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MULTIPLE CONDUCTOR FOR LARGE CURRENTS

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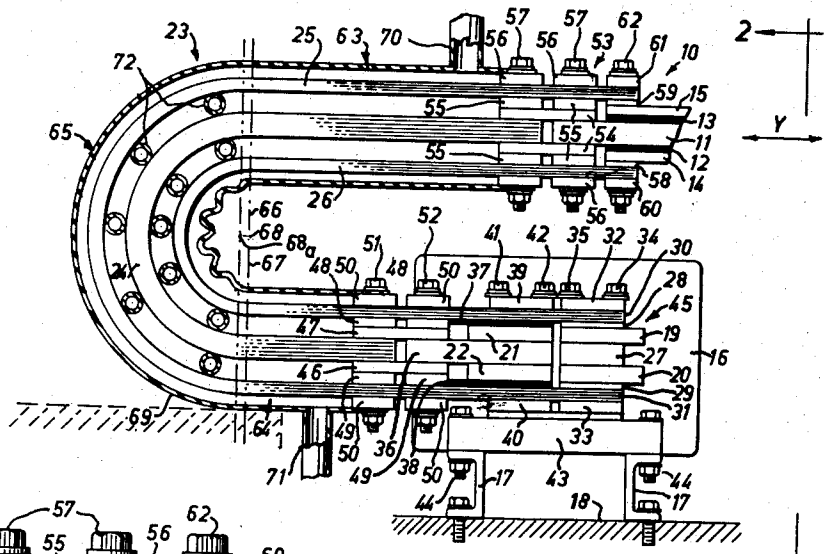


FIG. 1

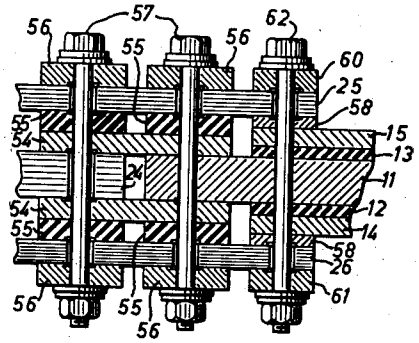


FIG. 3

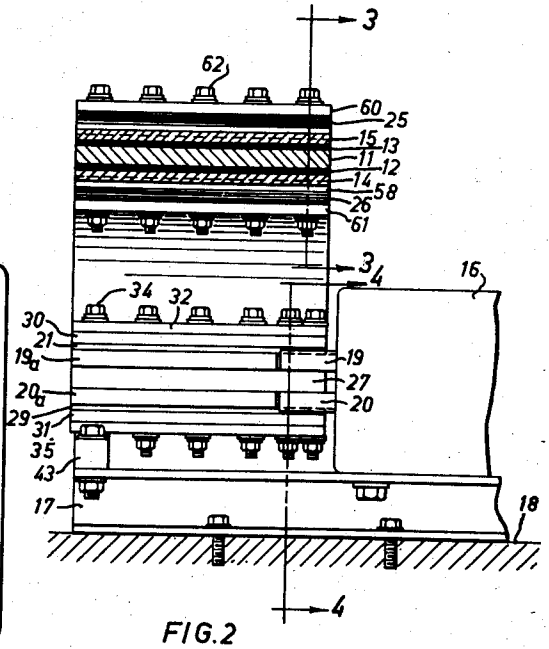


FIG. 2

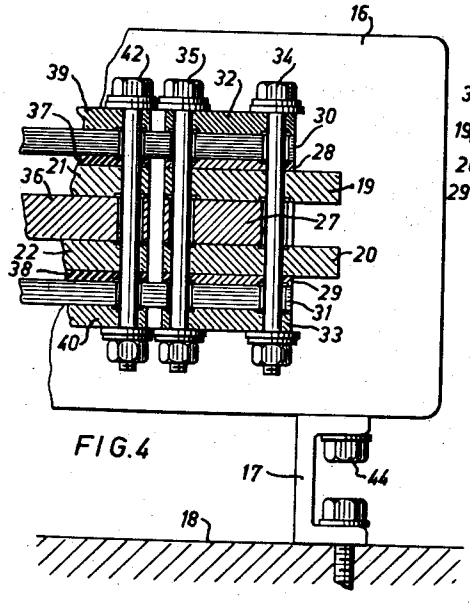


FIG. 4

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MULTIPLE CONDUCTOR FOR LARGE CURRENTS

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4 Claims. (Cl. 174—24)

This invention relates to a multiple conductor for alternating currents.

The design of heavy current industrial apparatus including the design of electric melting furnaces and the like has been limited in prior practice due to the magnetic field pattern which exists about the conductors used for carrying a heavy electrical current thereto and the low power factor of the conductors.

It is accordingly the main object of the present invention to provide a multiple conductor adapted to carry heavy electrical currents of the order of 20,000 amps. and larger at current densities of the order of up to about 10,000 amps. per square inch while confining the magnetic field effects of said conductor substantially to the structure of said conductor and with improved power factor.

It is another object of the invention to provide a heavy current multiple conductor construction in which a cancellation of a substantial portion of the mechanical forces effected by passage of electrical current therethrough, is accomplished.

A still further object of the invention is to provide a heavy current multiple conductor which may be connected to relatively moving points in utilizing apparatus and wherein such apparatus is not affected by magnetic fields generated by the passage of heavy electrical currents through the conductor.

Other objects of the invention will be appreciated by a study of the following specification taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 as an elevation of a preferred form of conductor according to the invention having a flexible portion extending between two rigid portions thereof.

Figure 2 is a view of Figure 1 looking in the direction 2—2;

Figure 3 is a partial sectional view on the line 3—3 of Figure 2; and

Figure 4 is a sectional view on the line 4—4 of Figure 2.

In Figure 1, the rigid conductor portion **10** comprises the inner conductor **11** for one voltage line spaced by insulating means **12** and **13** from the outer conductors **14** and **15** which latter together serve as the other voltage line. By way of example, the multiple conductor construction of the invention may be adapted to operate at a current density of 1,660 amps. per square inch at a total current carrying capacity of 20,000 amps. The inner conductor may be comprised of a copper bar one inch thick and twelve inches wide as is designated by the numeral **11**. The outer conductors **14** and **15** being electrically in parallel together carry the current for one side of the line supply and thus, according to the invention, are each equal to one-half the sectional area of the bar or conductor **11** so that they will each be twelve inches wide and one-half inch thick.

The rigid conductors **11**, **14** and **15** continue in the form of structure shown for electrical connection to

suitable utilizing apparatus. Because the outer conductors **14** and **15** carry current passing opposite in direction to the current flow in the conductor **11** at any one instant, the magnetic field generated by current flow in the central conductor **11** will be cancelled by the magnetic field generated by current flow in the outer conductors except at the side edges of the construction. However, by reason of the relatively shallow depth of the construction as compared with its width, the magnetic field pattern does not extend significantly beyond the side edges of the construction.

It should be appreciated that the mechanical forces involved may be substantial. Thus, in the example considered, the central conductor may repel the outer conductors with a force of about eight pounds per inch of length of the central conductor. It will therefore be understood that the mechanical problems associated with the design of single heavy current conductors of the prior art have been substantial.

In the construction of the present invention, however, the outer conductors attract one another with a force of about three pounds per inch of length. Accordingly, the net outward repulsive force for the total construction is reduced to about one-half that between a lone pair of conductors or about four pounds per inch of length of the multiple conductor construction herein. By this means, therefore, the mechanical design of the conductors is materially assisted by adoption of a construction of the invention as described.

The multiple conductor construction of the invention may be provided in a flexible form as is also shown in Figure 1, wherein the heavy current transformer **16** is supported on stationary arms **17** fixed to a machine bed **18** and has projecting therefrom the fixed single phase terminals **19** and **20**. It is to be assumed that the conductor **10** is adapted to be moved on a path Y parallel to the terminals **19**, **20**, **21** and **22**. While separate single flexible conductors have been provided heretofore formed of a plurality of sheets of metal to permit relative movement between connecting points, the present invention contemplates the provision of such flexible leads in the special magnetic flux cancelling arrangement shown.

The flexible portion of the multiple conductor **23** of the invention comprises the inner flexible conductor **24** formed of a plurality of sheets of copper. Adhering to the foregoing example, a plurality of plies of flexible copper sheet twelve inches wide may be provided to supply a total current carrying sectional area for the conductor **24** corresponding to that of the conductor **11**. The outer conductors **25** and **26** are similarly constructed but again embody one-half the number of plies of sheet copper or other flexible conductor material, so that each comprises one-half of the current carrying sectional area of the conductor **24**. In the construction shown, the transformer terminals **19** and **20** supply one side of a current source and the terminals **21** and **22** provide another side of current supply source to define a single phase output for the transformer **16**. Thus, terminals **19** and **20** are mutually connected by a copper bar **27** and carry connecting plates **28** and **29** adapted to be clamped to the fixed ends **30** and **31** of the outer flexible conductors **26** and **25** respectively, the latter being held firmly in place by means of the clamping plates **32** and **33** adapted to carry the insulated clamping bolts **34** and **35**. By this means, a circuit connection is made from the terminals **19** and **20**, to the outer flexible conductors **25** and **26**.

The terminals **21** and **22** have placed therebetween, the supporting plate **36** and are separated from the outer conductors by insulation **37** and **38** maintained in clamped assembly by the clamping bars **39** and **40** by means of

insulated bolts 41 and 42. Where it is desired that the transformer terminals 19 and 20 be grounded to the machine frame, then clamping plates 33 and 40 may provide electrical connection to the frame through the supporting bracket 41 fixed to the stationary frames 17 by bolts 44. It will be observed that the bracket 43 and the various connecting bars and clamping plates effect a rigid anchoring of the fixed end 45 of the multiple conductor construction of the invention.

A connection is now made from the fixed end 45 to the inner flexible conductor 24 by means of connecting plates 46 and 47 held by inner clamping plates 48 and 49 and outer clamping plates 50 fixed by insulated bolts 51 and 52. The movable end 53 of the flexible multiple conductor 23 is connected to the movable rigid conductor 10 in somewhat similar fashion. Thus, the inner flexible conductor 24 connects by conducting plates 54 to the inner conductor 11 and is separated by insulation 55 from the outer flexible conductors 26 and 25 which project therefrom under the clamping plates 56 held with insulated bolts 57 to make connection through conducting plates 58 and 59 to the rigid outer conductors 14 and 15 being held in assembly therewith by clamping plates 60 and 61 and suitable clamping bolts 62. It will be observed that the flexible multiple conductor portion embodies the arm portions 63 and 64 adapted to change in length as the movable end 53 is moved relative to the fixed end 45. The arm portions are joined by curved portion 65. The juncture of the armed portion and the curved portion may be represented by tangency lines 66 and 67 which emerge from a center of curvature 68. In a single conductor flexible conductor construction of the prior art, a free spacing is maintained between the metal plies or sheets making up the juncture in the region of curvature. Thus, for example, where the juncture was accomplishing a mean curvature of say three inches radius, the radius center for the innermost ply would be located at say the point 68 whereas the radius center of the outermost ply of the juncture would be displaced outwardly about one-eighth of an inch or more to the radius center 68*a*. It has been found that this method of insuring freedom of action between the plies of metal making up the flexible lead or conductor permits undue distortion in the curved portion to such a degree that parallelism of action may be difficult to maintain between one end of a moving conductor and the fixed end thereof, again leading to undue fatigue conditions in the plies of the flexible lead. This condition is aggravated where the flexible lead is required to carry very large currents and in some applications, has rendered the use of flexible leads impractical, thus obviating the practical design of some types of apparatus. According to the invention, while radius displacement is contemplated between the innermost and outermost ply of any one of the conductors, it has been found essential in heavy current applications, to restrict the displacement to less than about one-twentieth of the radius of curvature.

For very heavy current applications, the invention contemplates the lubrication of the plies of metal making up each of the conductors on the interfaces thereof by any suitable lubricant such as petroleum jelly, by means of which the radius displacement may be kept to less than one-fiftieth of the radius of curvature whereby the curvature of the flexible multiple conductor of the invention is of smooth contour obviating bulging and adapted for normal elastic behaviour of the metal thereof.

The conductor of the invention, particularly in the flexible form, may carry a flexible coolant casing 69 formed, for example, of rubber tubing, which extends for sealed connection at the bolts 57 and at the bolts 51 at the movable and anchored ends respectively of the conductor. As shown, the inlet tube 70 may provide for the introduction of inlet air, water, oil or other suitable coolant and the outlet fitting 71 may provide for an outlet of the coolant after passage over surfaces of the flexible conductor.

In order to provide extra support, separating bars or spacers, preferably in the form of the rubber tubes 72 may be placed between the outer and inner conductors as shown in Figure 1. The distance between the spacers may be maintained by textile cords or other suitable means (not shown).

While the invention has been disclosed in a single-phase connection by way of example, the application of the teachings herein to multi-phase conductor connections will be appreciated by skilled persons.

While there has been described what is at present considered a preferred embodiment of the present invention, it will be appreciated by those skilled in the art that various changes and modifications can be made therein without departing from the essence of the invention and it is intended to cover herein all such changes and modifications as come within the true spirit and scope of the appended claims.

What I claim as my invention is:

1. A multiple conductor for carrying large single phase electrical currents from a current source having a voltage between two output terminals thereof to a utilizing system having corresponding input terminals and comprising, in combination: an inner conductor of predetermined sectional area formed of a plurality of stacked flexible conducting sheets and of a width between the edges of said sheets substantially greater than the total thickness of said sheets between the major surfaces thereof; an outer conductor formed of a plurality of stacked conducting sheets of substantially said width for each of the exterior major surfaces of said inner conductor, each of said outer conductors having a corresponding exterior major surface overlying an exterior major surface of said inner conductor in parallel spaced relation thereto, said outer conductors being of a total sectional area substantially equal to said predetermined sectional area; means for connecting said inner conductor electrically between one output terminal and one input terminal; means for electrically connecting all of said outer conductors electrically in parallel between the other output terminal and the other input terminal; means supporting the ends of said multiple conductor for relative motion and defining a curved portion in said multiple conductor between said ends; and means for maintaining the spacing between said inner conductor and said outer conductors between said ends.

2. A multiple conductor for carrying large electrical currents from a current source having a voltage between two output terminals thereof to a utilizing system having corresponding input terminals and comprising, in combination: an inner conductor of predetermined sectional area formed of a plurality of stacked flexible conducting sheets and of a width between the edges of said sheets substantially greater than the total thickness of said sheets between the major surfaces thereof; an outer conductor formed of a plurality of stacked conducting sheets of substantially said width for each of the exterior major surfaces of said inner conductor, each of said outer conductors having a corresponding exterior major surface overlying an exterior major surface of said inner conductor in parallel spaced relation thereto, said outer conductors being of a total sectional area substantially equal to said predetermined sectional area; means for connecting said inner conductor electrically between one output terminal and one input terminal; means for electrically connecting all of said outer conductors electrically in parallel between the other output terminal and the other input terminal; means supporting the ends of said multiple conductor for relative motion and defining a curved portion in said multiple conductor between said ends; means for maintaining the spacing between said inner conductor and said outer conductors between said ends; and means for communicating a cooling medium about said conductor.

3. A multiple conductor for carrying large electrical

currents from a current source having a voltage between two output terminals thereof to a utilizing system having corresponding input terminals and comprising, in combination: an inner conductor of predetermined sectional area formed of a plurality of stacked flexible conducting sheets and of a width between the edges of said sheets substantially greater than the total thickness of said sheets between the major surfaces thereof; an outer conductor formed of a plurality of stacked conducting sheets of substantially said width for each of the exterior major surfaces of said inner conductor, each of said outer conductors having a corresponding exterior major surface overlying an exterior major surface of said inner conductor in parallel spaced relation thereto, said outer conductors being of a total sectional area substantially equal to said predetermined sectional area; means for connecting said inner conductor electrically between one output terminal and one input terminal; means for electrically connecting all of said outer conductors electrically in parallel between the other output terminal and the other input terminal; means supporting the ends of said multiple conductor for relative motion and defining a curved portion in said multiple conductor between said ends; means for maintaining the spacing between said inner conductor and said outer conductors between said ends; and a transformer support carrying said end supporting means at one end of said multiple conductor.

4. A multiple conductor for carrying large electrical currents from a current source having a voltage between two output terminals thereof to a utilizing system having corresponding input terminals and comprising, in combination: an inner conductor of predetermined sectional area formed of a plurality of stacked flexible conducting sheets and of a width between the edges of said sheets substantially greater than the total thickness of said

sheets between the major surfaces thereof; an outer conductor formed of a plurality of stacked conducting sheets of substantially said width for each of the exterior major surfaces of said inner conductor, each of said outer conductors having a corresponding exterior major surface overlying an exterior major surface of said inner conductor in parallel spaced relation thereto, said outer conductors being of a total sectional area substantially equal to said predetermined sectional area; means for connecting said inner conductor electrically between one output terminal and one input terminal; means for electrically connecting all of said outer conductors electrically in parallel between the other output terminal and the other input terminal; means supporting the ends of said multiple conductor for relative motion and defining a curved portion in said multiple conductor between said ends; means for maintaining the spacing between said inner conductor and said outer conductors between said ends; means for communicating a cooling medium about said conductor; and a transformer support carrying said end supporting means at one end of said multiple conductor.

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