Sept. 4, 1934. R. E. TARPLEY ET AL 1,972,720

CROSS SHOT WOVEN RESISTOR

Filed Feb. 2, 1932

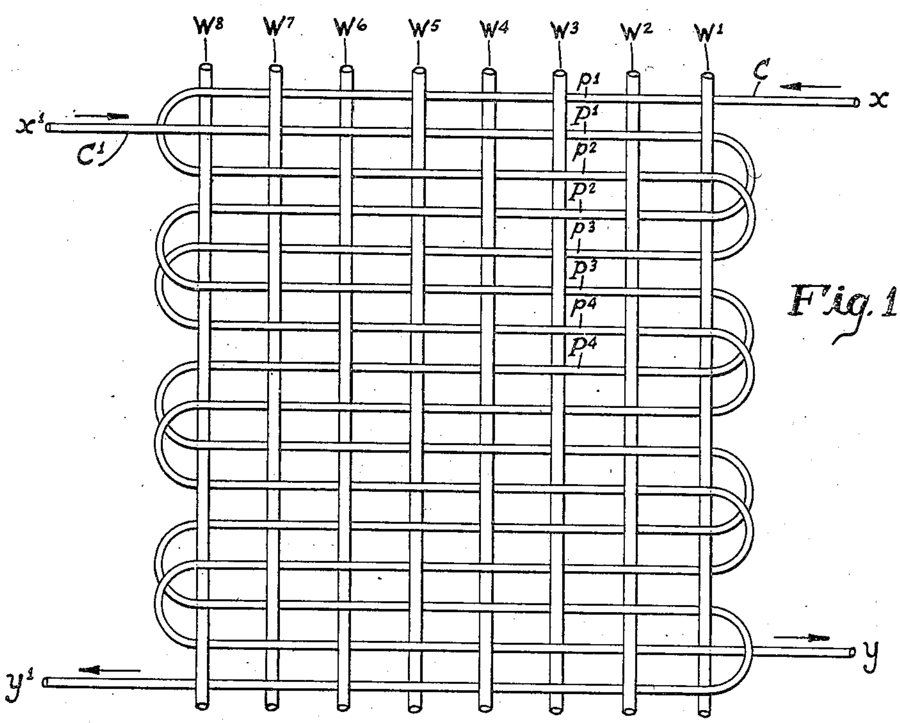

Fig. 1

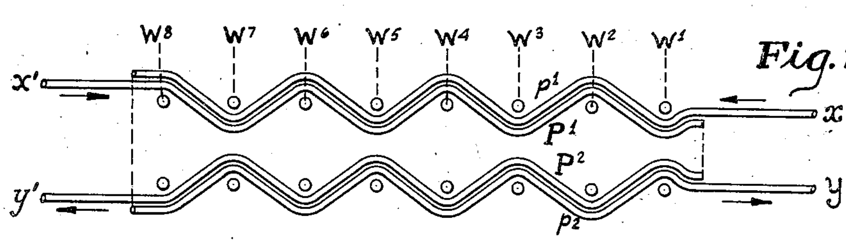

Fig. 2

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Patented Sept. 4, 1934

1,972,720

UNITED STATES PATENT OFFICE

1,972,720

CROSS-SHOT WOVEN RESISTOR

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Application February 2, 1932, Serial No. 590,334

6 Claims. (Cl. 201—63)

Our invention relates to resistors, or resistance units, having low or negligible inductance and capacity to ensure that their time constant is low throughout a wide range of frequencies, and to permit their use in both direct current and alternating current measuring systems without introduction of appreciable errors.

In accordance with our invention, a resistor is woven on a suitable warp, as of silk threads, from two conductors lying side by side through the warp and so connected that current flows through them in opposite direction with the result that the warp elements form the cores of non-inductive solenoids.

More specifically, the resistor is "cross-shot" woven, i. e. one shuttle moves across the warp in one direction and the other shuttle moves across the warp in the opposite direction before the positions of the warp elements are interchanged, as by the loom harness. At each end of the resistor, the conductors are connected together so that there is insubstantial difference of potential between adjacent picks of conductor throughout the resistor, and because of the cross-shot weave the current flows through adjacent picks in opposite direction to eliminate inductive effects.

Our invention further resides in the methods of making resistors and in the woven resistor hereinafter described and claimed.

For an understanding of our invention, reference is to be had to the accompanying drawing in which:

Fig. 1, on enlarged scale and with spacings exaggerated for clarity, illustrates the weaving pattern of our resistor.

Fig. 2 is an explanatory figure.

Resistors for use with alternating current, or both direct and alternating currents, in addition to the requirements of resistors satisfactory for direct current measurements, should have the characteristic that their effective resistance is independent of frequency and their reactance negligible at least throughout a substantial range of frequencies.

The ordinary resistor woven from a single resistance conductor does not have this characteristic for it exhibits substantial inductance and its time constant is therefore of substantial magnitude; further, for resistors of the same value of resistance and supposedly similar, the time constants varied widely. It was and is necessary with this type of resistor to measure their individual time constant and then select those resistors which are the least unsatisfactory for alternating current uses, and even these selected resistors are not satisfactory, for example they introduce large errors in phase angle measurements at higher frequencies, for example, 10,000 cycles and upwards.

In accordance with our invention, woven resistors can be made with time constants so low that the error introduced for widely different frequencies is negligible, and for resistors of the same resistance and type, the time constants are the same and do not vary widely as with supposedly similar resistors as made heretofore.

Referring to Fig. 1 the pattern of weave results in a woven resistor of very low time constant, suited for high precision measurement. In this resistor, the style of weave has been termed "cross-shot", because it is formed by the simultaneous weaving of two conductors on the warp, that is, one shuttle moves across the warp in one direction and another shuttle moves across the warp in the opposite direction before the harness of the loom transposes the positions of the warp elements.

As clearly shown, the first pick $p1$ of conductor C, and the first pick P1 of conductor C1, lie side by side, that is, both pass under the same alternate warp elements for example, 1, 3, 5, etc., and pass over every other warp element as 2, 4, 6, etc. Specifically, both picks pass under the warp element $w1$ at one selvedge edge and side by side pass alternately over and under elements $w2$ to $w7$, both finally passing over warp element $w8$ at the other selvedge edge. Similarly, the next pair of picks, $p2$ of conductor C, and pick P2 of conductor C1, lie side by side in the warp. Both pass over warp element $w1$, and alternately under and over elements $w2$ to $w8$, all as clearly indicated in Fig. 1, in which the size of the warp, of the conductors, and the spacing has been exaggerated to show clearly the relation of the picks to each other and to the warp elements.

In the completed resistor, the ends x, $x1$ of the different conductors which are of equal resistance are connected together, and the ends y, $y1$ are likewise connected together.

The effect of winding the resistor from two conductors as described and connecting them in this manner is readily apparent from Fig. 2. In each pair of picks $p1$, P1; $p2$, P2; $p3$, P3; etc., the current in one pick is flowing in one direction, while simultaneously current of the same value is flowing in opposite direction through the other pick of the pair, so that in effect each pair of picks forms a short bifilar winding.

From another aspect, it can be considered that the picks $p1$, $p2$, etc., of conductor C form inductive loops which are cumulative in their effect in causing the warp elements to be the cores of inductive solenoids, but the picks P1, P2, etc., of the conductor C1 also form inductive loops whose effects are cumulative but in opposition to the inductive effects of those of conductor C, with the result that the inductive effects of the individual windings annul each other; i. e. the individual warp elements form the cores of non-inductive solenoids.

Further as the adjacent picks of conductor throughout the warp are at substantially the same potential, the capacity effects are practically nil. For example, the average effective residual of 1000 ohm "cross-shot" woven resistors is about one micro-microfarad giving the very low time constant of about $.1 \times 10^{-8}$ seconds. The resistance error is about .001% for frequencies up to 50,000 cycles and even at much higher frequencies is within the limits of observation errors and hence practically negligible. By contrast, 1000 ohm resistors of simple weave have relatively large inductive residuals which vary from about 4.5 to 12 microhenries, introducing errors which are large for all resistors and which vary greatly for different resistors, of supposedly similar characteristics.

The resistance webbing may be mounted in any suitable manner, for example, in any of the various ways shown in co-pending Tarpley application Serial No. 586,518, filed January 14, 1932. The cross-shot woven resistor is shown in the aforesaid Tarpley application but is not therein claimed as it is our joint invention.

Another advantage of the cross-shot woven resistor over the old type of woven resistor and over other types of low time constant woven resistors disclosed in the aforesaid application and using a single conductor is that it facilitates weaving of resistors of the lower orders, i. e., less than 1000 ohms for example. Since the conductors of our resistor are in parallel, electrically, the smaller sizes of wire, as #35 or smaller, may be used, facilitating the weaving, and yet because of the parallel connection of the conductors comprising the resistor, its value is low.

A resistor of the same value of resistance, with a single wire of suitable fineness for weaving, is difficult to calibrate accurately and further the total mass or area of wire is so small that the heat is not sufficiently dissipated by radiation to avoid the effect of temperature upon the effective value of the resistor. Both of these disadvantages are overcome by our invention.

Aside from the fact that the cross-shot weave is better suited for the lower values of resistance, it has the further advantage that the residual inductance for a given resistance and given total cross-sectional area for the two wires is less than that of other woven resistors of the same resistance and cross-section shown in the aforesaid copending Tarpley application.

What we claim is:

1. The method of making a resistor having a low time constant which comprises simultaneously weaving two conductors on a warp in opposite directions, and electrically connecting the ends of the conductors at the same end of the warp to each other so that flow of current through the resistor will be in opposite directions in adjoining similarly disposed picks.

2. The method of making a resistor having a low time constant, which comprises simultaneously weaving two conductors on a warp by leading the conductors across the warp from opposite sides thereof, interchanging the positions of the warp elements, leading both conductors back through the warp in reverse directions, again interchanging the position of the warp elements, repeating the aforesaid sequence of operations to form a woven web, and connecting the ends of the conductor at the same end of the warp so that current in adjoining similarly disposed picks must flow in opposite directions.

3. The method of making resistors to ensure low and similar time constants which comprises forming each of said resistors by simultaneously weaving two conductors on a warp, the adjacent picks of the different conductors lying side by side across the warp, and connecting the ends of the conductors so that the current flows in opposite directions in the adjacent picks of the conductors.

4. A resistor of low time constant comprising two continuous conductors cross-shot woven back and forth on a warp so that adjoining picks from opposite sides of the warp lie side by side across the warp, and having the ends of the conductors at the same end of the warp connected together electrically so that current in adjacent similarly disposed picks must flow in opposite directions.

5. A resistor of low time constant comprising two continuous conductors woven back and forth on a warp in opposite directions, the adjacent picks of the different conductors lying side by side through the warp and having the ends of the conductors at the same end of the warp connected together so that the warp elements form the cores of non-inductive solenoids.

6. A resistor of low time constant comprising conductors woven back and forth side by side through a warp and having the conductors connected together so that the currents in adjacent conductors lying side by side through the warp flow in opposite directions.

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