(No Model.) 2 Sheets—Sheet 1.

E. THOMSON.

ELECTRIC METER.

No. 381,441. Patented Apr. 17, 1888.

Fig. 1.

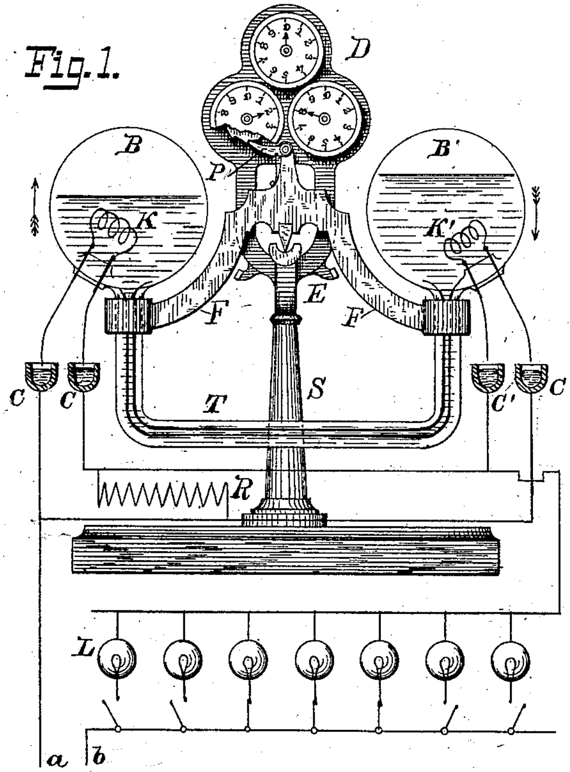


Fig. 5.

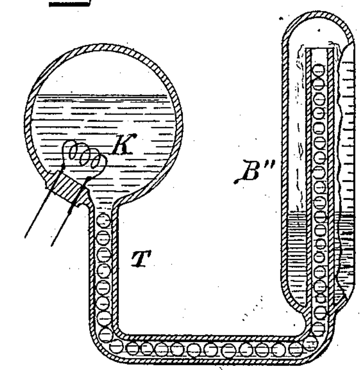


Fig. 2.

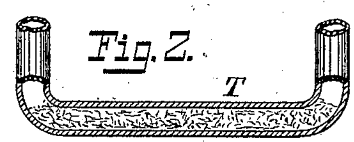


Fig. 3.

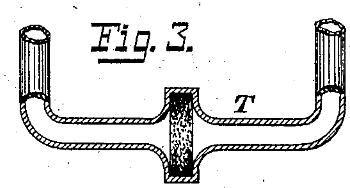


Fig. 4.

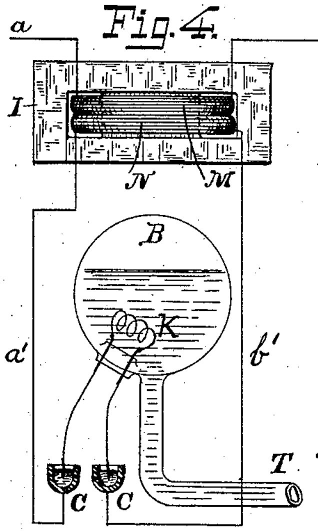
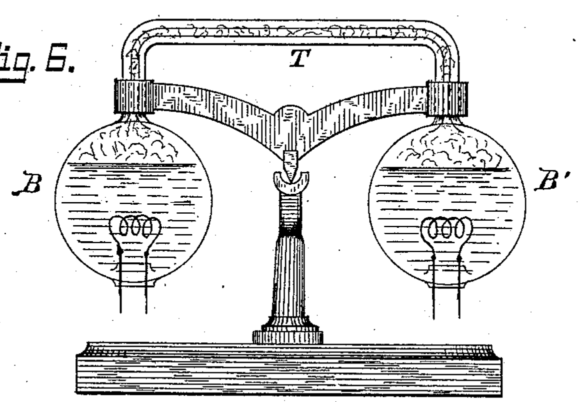


Fig. 6.



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(No Model.)

2 Sheets—Sheet 2.

E. THOMSON.

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Fig. 7.

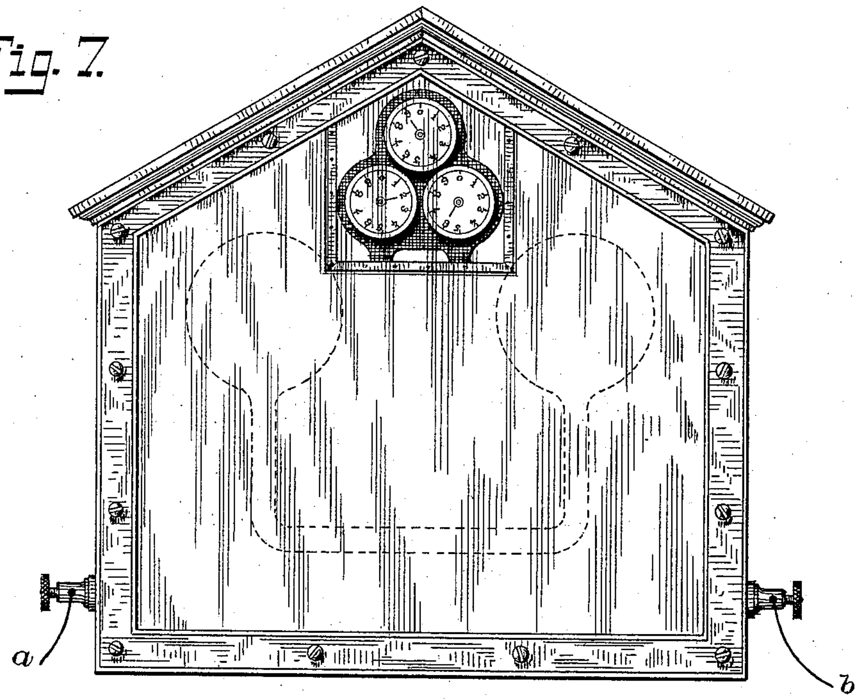


Fig. 8.

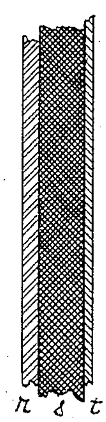
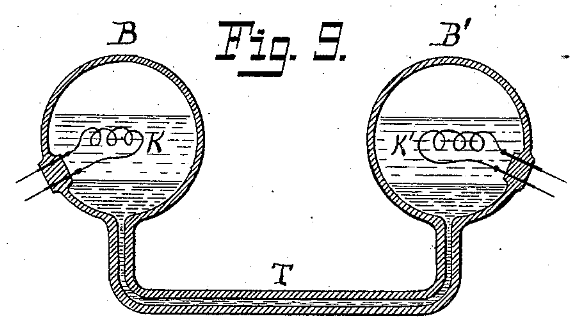


Fig. 9.



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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF LYNN, MASSACHUSETTS.

ELECTRIC METER.

SPECIFICATION forming part of Letters Patent No. 381,441, dated April 17, 1888.

Application filed October 19, 1887. Serial No. 252,792. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing at Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Electric Meters, of which the following is a specification, reference being had to the accompanying drawings, forming a part thereof.

My invention relates to the production of a simple and efficient electric meter adapted for use with either alternating or continuous currents; and it is based on the general principle which forms the subject of a separate application filed of even date herewith, Serial No. 252,793, of causing the heating effects of an electric current or the heating effect of a definite portion of such current, or of a current induced in a secondary conductor by such current, or portion of it, to evaporate a volatile fluid—such as alcohol, water, ether, or the like—inclosed in a sealed chamber.

My invention relates, briefly, to that particular form of my broad invention in which the vapor generated is used to force the volatile liquid from one receptacle to another through a tube, which I prefer to make with a rather narrow bore, or in which I place obstructing material—such as fiber or granular or spongy fibrous materials—so as to offer a resistance to the passage of the fluid from one receptacle to another.

My invention will best be understood by reference to the accompanying drawings, in which—

Figure 1 shows one of the most complete forms in which my invention may exist. Figs. 2 and 3 are modifications of one of the details. Fig. 4 shows a modification adapted to alternating currents. Fig. 5 represents a simple structure embodying the principles of my invention. Fig. 6 is an inverted apparatus. Fig. 7 is an end view of a case or covering for the apparatus. Fig. 8 is a section of the case. Fig. 9 is a modification of the invention.

Of course it will be understood that the devices shown in Figs. 1, 4, 5, 6, and 9 may be inclosed in a box or case either of wood or of metal, but preferably such as would tend to preserve the temperature uniform throughout the casing. When a metal case is used, therefore, a lining material more or less non-conducting for heat may be used. A wooden case possesses this characteristic sufficiently.

In Fig. 1, B B′ are two bulbs attached to each other by a tube, T, the whole being preferably of glass. The tube T may be either of narrow bore or may be so constructed as to exert considerable friction, thereby resisting a rapid flow of liquid through it.

K K′ are small resistances attached to wires sealed in the glass.

The structure is partly filled with alcohol or equivalent volatile fluid, which is boiled, and the whole is sealed when the alcohol or other vapor has completely filled the interior spaces, or a vacuum-pump may be applied for the same purpose and the structure then sealed.

At the top of the pillar S is a knife-edge support or supports, E, or other delicate suspension for a frame, F F, which carries the bulbs B B′ and the tube T. The suspension is such, preferably, that the center of gravity is above the point of support or the device is in unstable equilibrium, so as not to rest in a middle position, but to tip either way, according to the excess of weight on either side. In the figures the bulb B′ is in the act of going down and the bulb B of rising. The oscillatory motion operates the pawl P, so as to give motion to the dial or register D, as usual in such cases, each oscillation being adjusted to cause a definite motion of the dials. The oscillations are caused by the difference of level in the bulbs brought about by the heating effect of either coil K K′, which increases the vapor-tension above the liquid and gives rise to a flow of the liquid through the tube T, thereby raising the level in the other bulb. Mercury-cups C C and C′ C′ receive alternately the ends of the wires leading from the coils K K′, in accordance with the position of the bulbs, so that when B is down the coil K is in circuit and the coil K′ out of circuit, and vice versa. Of course other contact arrangements or circuit-closing devices may replace the mercury-cups, and I have used the latter merely as typical of any circuit-switches actuated upon a movement of the bulb system from side to side. Very numerous arrangements may be used to replace these, directly acting or indirectly acting and mechanically or electrically operative.

While the wires dipping into the cups C C may be made so as to make contact thereat just before the others in C′ C′ break their contact, and thus prevent a rupture of the circuit, yet this is not necessarily the condition, for by interposing a resistance, R, definitely selected between the cups, each cup of a pair being connected to one of the cups of the other pair, as shown, the resistance R being a bridge across this double connection, a circuit through R is kept, even though a break at C C and C′ C′ should occur in the transfer. It will also be understood that a rupture made at any one point—*i. e.*, at one cup only of each pair C C and C′ C′—by a movement of the bulbs would equally serve to throw the coils K K′, as the case may be, out of the circuit. It is understood, of course, that the connections by cups C C and C′ C′ must have definite resistances, or practically no resistance, at all times when closed.

My device thus constituted is connected, as shown, in circuit *a b*, which may represent wires feeding incandescent lamps in multiple, and usually with switches by which each lamp may be cut off or put in connection.

The operation of the devices shown in Fig. 1 is as follows: Assuming the bulb B to be depressed, so that its heating coil K is in circuit, and that the apparatus has been previously adjusted by selecting the resistance of the coils K K′ suitably and (when the resistance R is used) making the combined resistance of the coils K K′ bear a definite relation to the resistance of the resistance R, if a certain number of lamps L be fed by current flowing from the point *a* to the point *b* the coil K will be traversed by a current, or portion of it, as may be, and will cause slight warming of the liquid in the bulb B, with the result of a depressed level in the bulb, due to increased vapor-tension and a resisted flow of the fluid through the tube T into the bulb B′. This goes on until the accumulated weight in the bulb B′ is sufficient to tip the apparatus over and connect the coil K′, instead of the coil K, in circuit. The reverse action now takes place, resulting in a depression of the level in the bulb B′ and an elevation in the level of the bulb B, and after a time, depending on the amount of the overbalancing, a return of the level in the bulb B to its original position, the action, as above described, being repeated indefinitely. At each complete oscillation the pawl P moves the register D and counts a definite amount of current consumed.

The device is adapted for use with continuous currents and with alternating currents, providing the self-induction of the various parts of the apparatus be kept as low as possible. By varying the resistance R the meter can be calibrated, so that the reading on the dial will be in proportion to the current used in the lamps.

In Fig. 2, instead of a tube of narrow bore, is shown a tube filled with fibrous, granular, or porous material, which contracts the bore of the tube and leaves almost capillary spaces for the passage of the liquid. In Fig. 3 a slab of porous material acts as a diaphragm in the tube T, such tube being expanded to receive it. The object of the resisting material or of the forming of the tube so as to resist the passage of the fluid is to cause a balance to exist between the friction of the liquid and the heating effect of the current. The friction of the fluid varying as the square of its velocity and the heating effect varying as the square of the current, and the difference of vapor-tension being proportional to the difference of temperature within ordinary limits of working, result in the amount of fluid passing in a given time through the tube being nearly proportional to the current.

It may sometimes be desirable to make such an arrangement as is shown in Fig. 4, which represents an induction-coil, in the secondary circuit of which is placed the measuring-meter. *a b* are the mains supplying current to the primary coil M, and I is the iron core of the induction-coil, of which N is the secondary coil. Currents are induced in the secondary N, depending on the volume of current flowing in the primary M, and are carried to the meter by the wires *a′ b′*, as shown in the figure. The chief advantages of this arrangement are, first, that a break in the contact C C, or in the coil K, or in the circuit *a′ b′*, does not interfere with the mains *a b* and the lights L; secondly, that the secondary circuit *a′ b′* may be carried to a place where it would be inconvenient and well nigh impossible to carry the primary circuit or mains *a b*.

While the heating-coils K K′, Fig. 1, may be made of any resisting substance—in fact, may be simple strips of carbon or metal or the like carried by platinum wires sealed into the glass—I find that German-silver wire or platinum silver alloys borne on the platinum entering wires is suitable, and that its variation of resistance by temperature is so slight as not to affect the working. The secondary coil N is of insulated copper wire, preferably, whose resistance increases with the temperature, and I obtain satisfactory working with it, as sometimes means of compensation are useful in balancing the slight errors introduced by changes of external temperature, and by suitably varying the material and the relative resistances given to the coils N and K, Fig. 4, or to the coils R and K, Fig. 1, the amount of liquid transfer occurring at one temperature under other given conditions of current may be made the same as or slightly greater or less than that at other temperatures within ordinary changes of temperature of the air.

My apparatus as constituted, Figs. 1 and 4, is adaptable to use with alternating currents, and with the recording-dials of Fig. 1 is an efficient house-meter. Sometimes, however, it is only required to indicate for short periods. As adapted to this case Fig. 5 shows a simplified form. Here the bulb containing the heat-generating resistance K is connected with the tube T, which runs up into the graduated receptacle B″. Liquid driven over from the bulb by the heat in the resistance K overflows into B″ and can be there measured. The tube T is shown filled with pebbles or pieces of glass to prevent too free passage of liquid through it.

Fig. 6 shows the bulbs of Fig. 1 arranged in an inverted position and exemplifies the fact that, instead of a bodily movement of liquid from bulb to bulb, vapor alone passes through the tube T, of narrow bore, and condenses, so that if the coil in the bulb B receives current a gradual distillation occurs from it to the bulb B′. This action is much slower and is not so advantageous as that occurring in Fig. 1, and, moreover, has been embodied along with devices which make it capable of being used for meter purposes in a separate application for Letters Patent filed of even date herewith, Serial No. 252,793. It is merely introduced here as an aid in distinguishing the present case from the subject-matter of the said separate application.

It is of course not absolutely requisite that my devices, Fig. 1, be inclosed for use, particularly if the surrounding temperature is uniform and fairly free from disturbance by air-currents; but in practice a surrounding box or casing, Fig. 7, is provided to avoid errors and secure uniformity. The casing may be variously constructed. It may be a plain wood or metal box kept closed, and with posts for the attachment of terminals *a b* from the source of meter-current. The sides of the box may also be made, as in Fig. 8, of two or three thickness, *r s t*—such as an outer metal case, *r*, lined with wood or felt, *s*, and this again covered internally with copper or brass sheet, *t*—or a double metal box or casing with metal sides of two thicknesses separated by an air-space may be used.

Fig. 9 shows the bulbs containing two liquids, the upper layer being the vaporizable liquid and the lower layer a denser less volatile liquid, such as mercury. Though less sensitive than the arrangement Fig. 1, it is very positive in its actions.

I lay no claim herein, broadly, to a receptacle containing vaporizable liquid combined with a heating-coil, whereby a movement of the liquid for motive and indicating purposes is obtained, as that, with its modifications, forms the subject of another application for Letters Patent filed by me November 3, 1887, No. 254,222; but

What I claim in the present case is—

1. In an electric meter, a resistance or heating coil traversed by the current or a portion of the current, or by a current induced from the current to be measured or metered, a fluid subject to the heating effect of the resistance or coil, whereby a movement of such fluid is set up, a means of resisting the said movement of the fluid, and a registry dial or apparatus for recording the amount of such fluid movement occurring in any given time.

2. In an electric meter, a heating coil or resistance immersed in a vaporizable liquid like alcohol, a closed receptacle for said liquid connected with a second receptacle by a narrow tube, and registry apparatus for indicating the amount of transfer of liquid from one receptacle to the other during any given time.

3. In an electric meter, a suspended or oscillatory structure consisting of two or more receptacles connected together at their lower portions by a narrow tube or set of narrow passages and containing alcohol or other vaporizable fluid, a resistance or heating coil for each receptacle, and switch devices whereby upon each oscillation an alternation of electric connection from one heating-coil to the other is made, substantially as described.

4. In an electric meter, in combination with an oscillatory device containing vaporizable liquid, as described, and with a heating coil or coils or resistance, an induction-coil, one coil of which is traversed by the currents to be metered or measured and the other coil of which is connected in circuit with the heating or evaporating coil, as described.

5. In an electric meter, an induction-coil, one coil being in the circuit to the translating devices and the other in the circuit to the meter apparatus proper, as described.

6. In an electric meter, a receptacle for a vaporizable liquid *in vacuo*, said receptacle consisting of two chambers connected at the bottom with a restricted tube or passage or series of passages, and each chamber having a heating-conductor, substantially as described.

7. In an electric meter, a pivoted receptacle of two parts connected by a tube of narrow bore, each part containing a heating-conductor, switch devices for changing the current from one heating-conductor to the other, as described, and means for counting or indicating the movements of the pivoted receptacle.

Signed at Lynn, in the county of Essex and State of Massachusetts, this 14th day of October, A. D. 1887.

ELIHU THOMSON.

Witnesses:
OTIS K. STUART,
J. W. GIBBONEY.