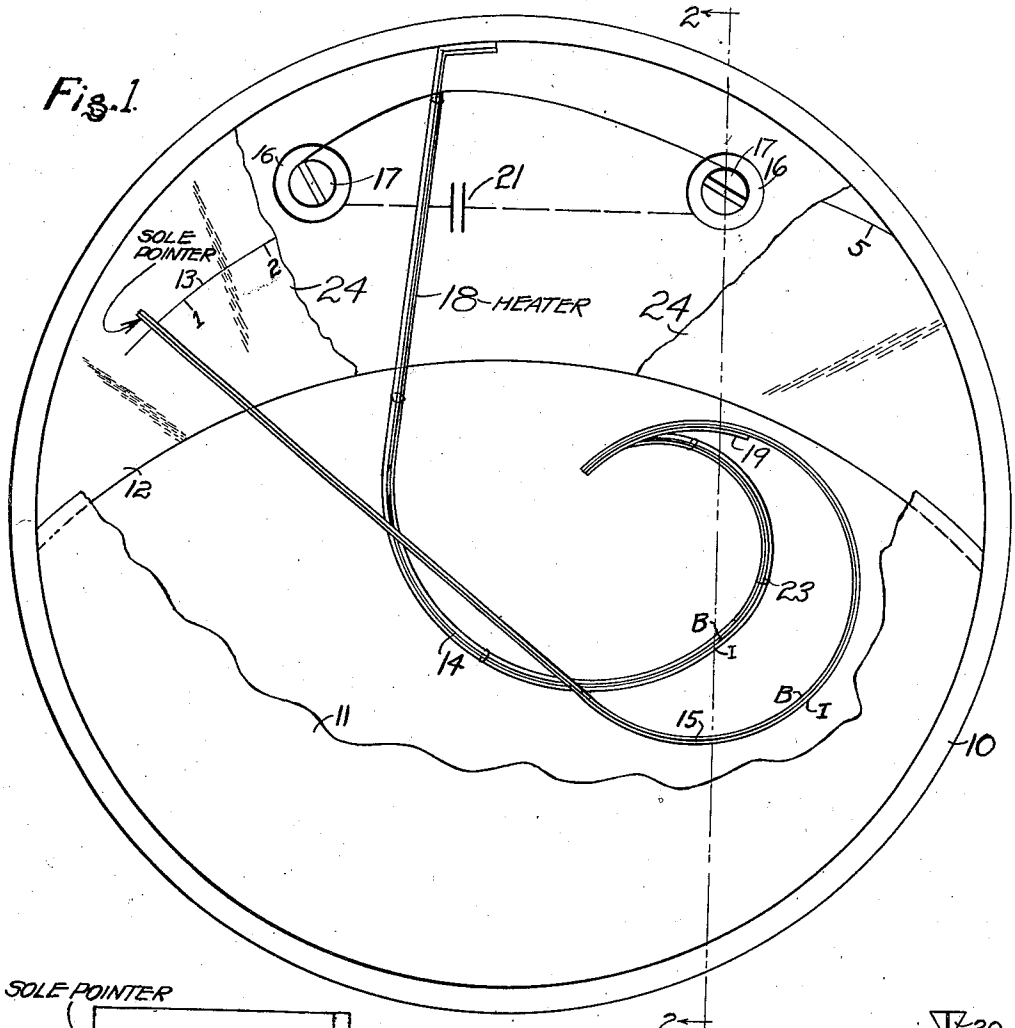
Aug. 20, 1940. W. D. HALL 2,211,773

THERMAL AMMETER

Filed Aug. 15, 1934

Fig. 1.



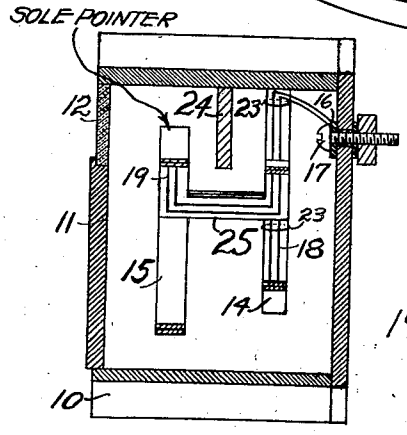


Fig. 2.

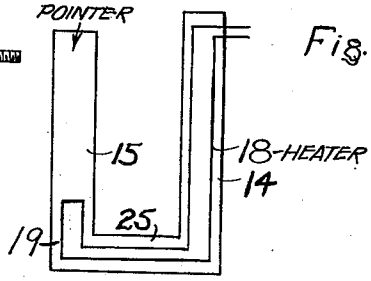
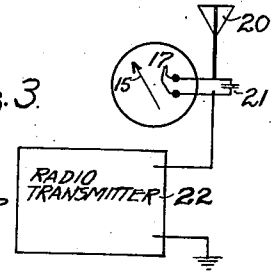


Fig. 4.

Fig. 3.



INVENTOR

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Patented Aug. 20, 1940 2,211,773

UNITED STATES PATENT OFFICE

2,211,773

THERMAL AMMETER

William D. Hall, Elkins, W. Va.

Application August 15, 1934, Serial No. 739,886

22 Claims. (Cl. 171—95)

My invention relates to thermal ammeters and has for its primary object the provision of a rugged yet accurate instrument. By a novel arrangement of bimetal strips, I have eliminated the bearings that are usually associated with instruments.

Frequency errors are greater in bimetallic than in certain other types of instruments and in order to reduce such errors, I have provided the instrument with a special means for compensating for skin effect errors.

The advantages of my instrument over prior bimetallic ammeters are apparent upon examination of the drawing in which Figure 1 is an elevation view of my instrument with portions of the scale and front panel cut away. Figure 2 is a sectional view of Figure 1, along the axis 2—2. Figure 3 shows how the meter may be connected with a radio transmitter in order that skin effect errors may be minimized. Figure 4 is a schematic view showing the relative arrangement of the heating wire and a flat bimetallic stamping.

The instrument is inclosed in case 10 which has front panel 11. Glass front 12 allows vision into the meter wherein bimetal strip 15 is seen in front of calibrations 13 on scale 24. The working parts of the instrument are bimetal strips 14 and 15, which are preferably stamped in one piece as a U-shaped blank, and the enameled constantan heater wire 18 which is secured to bimetal strip 14 by loops of thread 23. Said heater wire 18 is also thermally associated with one end of bimetal strip 15. By reference number 19, I have represented that portion of heater wire 18. Insulating washers 16 provide insulation between case 10 and terminals 17. In Figure 3 is shown a radio transmitter 22 with its antenna 20 connected in series with terminals 17. As a means for reducing the skin effect error of the meter within its operating range, condenser 21 is placed in shunt with said terminals. In order to reduce the size of the case 10, I have spiralled the bimetal strips 14 and 15.

Bimetal strip 14 is rigidly fixed at its upper end and suspends connection 25. Said connection suspends room temperature compensating strip 15, the free end of which is so disposed in relation to scale 24 that movements of the strip are readily detectable on the scale. The connection 25 is entirely suspended and causes the movements of the strips to be algebraically added and indicated on the scale. In response to an increase of room temperature, both bimetal strips will tend to uncoil and the free end of strip 15 will not move. Hence, it may be said that the strips have opposite deformations with respect to said scale in response to ambient temperature changes.

In response to an increase in the flow of current thru heater 18, bimetal strip 14, immediately deforms giving connection 25 and bimetal strip 15 a clockwise motion. As the indicating strip 15 approaches a final reading, the strip 14 ceases to deform rapidly. In overcoming that objection, I have provided heater 19, at one end of bimetal strip 15. This heater causes the strip 15 to deform at a slow, nearly uniform rate. Such deformations of bimetal strip 15 while bimetal strip 14 is "drifting," will tend to compensate for the drifting and hence reduce the time necessary to attain a final scale reading.

It is understood that either alternating or direct currents may be measured by a radio frequency ammeter of the type disclosed and therefore use of my invention on currents other than radio frequency currents does not depart from the scope of the claims.

When used on radio frequency currents, it is desirable to compensate for the skin effect errors of my instrument by use of a small fixed condenser in shunt with the instrument. Although the specific resistance of heater 18 is constant for all frequencies, the apparent resistance is greater for high frequency alternating currents than for direct currents. The heating effect of a flow of high frequency current thru the heater may be the same as the heating effect of a direct current if the high frequency current has less magnitude than the direct current. By placing a condenser of proper size in shunt with the heater, current may be diverted around the heater in such quantity that the skin effect errors at one particular frequency are compensated for. Furthermore, the instrument consumes less power from the circuit inasmuch as the reactive energy flow through the condenser does not generate heat. Therefore, the general principle of utilizing two parallel current paths having different phase angles of impedance increases the efficiency of the ammeter.

In passing through the measuring device, current may flow through two distinct paths, namely, condenser 21, and heating wire 18. These paths have different phase angles of impedance. The size of the condenser 21 is preferably determined by first placing a large condenser in parallel with the ammeter and reducing the size thereof until the value of capacity is obtained at which the instrument gives a correct reading. The reverse procedure, that is, starting

with small condensers and subsequently adding capacity until a correct reading is obtained may also be used.

My invention inaugurates a new principle in the manufacture of high frequency ammeters. Prior inventors have used precision work in developing instruments having small heating wires, hence small skin effect. Others, have developed special shunts of negligible resistance so that changes in resistance due to frequency had little effect. With those devices, considerable expense is involved in construction, whereas with my device the ammeters may be made inexpensively and then connected with the proper size condenser. This new principle wherein instruments are manufactured with disregard to the skin effect and then modified with "means" for reducing the errors due to skin effect is believed by me to be new and of considerable merit.

I have discovered an ammeter especially suited for radio frequency work. Those skilled in the art understand that the primary function of a radio frequency ammeter is to permit adjustment of the transmiter for maximum current rather than for a particular current. My instrument seems to be one of the simplest meters for that purpose. The problems involved in the measurement of radio frequency currents and especially currents varying at rates greater than three million cycles per second are much greater than for low frequency alternating currents.

In this invention, current is passed through a heating wire which is positioned adjacent the bimetallic strip to be heated. Passing current directly through the strips to heat them is old in art and is the full equivalent in the light of the appended claims of the indirect heating set forth.

The bimetallic leg 14 is secured behind the center of scale 12. Accordingly, legs 14 and 15 are parallel when the latter has been deflected to approximately half scale reading. This location of leg 14 in a central position has two advantages, one being that the scale calibrations 13 are less skewed and the other residing in the fact that errors due to ambient temperature changes are minimized at half deflection or in other words the scale position where the readings are most frequently taken.

Applicant has pending, an application Serial No. 46,955 filed October 26, 1935, entitled Thermal ammeters which claims some of the subject matter disclosed in this application.

I claim:

1. In a measuring instrument, the combination with bimetallic means having two oppositely actuated sections, one section being heated by and deformed by the current to be measured and the other section being arranged to compensate for ambient temperature changes, means supporting only one end of one section of said bimetallic means, whereby the relatively unsupported end of the other section of said bimetallic means is moved in accordance with the current-produced deflection of the current-heated section and acts solely as the pointer for the instrument and a scale having graduations cooperating with said relatively unsupported end to indicate the deflection of said bimetallic means.

2. In a measuring instrument, a base, a bimetallic strip and means connecting one end thereof to said base to constitute the sole support for said strip, whereby the outer end of said strip is free to deflect in accordance with the temperature of said strip, said strip being adapted to deform in response to the heating effects of an electric current, a scale, and pointer means for indicating on said scale the current-produced deflection of said strip, said pointer means comprising a bimetallic strip having a free end movable adjacent said scale and an inner end connected to and supported by the outer end of said first strip, said strips being so related that ambient temperature deflections of the two strips compensate for each other.

3. In a measuring instrument, the combination with a supporting structure carrying a scale, of heat-sensitive and current responsive means of U-shape, the legs of said U-shaped means being bimetallic strips similarly disposed to compensate for ambient temperature changes, means securing the outer end of one strip to said supporting structure to position the outer end of the other strip adjacent said scale to act thereby as the sole pointer for the instrument, and means for heating the first of said bimetallic strips by the current which is to be measured.

4. An electrical instrument comprising heat-responsive indicating means, a circuit through which current may be passed to heat said indicating means, and means constituting a part of said circuit to reduce the skin effect error when high frequency alternating current is passed therethrough.

5. An electrical instrument comprising heat-responsive indicating means, a circuit in heat transfer relation to said indicating means through which current may be passed to heat said indicating means, and a capacitive impedance shunted across said circuit to reduce the skin effect error when high frequency alternating current is passed therethrough.

6. In a thermal ammeter, a resistance through which current to be measured may be passed, indicating means responsive to the heat developed by current flow through said resistance, and means for reducing skin effect errors when high frequency alternating curent is passed through said resistance.

7. A thermal ammeter comprising a thermostatic element, an elongated strip, means cooperating with said element and strip to indicate the difference of the average thermal conditions of said element and strip, and a heating circuit through which current may be passed, said heating circuit being positioned in heat transfer relation to said thermostatic element and to a substantial length of one end portion of said strip.

8. In an electrical instrument, the combination with a scale, of heat responsive indicating means cooperating with said scale; said indicating means comprising a pair of bimetalic strips, supporting means for one end of one strip, means connecting said strips to compensate the respective deflections thereof due to ambient temperature changes, and a heating circuit through which current may be passed, said heating circuit being positioned in heat transfer relation to said first strip and to a limited portion of said second strip adjacent said connecting means.

9. A thermal ammeter comprising a heating circuit through which radio frequency currents may be passed, said heating circuit being substantially non-inductive, whereby the reactance of the circuit to radio frequency currents is small, a supporting structure, a bimetallic strip, means for securing one end of said bimetallic strip to said supporting structure to constitute the sole support for said strip, whereby the other end of said strip is free to deflect in accordance with the temperature of said strip and means includ-

ing a graduated scale cooperating with the other end of said strip for indicating the deflection thereof; said heating circuit and said bimetallic strip being in a close heat transfer relation, whereby indications will be had quickly after current is supplied to said heating circuit.

10. An ammeter and an admittance shunted across said ammeter; said admittance being of such value that the frequency error of the ammeter is substantially reduced, and such that a lower percentage of the current flows through the ammeter when periodically varying currents are measured than when currents having a lower frequency of variation than said periodically varying currents are measured.

11. In a measuring instrument, a circuit through which current to be measured may be passed, indicating means responsive to the current flow through said circuit, and means cooperating with the circuit to reduce the frequency error when high frequency alternating current is passed therethrough.

12. A bimetallic ammeter comprising, a bimetallic strip, indicating means responsive to the deflection of said strip, and a heating wire positioned near the strip, said heating wire being arranged in a non-inductive manner, whereby radio frequency currents may be measured without appreciable inductive drop.

13. A bimetallic ammeter comprising a bimetallic strip, means supporting one end of said strip whereby the other end is free to deflect in accordance with the temperature of the strip and act as the sole pointer for the ammeter, means whereby said strip is heated by the currents to be measured, a scale, and pointer means for indicating on said scale the current-produced deflection of said strip, said pointer means comprising a bimetallic strip having an inner end connected to the outer end of said first strip, said bimetallic strips being so related that ambient temperature deflections thereof compensate for each other near the middle of the current range of said scale.

14. A bimetallic ammeter comprising a supporting structure carrying a scale, a bimetallic strip and means securing one end thereof to said supporting structure at a point on an axis, which axis is substantially perpendicular to the central portion of the graduation curve of said scale, means for heating said bimetallic strip by the current to be measured, and pointer means for giving indications on said scale, said pointer means including a strip having an inner end connected to the outer end of said first strip.

15. In a measuring instrument, a resistance through which the current to be measured may be passed, indicating means responsive to the heat developed due to the current flow through said resistance, a condenser, and low frequency electrical conductors paralleling said condenser and resistance, said condenser being of such size as to appreciably change the reading of the indicating means at high frequency.

16. A current-responsive device comprising a pair of parallel current paths having different phase angles of impedance, and means responsive to the current flowing in one path, said paths having such values of impedance that the frequency error of response is reduced.

17. A measuring device comprising a pair of parallel current paths, a resistance included in one of said paths, and indicating means having an element which flexes in response to temperature changes of said resistance, said indicating means being arranged to give indications in accordance with the shape of said element, said paths having such impedance values that errors due to skin effect which occur in the path of lower impedance are compensated for by the change of reactance with frequency in the high impedance path.

18. A measuring device comprising a pair of parallel current paths one of which has higher impedance than the other, means included in the high impedance path for reducing errors due to skin effect which occurs in the low impedance path, a heater included in one path, and means responsive to the temperature of said heater.

19. A thermal current-responsive device comprising a pair of thermally actuated elements, means responsive to the difference in the actuations of the elements, and a circuit through which current may be passed to heat said elements, said circuit being positioned in heat transfer relation with said first element and with a limited portion of said second element.

20. A measuring device comprising a base, a bimetallic strip and means connecting one end thereof to said base, an electrical current path for heating said strip, a scale, and a pointer for indicating on said scale the current-produced deflection of said first strip, said pointer consisting of a bimetallic strip connected at one end to the movable end of said first strip, said bimetallic strips being so related that their ambient temperature deflections compensate for each other.

21. In a current responsive device, indicating means, and a circuit for energizing said indicating means, said circuit having two parallel current paths having different phase angles of impedance and so related that the effective energization of said indicating means is the same over a range of frequencies, whereby the power consumed by the device at radio frequencies is less than the power consumed by the device due to a direct current having the same magnitude as the radio frequency current multiplied by the skin effect resistance ratio of the resistance component of the parallel paths.

22. In a high frequency ammeter, a wire which consumes appreciable energy upon the passage of the currents to be measured therethrough, a path of higher impedance than said wire, said path being shunted across said wire and so related therewith that at radio frequencies the said path carries a greater percentage of the current than it does when direct currents are passed through the ammeter, whereby the current flow in said high impedance path causes material reduction of the current in said wire thereby diminishing the energy lost in said wire at high frequencies, and means for giving indications in response to the heating effects of the current flowing through said ammeter.

WILLIAM D. HALL.