Feb. 6, 1951 B. STÅLHANE 2,540,600

MEANS FOR GENERATING OR INFLUENCING
AN ALTERNATING CURRENT
Filed Dec. 28, 1946

Fig.1

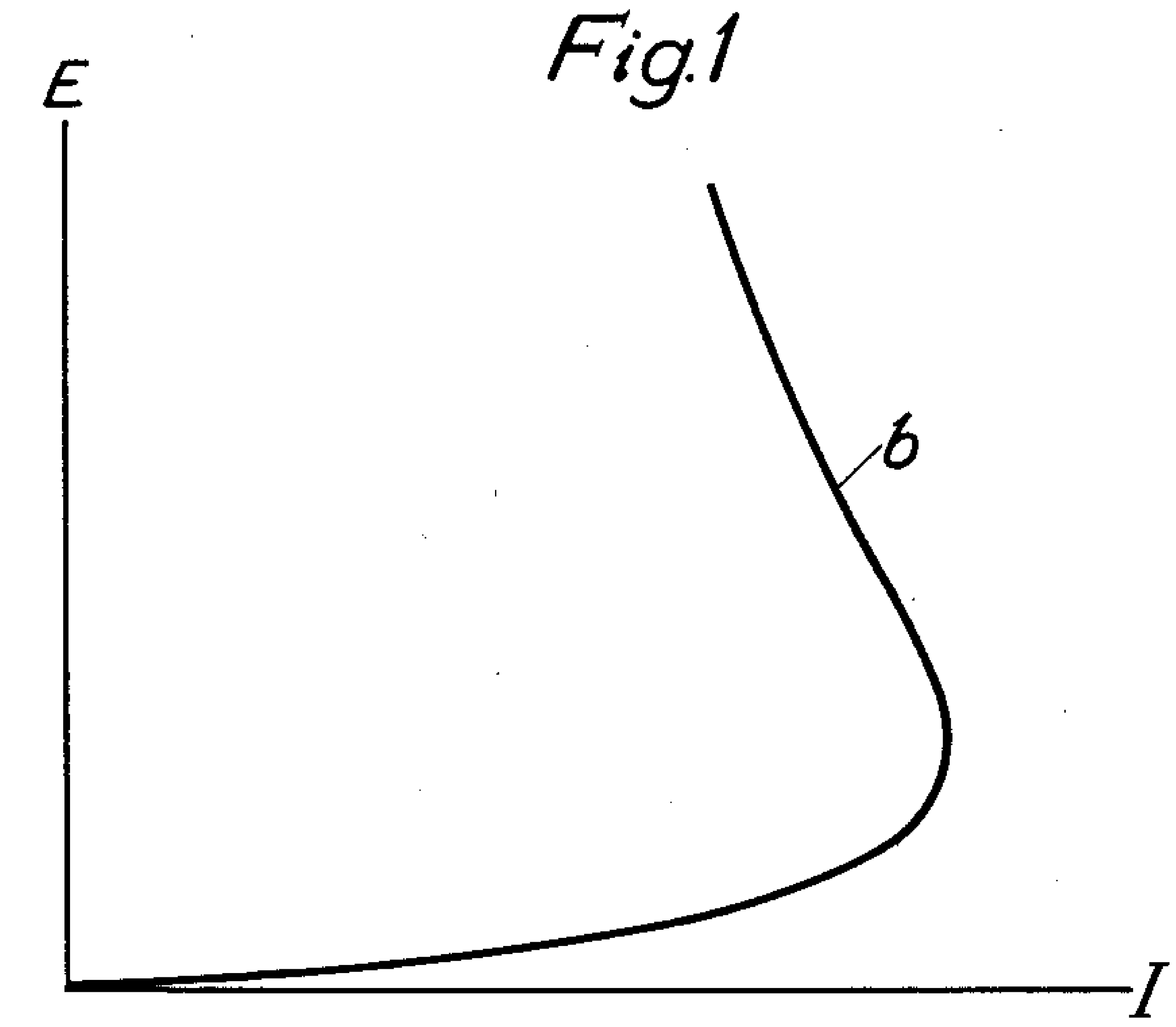


Fig.2

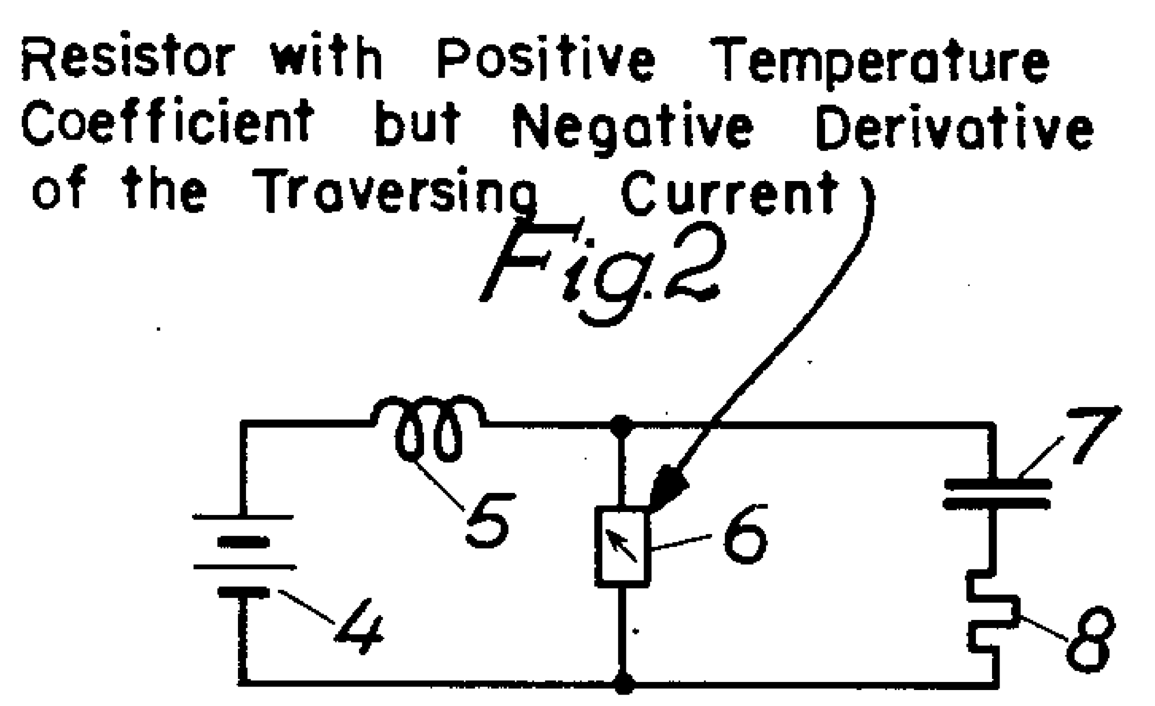


Fig.3

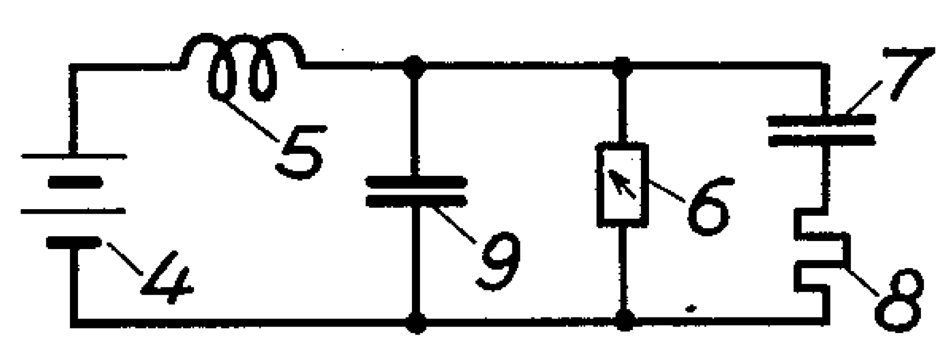


Fig.4

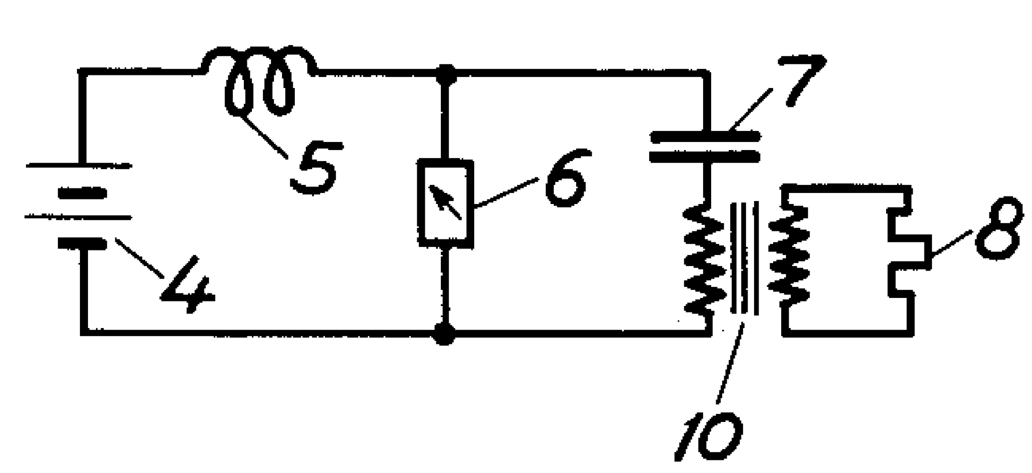


Fig.5

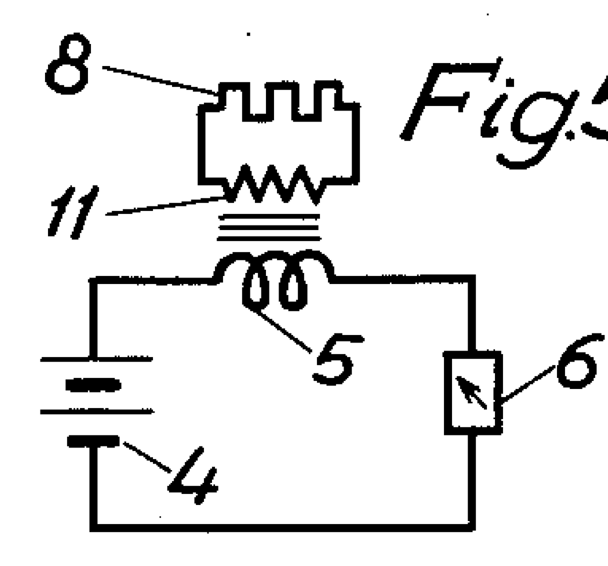
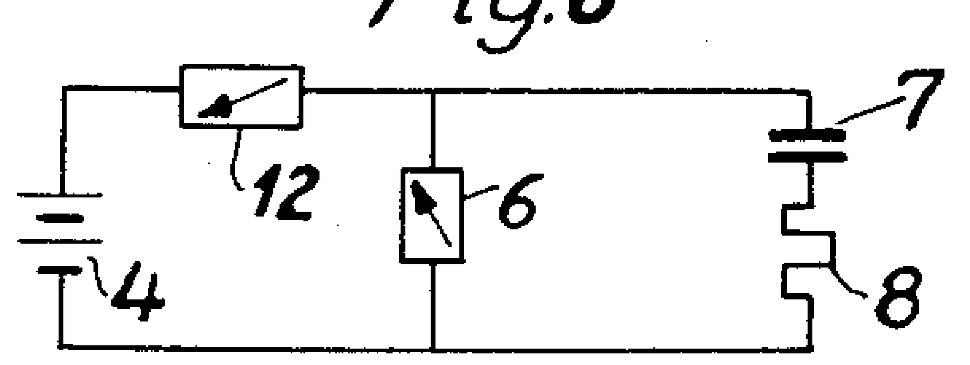


Fig.6



Inventor
Bertil Stålhane
By [signature]
Attorney.

Patented Feb. 6, 1951

2,540,600

UNITED STATES PATENT OFFICE

2,540,600

MEANS FOR GENERATING OR INFLUENCING AN ALTERNATING CURRENT

Bertil Stålhane, Stockholm, Sweden, assignor to Allmänna Svenska Elektriska Aktiebolaget, Vasteras, Sweden, a Swedish corporation

Application December 28, 1946, Serial No. 719,013
In Sweden December 29, 1945

8 Claims. (Cl. 323—68)

The present invention refers to a means for generating or influencing an alternating current, according to which a resistor traversed by the current and having a positive temperature coefficient ("thermo-positive resistor"), from which heat is removed by conduction, operates in a region, where the derivative of the traversing current with respect to the direct current voltage applied to the resistor is negative. According to the invention an inductance or an analogous device is connected in series with the thermo-positive resistor.

In the accompanying drawing Fig. 1 shows the current-voltage characteristic of a resistor capable of being employed according to the invention, and Figs. 2–6 different forms of oscillating circuits for realizing the invention.

In Fig. 1 the abscissae I designate the current through a resistor and the ordinates E the voltage across the said resistor, said voltage being, however, regarded as an independent variable, since the current reaches a maximum for a certain value of the voltage. The curve *b* represents the current-voltage characteristic of the resistor. It is seen that the ohmic value of the resistor, which is represented by the tangent of the angle between the line from the origin to a point of the curve and the I-axis, always increases with increasing voltage, whence also the power dissipated in the resistor and thus its temperature increases. On the other hand the derivative

$$\frac{dI}{dE}$$

continuously decreases along a large portion of the curve and becomes zero for a certain value of E and for higher values negative.

It is known that an iron wire resistor, which is essentially cooled by a surrounding hydrogen atmosphere of a certain pressure, gives an approximately constant current within rather wide limits of the voltage. This is valid for a certain value of the temperature coefficient of the resistor and at a certain arrangement of the resistor in a cooling medium, if the heat losses are proportional to the temperature or increase somewhat more rapidly than the latter. If on the other hand the specific heat losses of a resistor of iron or a material with a similar temperature coefficient, for instance nickel or tungsten, are caused to decrease at increasing temperature, that is, if the rate of transfer of heat away from the resistor in proportion to the temperature is lower as the temperature rises, which may be accomplished for instance by removing the heat

essentially by conduction through certain metals as iron or nickel, the current-voltage characteristic *b* shown in Fig. 1 may be obtained, according to which the current from a certain temperature—in practice about 200° C.—decreases at increasing voltage, and such a resistor gives a leading current. The negative derivative

$$\frac{dI}{dE}$$

reaches a maximum at about 500° C. and then slowly decreases at least to the neighbourhood of 1000° C. It may be mathematically proved that such a resistor connected in series with a negative impedance element to a constant voltage will cause oscillations up to a certain frequency, i. e. an alternating current superposed on a direct current.

The highest or most favorable frequency, at which the resistor operates, depends not only on the value of the negative current-voltage derivative in the operating region but also on the proportion between direct current load and heat capacity of the resistor. In the first line, the use for low frequencies is intended, for instance within the limits 1–100 cycles/second. In such a resistor connected in an alternating current circuit, the current will be in advance of the impressed voltage, and the phase difference will be the larger the lower the frequency. Up to a certain frequency the phase difference is larger than 90°, which just means that the resistor will give an active negative alternating current component, thus have the faculty of generating an oscillation. The reactive component of the current corresponds in this case to the action of a capacity, which is evident from the following.

As an increase of temperature of the resistor by the traversing current, thus an absorption of energy, is followed by a reduction of current at increasing voltage, the resistor operates substantially as a capacity combined with an ohmic resistance, as distinguished from a thermo-negative resistor, in which an increase of temperature is followed by a voltage reduction at increasing current, and which therefore substantially operates as an inductance combined with an ohmic resistance. The resistor employed according to the present invention may therefore in certain cases influence an alternating current in analogy with a capacitor and should therefore be employed in series with an inductance or with a resistor operating as an inductance.

In Fig. 2, **4** designates a direct current source, **5** a reactor and **6** a resistor having a characteristic shown in Fig. 1. The voltage variations across this resistor are utilized in a shunt containing a condenser 7 for blocking a direct current and a load 8 conventionally shown as an ohmic resistor. As aforesaid, the resistor 6 operates as a capacity and therefore together with the reactor forms an oscillating circuit, when they are connected in series to a constant voltage obtained from a direct current source, the impedance of which is supposed to be nearly zero, for instance a battery. By reason of the negative characteristic of the resistor, it is able to generate an alternating current in this circuit within a certain frequency region. The arrangement is of special interest for the reason that, as distinguished from direct current fed oscillating circuits with an arc, an electronic or an ionic valve as active element, it can theoretically be dimensioned for feeding by a direct current voltage of any low value. Practically, feeding voltages of between 1 and 12 volts are intended to be used. An important advantage over direct current fed oscillating circuits based on the use of negative resistors with a falling characteristic is that no energy dissipating means for obtaining a constant feeding direct current are necessary. The circuit according to the invention is instead fed by constant direct current voltage.

In certain cases it may be advisable to increase the capacity of the oscillating circuit by connecting a condenser 9 in parallel to the resistor 6, as shown in Fig. 3, which otherwise is identical to Fig. 2 and has corresponding reference numerals.

In Fig. 4, the load 8 is connected through a transformer 10, while the connection is otherwise identical to Fig. 3.

In Fig. 5, the reactor 5 has a secondary winding 11 feeding the load 8.

In certain cases the resistor 6 may form the load itself. The resistor is heated intermittently to glow temperature by the pulsating direct current, and if the frequency has an appropriate low value, the resistor may in such case serve for instance as a flash light.

It may be possible, as shown in Fig. 6, to replace or supplement the reactor 5 by a thermonegative resistor 12, which is indicated conventionally by a rectangle having an arrow directed obliquely downwards to the left and which operates in the region, where its

$$\frac{dE}{dI}$$

is negative, and which in such case essentially behaves as a reactor.

If the resistor 6 is series-connected with an essentially constant resistor, a more steep characteristic of the curve *b* in Fig. 1 may be obtained although at a lower total efficiency.

I claim as my invention:

1. In an alternating current circuit, a resistor having a positive temperature coefficient but a negative derivative of the traversing current with respect to impressed voltage, means for conducting off heat from said resistor rapidly enough so that said resistor gives a leading current, a current source and an impedance element of inductive character in series with said resistor.

2. In a circuit as claimed in claim 1, said source being a direct current source.

3. In an alternating current circuit, a resistor having a positive temperature coefficient but a negative derivative of the traversing current with respect to impressed voltage, means for conducting off heat from said resistor rapidly enough so that said resistor gives a leading current, a current source and an impedance element of inductive character containing a thermo-negative resistor in series with said first resistor.

4. In a circuit as claimed in claim 1, said source being a direct current source of small impedance.

5. In a device as claimed in claim 1, a reactor having a primary winding in series with said resistor, and a load connected to the secondary winding of said reactor.

6. In a device as claimed in claim 1, a condenser connected in parallel to said resistor.

7. In a device as claimed in claim 1, a substantially constant resistor in series with said first resistor and impedance element.

8. In a device as claimed in claim 1, said heat conducting means being metallic.

BERTIL STÅLHANE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,887,599	Nyquist	Nov. 15, 1932
2,040,677	Suits	May 12, 1936
2,294,908	Hussey	Sept. 8, 1942
2,360,932	Bullington	Oct. 24, 1944
2,406,804	Chatterjea et al.	Sept. 3, 1946
2,407,288	Kleimack et al.	Sept. 16, 1946
2,410,076	Johnson	Oct. 29, 1946