

July 18, 1933.

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1,918,259

ELECTRICAL RESISTANCE

Filed Oct. 23, 1930

2 Sheets-Sheet 1

FIG. 1

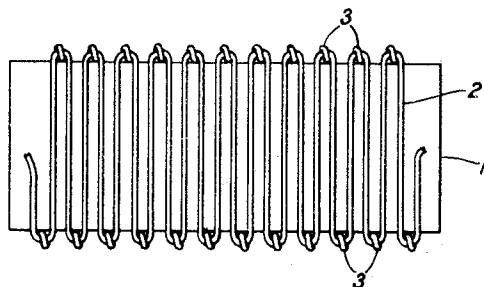


FIG. 2

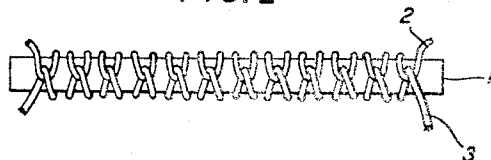


FIG. 3

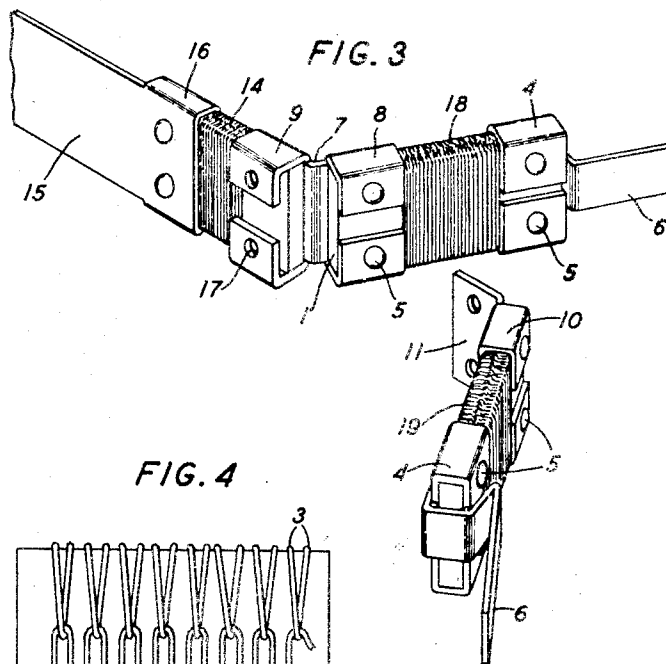
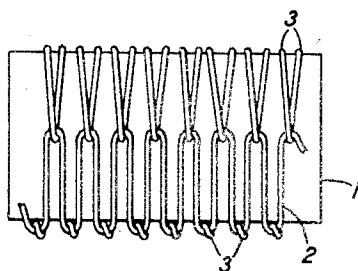


FIG. 4



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FIG. 5

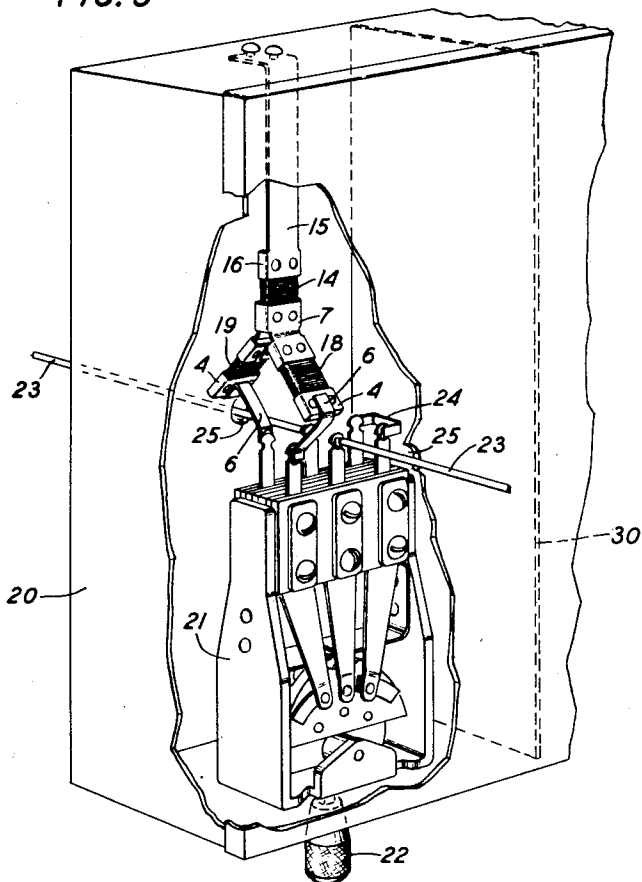
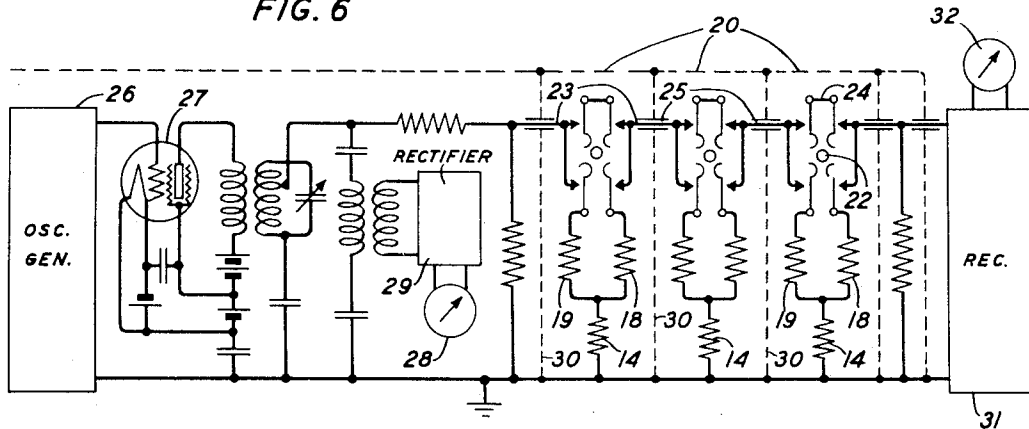


FIG. 6



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ELECTRICAL RESISTANCE

Application filed October 23, 1930. Serial No. 490,594.

This invention relates to resistance windings and particularly to that form of resistance element which has very low distributed capacity and substantially no self-inductance and therefore acts in an electrical circuit as a pure resistance.

One of the objects of the invention is to provide a resistance element which has the characteristics mentioned above and which is very simple and easily constructed.

A further object of the invention is to provide a resistance winding of the zigzag type which does not require a special form of supporting member. Heretofore it has been the practice to employ supporting members provided with pins, hooks, lugs, tongues, holes, grooves, or the like for receiving the loops of wire. In the present invention a plain block or card of insulating material is employed for supporting the winding and the latter is retained thereon in a manner which will hereinafter be described.

A further object of the invention is to provide a resistance winding of the zigzag type in which the turns of wire are automatically spaced from each other any predetermined distance when the winding is applied to the supporting member.

A further object of the invention is to provide a resistance winding of the zigzag type in which, on a supporting member of given size, the turns of wire may have any desired length up to a length equal to the transverse perimeter of the supporting member.

A further object of the invention is to provide a resistance winding which can be used as an attenuator in electrical circuits in which very high frequency alternating currents are present without the production of counter-electromotive forces due to self-inductance of the winding.

A further object of the invention is to provide means for protecting the resistance element from magnetic fields which may be present in its vicinity in order that no currents shall flow in the winding other than those applied to its terminals.

The novel features which are believed to characterize the invention are set forth with particularity in the appended claims. The

invention itself, however, both as to its organization and construction together with further objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawings in which Fig. 1 is a side view and Fig. 2 a plan view showing a resistance element wound in accordance with the invention. Fig. 3 is a perspective view partly exploded showing the preferred method of mounting the resistance units. Fig. 4 is a view similar to Fig. 1 showing a modified winding arrangement. Fig. 5 is a perspective view showing one of the assemblies of Fig. 3 mounted in a shielding container, and a switch for connecting the unit to a circuit. Fig. 6 is a schematic diagram of a circuit showing several assemblies in use as attenuators.

Referring to Figs. 1 and 2, the reference numeral 1 indicates a flat card or block which receives and supports the resistance winding 2. The card or block 1 may be of any suitable insulating material such as bakelite, a phenolic condensation product, and may be of any desired length, width or thickness. Starting near one end of the card or block the conductor 2 is wound (with the aid of cord 3 as will be described) back and forth across the surface of the card in zigzag arrangement. At the same time that the conductor is being wound on the card a continuous retaining cord 3 of insulating material such as cotton or linen thread or twine is wound on the opposite face of the card beginning at the same end. As the cord and conductor are brought to an edge of the card, one is looped around the other and they are then brought to the opposite edge of the card and are again interlooped. From this it may be seen that each loop of the conductor engages a corresponding loop in the retaining cord. The conductor and retaining cord form similar windings upon the card or block and each engages all of the loops in the other.

Although the interloopings of conductor and cord have been shown in Figs. 1 and 2 as spaced apart, it will be understood that the turns may be arranged one against the

other, but out of electrical contact, without departing from the spirit of this invention. The thickness of the retaining cord will determine the spacing of the turns of the conductor and if the diameter of the retaining cord is large compared with that of the conductor, adjacent strands of the conductor will tend to be spaced from each other even though adjacent strands of the retaining cord are applied as closely as possible and are squeezed together.

In Figs. 1 and 2 the conductor is shown as extending across only one face of the block or card but it will be understood that the invention is not confined to this arrangement. The turns of the conductor may have any desired length and the extent of each turn is limited only by the perimeter of the block. The turns of the conductor may extend across just a portion of one face of the card, as shown in Fig. 4. They may also extend across two or three faces as desired; however, it is best to confine the turns to only one face of the card in order that the windings may have no cross-sectional area, thus obviating inductance from this source. In any case, the turns of the retaining cord will extend across those portions of the surface of the card across which no turns of the conductor extend.

When current is applied to a conductor arranged as described above, the flow of current in adjacent transverse lengths of the conductor will be in opposite directions. Any magnetic field that is produced by the flow of current in any transverse length of the conductor will be opposed and nullified by the magnetic field produced by the flow of current in the opposite direction in the adjacent transverse lengths of the conductors. From this it may be seen that the algebraic sum of the inductive effects of all the turns of the conductor will be approximately zero and the resistance unit will have substantially no self inductance.

Fig. 3 shows an arrangement for mounting the resistance element shown in Fig. 1. A low impedance terminal band 4 is applied to one end of the card or block 1 of the resistance element 18 and is secured thereto by the rivets 5. The band 4 engages the block and retains one of the ends of the cord 3 which is disposed between the band and the block. One end of the conductor 2 may be soldered to the terminal band 4. The band has formed integrally therewith a tab 6 by means of which the conductor 2 may be connected in an electrical circuit. The card or block 1 has secured to its opposite end by rivets 5 a member 7 comprising terminal bands 8 and 9 angularly disposed with respect to each other. The ends of the conductor 2 and the cord 3 are retained by the member 8 in a manner similar to that of the terminal band 4. Another resistance unit 19 constructed in ac-

cordance with the invention has attached to one end thereof a band member 4 and to the other end a terminal band 10 provided with a tongue 11. The terminal band 9 of the member 7 receives one end of a third resistance unit 14, wound in accordance with the invention, and the tongue 11 of the terminal 10. One end of the conductive winding of resistance unit 14 is soldered to the terminal band 9. The tongue 11 and resistance unit 14 are secured to the terminal band 9 by rivets passing through the holes 17. A conductive member 15 of any desired length has integrally formed therewith a terminal band 16 which is secured to the resistance unit 14. The other end of the conductive winding of resistance unit 14 is soldered to the terminal band 16. The terminal bands 4, 8, 9, 10 and 16 and their associated elements 6, 7, 11 and 15 are formed of a highly conductive material such as copper. The assembly described above and shown in Fig. 3 is a Y-shaped arrangement in which two of the resistance units having external terminals 6 are connected in series through the member 7, and in which the resistance unit 14 may form a shunt to ground through the member 15, which is preferably grounded.

It is obvious that the resistance assembly such as that shown in Fig. 3 is adaptable for use in a great many electrical circuits and for numerous purposes. The assembly was developed for use as a high frequency attenuator. It is proposed to use one or more of these assemblies shown in Fig. 3 as attenuators in testing vacuum tube circuits at a frequency of 20 megacycles. At frequencies of that order of magnitude, self-inductance in the attenuator would produce very objectionable effects. Attenuator units constructed as described and shown, are well suited for use at such frequencies by reason of the fact that they have little or no self inductance. In practice it is proposed to use No. 46 American wire gauge insulated manganin wire as the conductive winding of the resistance pad that enters into the assembly shown in Fig. 3. Sufficient wire will be used in each of the resistance elements 18 and 19 to provide resistance of 58.80 ohms in each winding. Sufficient wire to provide 14,540 ohms resistance will be used in the resistance element 14. It is important that the terminal bands 4, 8 and 10 and 16 and their associated elements 6, 7, 11 and 15 be of moderately heavy copper and that the conductive winding be securely soldered to the terminal band in order that the impedances of these terminals shall be negligible in comparison with the impedances of the windings.

When resistance elements are used as attenuators in electrical circuits in which very high frequency alternating currents are flowing, it is necessary that the resistance ele-

ments be protected from electrical or magnetic disturbances that may be present in the vicinity of the apparatus. Protection against such disturbances is accomplished by shielding. Fig. 5 shows an arrangement for shielding one of the resistance assemblies shown in Fig. 3. A quadrangular metallic shielding container 20 is provided. It may be of any suitable conductive material such as cooper or aluminum. One of the resistance assemblies is disposed in the shielding container in such position that no portion of the assembly except the member 15 shall be in contact with any portion of the shielding container. The member 15 may be employed for mounting the resistance assembly in the compartment and it may terminate at the wall of the container 20 and be secured by rivets as shown in Fig. 5.

A double-pole double-throw key switch 21 is mounted inside the shielding container 20 and has its operating lever 22 extending through an aperture in the shielding container so as to be operable from outside. The key switch 21 has six terminals. The dimensions of the shielding container 20 are such that when the resistance assembly and key switch are mounted in the container the terminal tabs 6 can be soldered directly to two of the terminal prongs of the switch 21 and intermediate lead wires are not required. Leads 23 for connecting these resistance assemblies to an electrical circuit are connected preferably by soldering to the two central terminal prongs of the switch. A low impedance conductive member 24 is connected across the remaining two terminals. It will be apparent that with this switching arrangement the resistance elements 18 and 19 or the short-circuiting member 24 may be inserted in the path through the lead 23 or that path can remain open. The shielding container 20 is provided with apertures 25 through which the leads 23 may pass and these apertures should be so positioned with respect to the terminal prongs of the key switch that the portion of the leads inside the shielding container may be as short as possible. The apertures 25 should be sufficiently large to permit the lead 23 to pass through without touching the wall of the shielding container.

Fig. 6 shows a schematic diagram of a circuit in which a plurality of the assemblies shown in Fig. 5 are employed as attenuators. Reference numeral 26 indicates an oscillation generator capable of producing a 20 megacycle frequency alternating current or a current of any desired frequency. The oscillation generator 26 works into a vacuum tube amplifier 27 and the alternating current out-

put of the amplifier is measured by the measuring instrument 28 connected to the rectifier 29. The alternating current from the amplifier 27 is attenuated any desired amount by means of a plurality of the switch controlled resistance assemblies shown in the shielding container in Fig. 5. For this purpose a plurality of the shielding containers 20 each containing one of the switch controlled resistance assemblies and having leads 23 passing from one container to the next are provided. As shown by the dotted lines in Fig. 6 one shielding container 20 divided into a plurality of compartments by the shielding partitions 30 may be provided instead of a plurality of individual shielding compartments such as the one shown in Fig. 5. Each of the compartments contains one of the switch controlled resistance assemblies and the leads 23 may pass from one compartment to the next. After the alternating current from the amplifier 27 has been attenuated it is applied to the input of a radio receiving set 31 or any other vacuum tube circuit that is to be tested. A measuring instrument 32 is connected to the output of the radio receiving set or vacuum tube circuit for indicating the magnitude of the output of the circuit.

While a single embodiment of the invention has been illustrated and described, the invention is not limited to the specific arrangement shown as variations may be made in the apparatus employed and its assembly and arrangement without departing from the scope of the invention as set forth in the claims.

What is claimed is:

1. A resistance unit comprising a card of insulating material, a flexible conductor carried on one side of the card in zigzag arrangement transversely thereon and retaining means on the other side of the card, said means comprising a continuous flexible cord interlaced with consecutive loops of said conductor, the diameter of the cord being large compared with that of the conductor, and adjacent turns of the conductor being spaced from each other by an amount determined by the thickness of the retaining cord.

2. In a high frequency attenuator, a resistor comprising a flexible conductor arranged transversely on only one side of a card in a zigzag manner, the card being composed of dielectric material, and means for retaining the conductor in its zigzag position, said means comprising a continuous cord arranged transversely on the opposite side of the card in a zigzag manner, the loops of the cord being interlaced with similar loops of the conductor.

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