

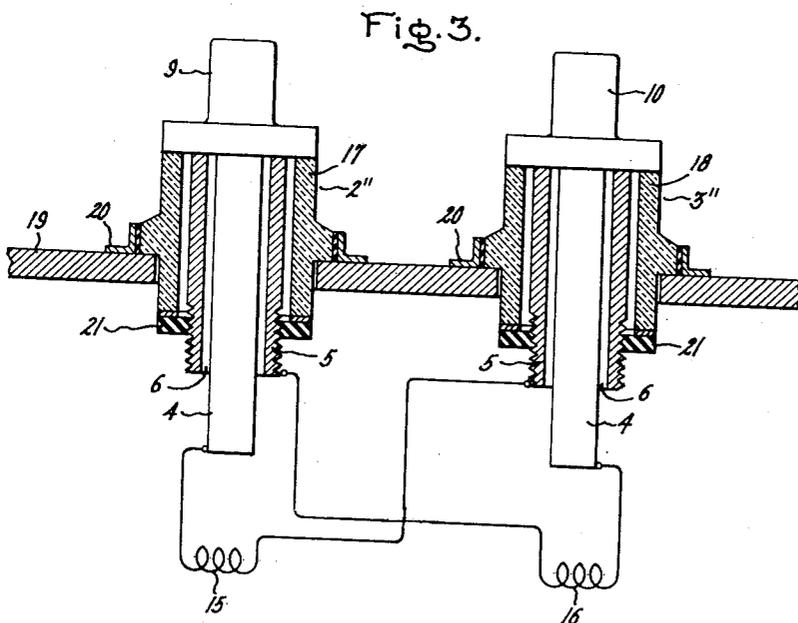
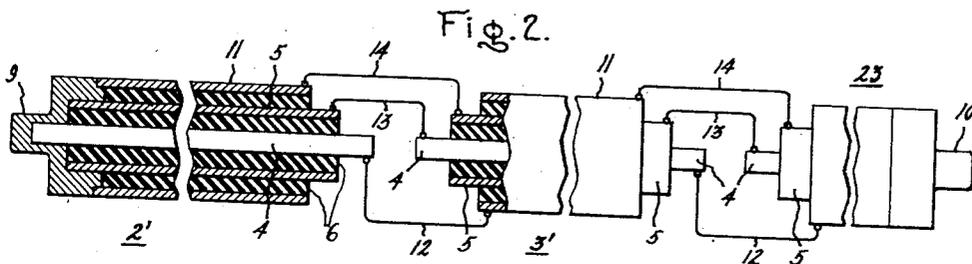
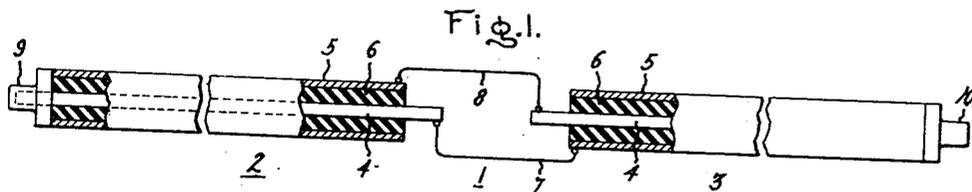
July 27, 1954

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2,684,993

PARALLEL CONNECTED CONCENTRIC CONDUCTOR

Filed July 19, 1949



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UNITED STATES PATENT OFFICE

2,684,993

PARALLEL CONNECTED CONCENTRIC CONDUCTOR

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Application July 19, 1949, Serial No. 105,546

8 Claims. (Cl. 174—17)

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My invention relates to electrical conductor structures and, more particularly, to electrical conductor structures which are adapted to carry relatively large 60 cycle alternating currents and alternating currents of frequencies higher than 60 cycles.

When an alternating current is caused to flow in a conductor, certain magnetic forces are set up within the conductor which give rise to a phenomenon which is commonly recognized and designated "skin effect," whereby a relatively larger portion of the current is forced to flow in the radially outermost portions of the conductor and the innermost portions of the conductor carry a relatively small portion of the current. This skin effect becomes more pronounced as the current increases, as the diameter of the conductor increases, and also as the frequency of the alternating current conducted increases. As a result, it has been common practice where a conductor of large cross-section is required to make the conductor in the form of a hollow tube since, if a solid conductor were used, the center portion would carry such a small part of the current that the additional cost and weight of the copper or other conductive material in this center portion is unjustified. This hollow conductor construction, however, results in a considerable waste of space in the center of the conductor.

It is, therefore, an object of my invention to overcome skin effect and thereby to make use of the otherwise wasted space or wasted conductive material through the center of a conductor of large cross-sectional area.

This invention, in its broader aspects, consists essentially in the combination of two or more series connected conductor sections, each section including two or more concentric conducting members. The members of smaller diameter in one section are interconnected with members of larger diameter in other sections to provide a number of parallel conductive paths, each path including conductors of various diameters and insulated from the other paths except at the terminal ends of the complete conductor, so that the total current being conducted is divided equally among the various parallel paths and all of the conductors in each section carry approximately equal currents.

For additional objects and advantages, and for a better understanding of the invention, attention is now directed to the following description and accompanying drawing, and also to the appended claims in which the features of the in-

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vention believed to be novel are particularly pointed out.

In the drawing, Fig. 1 is a view, partially in section, of one embodiment of my invention; Fig. 2 is a similar view of a second embodiment of my invention; and Fig. 3 is a view, partially in section, of my invention as incorporated into an induction apparatus such as a transformer.

In Fig. 1, conductor 1 consists of conductor sections 2 and 3, each of which employs an inner conducting element 4 and an outer conducting element 5. Elements 4 and 5 are insulated from one another by a suitable insulating material 6. The inner conductor 4 in section 2 is connected to the outer conductor of section 3 by a suitable connector 7, and the inner conductor of section 3 is connected to the outer conductor of section 2 by a suitable connector 8. At the terminal ends of the sections 2 and 3 remote from the junction formed by the connectors 7 and 8, the inner conductor 4 and outer conductor 5 are connected together through suitable terminals 9 and 10. Thus, between the terminals 9 and 10 there are two parallel paths through which the electrical current may be conducted; one path from terminal 9 through inner conductor 4 of section 2, connector 7, outer conductor 5 of section 3 to terminal 10, and the other parallel path from terminal 9 through outer conductor 5 of section 2, connector 8 and inner conductor 4 of section 3 to terminal 10. These two parallel paths are electrically equivalent and both paths, therefore, carry equal amounts of the current, since each path includes one section of inner conductor and one section of outer conductor. Therefore, the inner conductor elements and outer conductor elements share the current equally and skin effect is thereby avoided.

Fig. 2 illustrates another embodiment of my invention, the conductor illustrated employing three concentric conductor elements and three conductor sections to obtain more complete advantage of the principle of my invention where, for instance, a conductor of extremely large cross-sectional area is needed. An additional outer conductor element 11 is added to each section and a complete section 23 is added. Interconnections 12, 13, and 14 between conductor elements of different diameters in successive sections result in three parallel conductive paths, each including one conductor element of each diameter so that each of the three paths is the electrical equivalent of the other two and each, therefore, carries an equal share of the total current. It will be understood that the principle of

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my invention may be further extended by the addition of conductor elements and conductor sections beyond the two or three shown here.

In Fig. 3, the conductor of my invention is shown combined with a transformer employing parallel connected transformer coils. Here, my conductor sections 2'' and 3'' constitute insulating bushings which are employed as insulated "lead-in" conductors and the transformer coils 15 and 16 themselves perform the function of interconnections between the inner conductor elements 4 in one section and the outer conductor element in the other section. Although only two parallel connected coils and two conductor elements per section are employed here, the number of coils and elements could be increased to three or more.

In their office as "lead in" conductors in Fig. 3, conductor sections 2'' and 3'' are surrounded and supported by tubular insulating members 17 and 18 which are, in turn, supported upon the transformer casing 19 where they are retained in place by metal supports 20. Outer conductor element 5 and insulator tubes 17 and 18 are maintained in assembled, though spaced, relationship by conducting or insulated flange nuts 21 which may be threaded over the lower portions of elements 5. The insulator 6 in an embodiment such as shown in Fig. 3, may consist entirely of air, but in other embodiments this insulator may be of any suitable insulating material such as, for example, a resilient plastic.

While certain specific embodiments have been shown and described, it will, of course, be understood that various modifications may be made without departing from the invention. The appended claims are, therefore, intended to cover any such modifications within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A pair of insulated lead-in conductor sections for making electrical connection between the exterior and interior of a casing, said conductor sections extending through a wall of said casing and each comprising an inner conducting element and an outer conducting element with said outer element being insulated from and surrounding said inner element over substantially all of the respective lengths of said elements, the ends of said elements in each lead-in conductor section exteriorly of said casing being directly interconnected, and at the ends of said conductor sections positioned interiorly of said casing, the interior conducting element for one section being conductively connected to the outer conducting element of the other section and the outer conducting element of the said one section being conductively connected to the interior conducting element of the said other section, one pair of conductively connected elements being insulated from the other pair of conductively connected elements within said casing.

2. An electrical conductor comprising a plurality of sections interconnected at their ends, each section including a plurality of conducting elements of different outer dimensions including an innermost conducting element and outer hollow elements of progressively increasing size, each such element surrounding and being insulated from the next smaller element over substantially all of the respective lengths of said elements, interconnections at the ends of adjacent sections from individual elements in one section to individual elements in the other section, each of said

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interconnections connecting an element of one size in one section to an element of a different size in the adjacent section, the ends of the conducting elements at the terminal ends of the terminal sections of said electrical conductor being directly interconnected so that said electrical conductor comprises a number of parallel conductive paths equal to the number of elements in each section.

3. An electrical current conductive apparatus including two pairs of concentric electrical conductor elements, each pair comprising an inner conductor element and a hollow outer conductor element, said inner conductor element and said outer conductor element in each pair being insulated from each other over substantially all of the respective lengths of said elements, the two elements in each pair being directly connected together at one end and the other end of the inner element of each pair being connected respectively to the other end of the outer element of the other pair.

4. An electrical current conductive apparatus including a plurality of conductor sections interconnected at their ends, each section including a plurality of conducting elements of different outer dimensions including an innermost conducting element and outer hollow elements of progressively increasing size, each such element surrounding and being insulated from the next smaller element over substantially all of the respective lengths of said elements, interconnections at the ends of adjacent sections from individual elements in one section to individual elements in the other section, each of said interconnections connecting an element of one size in one section to an element of a different size in the adjacent section, the ends of the conducting elements at the terminal ends of the terminal sections of said electrical conductor being directly interconnected so that said electrical apparatus includes a number of parallel conductive paths equal to the number of elements in each section, each of said paths including the same number of elements of each size.

5. An electrical conductor comprising a plurality of sections interconnected at their ends, each section including a plurality of coaxial cylindrical conducting elements of different outer diameters including an innermost element and outer hollow cylindrical elements of progressively increasing diameter, each such element surrounding and being insulated from the next smaller element over substantially all of the respective lengths of said elements, interconnections at the ends of adjacent sections from individual elements in one section to individual elements in the other section, each of said interconnections connecting an element of one size in one section to an element of a different size in the adjacent section, the ends of the conducting elements at the terminal ends of the terminal sections of said electrical conductor being directly interconnected so that said electrical conductor comprises a number of parallel conductive paths equal to the number of elements in each section, each of said paths including the same number of elements of each size.

6. A pair of insulated lead-in conductor sections for making electrical connection between the exterior and interior of a casing, said conductor sections extending through a wall of said casing and each comprising at least one inner conducting element and at least one outer conducting element, with the respective conducting ele-

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ments in each section being insulated from each other and coaxially positioned with respect to each other, the ends of said elements in each lead-in conductor section exteriorly of said casing being directly conductively interconnected, and at the ends of said conductor sections positioned interiorly of said casing the conducting elements of one section being conductively connected to the conducting elements of the other section in such manner that a conducting element of a given diameter in one section is always connected to a conducting element of a different diameter in the other section.

7. A pair of insulating bushings for making electrical connection between the exterior and interior of an enclosing casing, each of said bushings having an outer insulating shell and an outer and an inner conducting element coaxially disposed radially inwardly of said insulating shell, the outer conducting element of each of said bushings being insulated from and surrounding the inner conducting element of said bushing, the ends of said elements for each of said bushings which are disposed exteriorly of said casing being directly conductively interconnected, and at the ends of said respective bushings extending interiorly of said casing the inner conducting element of each bushing being conductively connected to the outer conducting element of the other bushing and the outer conducting element of each bushing being conductively connected to the inner conducting element of the other bushing.

8. A pair of insulating bushings for making

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electrical connection between the exterior and interior of an enclosing casing, said bushings extending through a wall of said casing and each comprising an outer insulating shell and at least one inner conducting element and at least one outer conducting element disposed radially inwardly of said insulating shell, with the respective conducting elements in each bushing being insulated from each other, the conducting elements in each bushing being coaxially positioned with respect to each other, the ends of said conducting elements in each bushing positioned exteriorly of said enclosing casing being directly conductively interconnected, and at the ends of said bushings positioned interiorly of said casing the conducting elements of one section being conductively connected to the conducting elements of the other section in such manner that a conducting element of a given diameter in one section is always connected to a conducting element of a different diameter in the other section.

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