a suitably wound transformer.

Variations in the resistance of d', and d^2 cause variable currents to pass through K which induce currents in the secondary windings of this transformer K', which send currents into a local telephone or into the second line.

If the instrument is used as a microphone the diaphragm *i* would be spoken on to, whereas if the invention was to be used as a telephone relay; the incoming current would pass around a suitable electromagnet or solenoid 2 and thus affect the diaphragm *i*. This arrangement is shown in Fig. 8. I do not however limit myself to these particular arrangements but give these simply as illustrations there being evidently many other ways of arranging the hot wires involving the invention.

It will be understood that the devices denoted by the reference letters I' I^2 I^3 R' R^2 *d d'*, and *c* may have any values to suit particular circumstances—I^3 may be made to include capacity C as well as K. I am aware that it has been previously proposed in a hot wire electrical measuring instrument to compensate for the heat capacity of the wires by the use of condensers and inductive resistances and I only claim these devices in magnifying apparatus in which change of resistance is the governing factor.

What I claim and desire to secure by Letters Patent of the United States is:—

1. The method of reproducing in magnified form the effects of small forces which consists in establishing in the circuit containing a resistance medium electrical conditions corresponding to and greater than said small forces and subjecting different portions of the resistance medium simultaneously to the action of two associated media of different activities with relation to said resistance and causing variations of resistance by varying the relative extents of the portions of the resistance medium subjected simultaneously to the associated media by and in accordance with the said small forces.

2. The method of producing small electrical impulses in magnified form which consists in heating a resistance medium included in a charged circuit by the current passing through said circuit to thereby increase the resistance of said circuit, and subjecting different portions of the resistance medium to the action of two associated media of different activities with relation to said resistance medium and causing variations of resistance in the said circuit including the resistance medium by varying the relative extents of the portions of the resistance medium subjected simultaneously to the associated media by and in accordance with said small electrical impulses.

3. The method of magnifying the effect of small forces which consists in establishing in an electric circuit a condition of resistance by heat generated by the passage of current through a predetermined portion of said circuit, and causing a variation of such resistance by the application to said resistance, in accordance with motions produced by the forces to be magnified, of a medium capable of causing a variation in said resistance by varying the heat thereof.

4. The method of magnifying the effect of small forces which consists in establishing in an electric circuit a resistance by heat developed by the passage of the current through a predetermined portion of said circuit, and causing a variation in said resistance by presenting portions of the heated part of the circuit to a medium capable of varying the resistance, by a relative movement between the resistance portion of the circuit and the said medium, due to the action of the small forces.

5. The method of magnifying small forces which consists in establishing in an electric circuit a predetermined temperature condition by the action in said circuit of an electric current representing greater energy

than the small forces, and then controlling the effect of the electric current by a heat modifying medium acting on the temperature condition due to the electric current and in accordance with variations in the small forces.

6. The method of electrical transmission of intelligence which consists in establishing in an electric circuit a resistance to the passage of current therethrough by heat developed in a predetermined portion of said circuit due to the passage of current therethrough, and varying such electrical resistance by the action of a fluid thereupon in accordance with variations in transmitted electrical impulses designed to convey the desired information.

7. The method of relaying electrical impulses which consists in producing in a relay circuit a resistance to the passage of the relay current by heat developed by said current, and varying such resistance by the action of a modifying medium controlled by and in accordance with the impulses to be relayed.

8. The method of magnifying the effects of small electric currents which consists in causing in an electric circuit a current of greater power than the said small currents, and establishing in such electric circuit a resistance to the passage of such larger current by heat due to the passage of the larger current through a resistance member, and varying the relation of the resistance member to a heat controlling medium by and in accordance with the action of the small currents upon such resistance member.

9. The method of magnifying small forces which consists in establishing a resistance condition in a portion of an electric circuit by the action of heat generated by the passage of current in said circuit, varying the resistance by subjecting the heated portion of the circuit to a heat varying medium by and in accordance with the small forces, and establishing electrical conditions to compensate for disturbances due to a lag in the thermal change in the resistance portion of the circuit.

10. The method of relaying feeble electric currents which consists in establishing a resistance condition in a movable portion of an electric circuit by the action of heat generated by the passage of current through said movable portion, and varying the resistance of such movable portion by actuating it to varying extents into and out of active relation to a temperature controlling medium by and in accordance with said feeble electric currents.

11. A means for magnifying the effects of small forces comprising an electric circuit including a section of conductor responsive to the current in the electric circuit to attain a higher temperature than the remainder of the circuit, and means responsive to the small forces to bring into engagement with the heated conductor section a medium capable of varying the temperature of the said conductor section from that produced by the passage of the electric current therethrough.

12. A means for magnifying the effect of small forces comprising an electric circuit including a resistance element adapted to be heated by the passage of the current in said circuit and increasing in resistance with a rise in temperature, and means controlled by the small forces for varying the temperature of the resistance element in accordance with said small forces and independent of the current flowing through said resistance element.

13. A means for magnifying the effect of small forces comprising an electric circuit including a resistance element changeable in resistance with changes in temperature, a chilling medium in operative relation to the resistance element, and means for causing a movement of the resistance element into and out of operative relation to the chilling medium by and to extents commensurate with the small forces.

14. A means for magnifying the effect of small electrical impulses comprising an electro-mechanical means responsive to said small electrical impulses, an electric circuit including a predetermined portion offering a resistance to the passage of current through the circuit by heat developed by the current traversing said portion, means for establishing a heat modifying element in operative relation to the resistance portion of the circuit, and connections between the resistance portion of the circuit and the electro-mechanical devices responsive to the small forces for producing a relative movement of the resistance portion of the circuit into and out of said medium in accordance with said small electrical impulses.

In testimony whereof I affix my signature in presence of two witnesses.

ERNEST SYDNEY HEURTLEY.

Witnesses:

J. S. AITNERS,

W. CHOWLES.