

[54] **CABLE JOINTS WITH COMMUNICATING FLUID DUCTS AND METHODS OF MAKING SAME**

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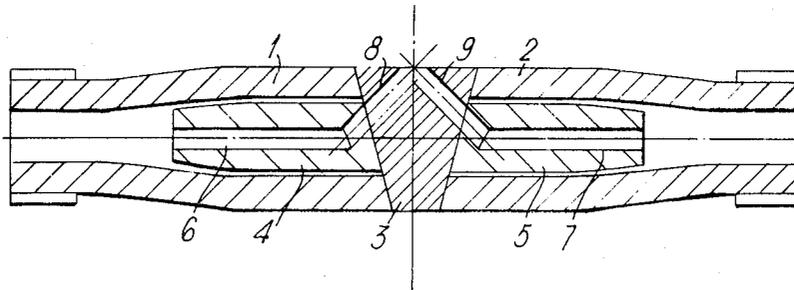
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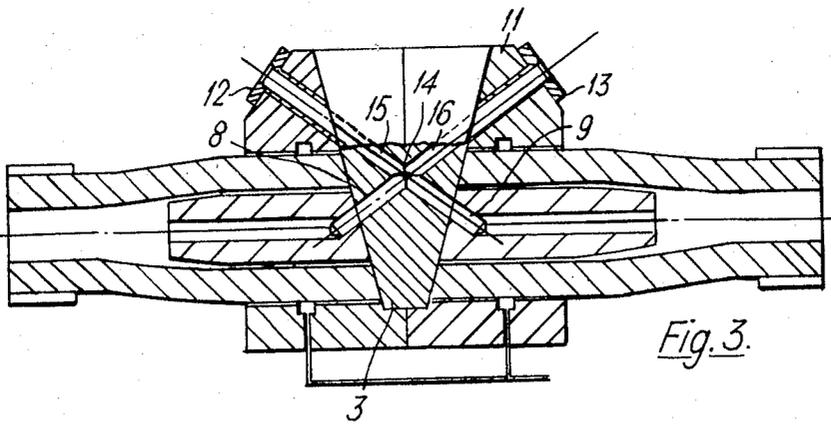
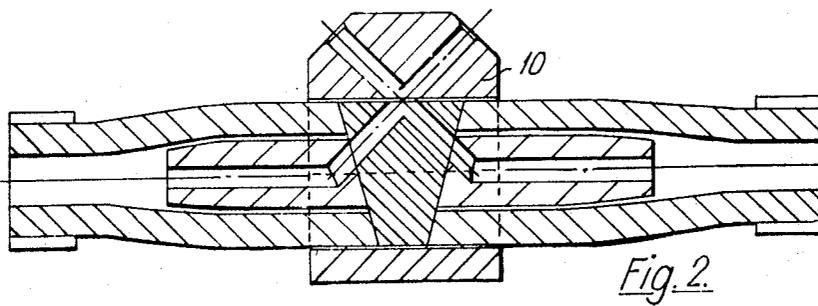
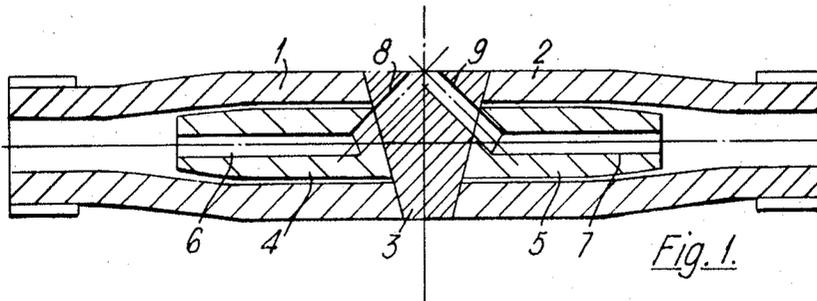
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[57] **ABSTRACT**

In making a joint between two hollow core conductors by forming a body of metal between the spaced ends of the conductors in such a way that it adheres to the facing cut ends of the two conductors and fills the space between them, at least one pair of straight ducts is formed within the said body, during or after its formation. The ducts of the or each pair extend from the central duct of respective conductors outwards at an acute angle to the common axis of the conductors to communicate with one another, as by directly intersecting within the body or at or adjacent to its surface, or by opening into a common recess in that surface. The ducts are preferably formed by drilling inwards from the outer surface of the body which is itself preferably formed by an MIG welding process.

19 Claims, 3 Drawing Figures





CABLE JOINTS WITH COMMUNICATING FLUID DUCTS AND METHODS OF MAKING SAME

This invention relates to a method of making joints between electric power cable conductors, of the kind (hereinafter referred to as "hollow core conductors") having a central duct and to joints made by the method. More particularly, the invention is concerned with a method which comprises forming a body of metal between the spaced ends of two hollow core conductors in such a way that said body adheres to the facing cut ends of the two conductors and fills the space between them.

One method of forming such joints is the subject of copending patent applications, Ser. Nos. 813,523 and 813,621 both filed on the Apr. 4, 1969 in the names of John S. Cleaver, Peter Guilford, Frederick J. Kimpton, Thomas J. Page and Norman R. Steinberg. The specification of application, Ser. No. 813,523 describes various methods of making such joints in such a way as to provide for the flow of fluid from one conductor to the other, after the joint has been made.

The object of the present invention is to provide an improved method of making such joints with provision for fluid flow between hollow core conductors and, in accordance with the invention, during or after the formation of the body of metal between the conductor ends, at least one pair of straight ducts is formed within the metal body, one duct of the or each pair extending from the central duct of one conductor outwards at an acute angle to the common axis of the conductors to communicate with the other duct of the pair, which extends outwards from the central duct of the other conductor at an acute angle to the said axis.

The or each pair of ducts is preferably formed by drilling inwards from the outer surface of the metal body at an appropriate angle, successively towards each of the conductor ducts, in such a way that the two bores thus formed in the body intersect within the body, or meet at or adjacent to the surface of the body, or open into a recess in the surface of the body but other methods of forming the ducts can be used.

One such alternative method is to form the ducts by means of removable mould cores arranged in position between the conductor ends before the metal body is formed between them. This method is especially applicable when the body of metal filling the space between the conductor ends is formed by a method other than the MIG welding process, referred to in the above-mentioned copending applications, for example by pouring molten metal into the cavity or by an exothermic powder process (as referred to in a pending U.K. Pat. application No. 55413/69). The design of the cores is simplified if the ducts intersect the surface of the metal body at spaced positions and are interconnected by a surface channel from which the core may be removed laterally. When such removable mould cores are used to form the ducts they may be enclosed in thin tubes of a metal which may adhere to the cast metal and the tubes may remain *in situ* in the metal body, when the cores are removed, to form linings for the ducts.

Whatever method of forming the ducts is used, the conductor ducts are preferably closed by duct plugs before the formation of the joint so as to prevent flow of oil from the ducts before and during the jointing operation. Such plugs will remain *in situ* after the body has been formed and are designed to allow fluid to flow from the conductor ducts into the ducts formed in the metal body.

For example, when the ducts are formed in the body by drilling, the duct plugs may each be formed with a central bore which is closed at the end of the plug adjacent to the cut end of the conductor but extends for a sufficient distance through the plug to enable it to become connected to an acute angle duct, drilled through the body and the closed end of the plug. When removable cores are used to form the ducts in the body the inner ends of the cores may act as plugs for temporarily closing the ends of the central bores in the duct plugs, during the formation of the body around the cores.

Although in most cases only one pair of ducts lying in the same radial plane at least if they communicate directly need

be provided, it is possible to form in the same way further pair or pairs of ducts, each pair lying in a different radial plane or otherwise spaced from any other pair.

Examples of methods of making joints and joints made by the method in accordance with the invention will hereinafter be described with reference to the accompanying drawings in which

FIG. 1 shows a completed conductor joint in accordance with the invention and

FIGS. 2 and 3 show stages in two methods in accordance with the invention.

FIG. 1 shows a sectional elevation of a completed joint between two hollow conductors 1 and 2, each of which has been cut at an appropriate angle to provide a cavity between their cut ends in which a body of metal 3 has been formed for example by the MIG technique referred to in the above-mentioned cognate applications. Prior to the jointing operation, duct plugs 4 and 5 have been driven into the conductor ducts, the plugs being slightly oversized in order to bring about some separation of the conductor elements and thus to facilitate extraction of oil from the conductor ducts during the jointing operation. Each of the plugs 4 and 5 has a central blind bore (6 and 7) extending to within a short distance of the external end of the plug, which is preferably preshaped to make a flush surface with the cut end of the conductor into which the plug is inserted.

From the drawing it will be seen that, after the body 3 has been dressed down to the external shape of the conductors 1 and 2, two ducts 8 and 9 have been drilled in the body and into the duct plugs 4 and 5 at an acute angle with the cable axis such that the duct 8 mates with the duct 6 and the duct 9 mates with the duct 7 and the two ducts 8 and 9 meet in and adjacent to the peripheral surface of the body 3.

After the ducts 8 and 9 have been drilled, the conductor screen is continued over the body 3 either directly or after a thin metal sheet has been applied to cover the junction between the ducts 8 and 9.

One method of ensuring the correct alignment of the ducts 8 and 9 when they are formed after the body 3 has been dressed down is shown in FIG. 2, from which it will be seen that a drilling jig 10 is clamped onto the joint between the conductors.

An alternative method which enables the drilling to be carried out before the body 3 has been dressed down is shown in FIG. 3. In this method a casting jig 11 which is provided with vacuum ducts for the extraction of oil from the conductor ends is itself used as a drilling jig. For this purpose steel inserts 12 and 13 are provided in the copper body of the casting jig which also serves as a heat sink. When this method is used, it is necessary temporarily to plug the ducts in the body 3 during dressing down in order to avoid the collection of swarf in the ducts during the dressing down process.

It will be noted that, in the joint shown in FIG. 3, the ducts 8 and 9 intersect at a point 14 within the body 3. After dressing down the body, the outer ends 15 and 16 of the ducts 8 and 9 which extend beyond the intersection 14 can be closed permanently for example by means of self-tapping screws which can themselves be dressed down to the profile of the joint surface.

In a further alternative method which is not illustrated in the accompanying drawings a casting jig is employed similar to that illustrated in FIG. 3 but without steel inserts 12 and 13 and a drilling jig is fitted into the upper part of the cavity of the casting jig after the cast body 3 has been formed.

It may be desirable before drilling a bore at an acute angle to the conductor axis to drill a shallow start hole perpendicular to the conductor surface, and the jigs used may provide for this step.

Although in the examples shown in the drawings the ducts in the cast body have been shown arranged in a vertical radial plane, they can be arranged in any other radial plane and, as indicated above, more than one pair of ducts may sometimes be used in order to increase the oil flow from one conductor to

the other. Arrangement of the ducts in a plane other than the vertical plane may assist in flushing out drilling swarf from the ducts before their ends are sealed by a conductor screen or otherwise.

It may be found advantageous in some circumstances to use a drill with a hollow center which would allow the core of metal cut by the drill to be removed in one piece thus reducing the danger of swarf being occluded in the ducts.

Free flow of oil from the ducts can be tested for by temporarily inserting an expansible plug into each duct in turn while checking the flow of oil from the other duct of the pair.

By making the ducts in the body of the same cross-sectional area as that of the bore of the duct plugs, the joint in accordance with the present invention can be designed to offer very little increase in the resistance to flow of fluid through the conductors.

What we claim as our invention is:

1. A method of making a joint between two hollow core conductors having central ducts comprising positioning end parts of said conductors in axial alignment with cut ends thereof spaced from one another and introducing metal between said cut ends to form a body of said metal that adheres to said cut ends and fills the space between them, forming at least one pair of straight ducts within said body, each duct of said pair extending from the central duct of a respective one of said conductors outwards at an acute angle to the common axis of the conductors and communicating with the other duct of the pair.

2. A method as claimed in claim 1 wherein each duct of said pair is formed after the formation of the said body by drilling inwards from the outer surface thereof.

3. A method as claimed in claim 2 wherein the ducts of said pair intersect one another within said body.

4. A method as claimed in claim 2 wherein the ducts of said pair intersect one another at the surface of said body.

5. A method as claimed in claim 2 wherein the ducts of said pair intersect one another adjacent to the surface of said body.

6. A method as claimed in claim 2 comprising the preliminary step of inserting in the ends of said hollow core conductors duct plugs each formed with a central bore which is closed at the end of the plug adjacent to the cut end of the conductor and in which each of the said ducts is drilled not only through

the said body but also through the closed end of the respective duct plugs.

7. A method as claimed in claim 2 comprising using a drill with a hollow center to form the said ducts.

8. A method as claimed in claim 1 comprising forming a recess in the surface of said body and forming said pair of straight ducts in communication with said recess.

9. A method as claimed in claim 6 in which said ducts are formed during the formation of the said body by removable cores.

10. A method as claimed in claim 7 comprising enclosing said cores in thin tubes of a metal to which the metal of said body will adhere.

11. A method as claimed in claim 1 comprising the preliminary step of inserting duct plugs in said hollow core conductors to prevent flow of oil before and during the formation of said metal body.

12. A method as claimed in claim 1 in which the said body of metal is formed by an MIG welding process.

13. A joint between two axially aligned hollow core conductors having central ducts comprising a body of metal adhering to facing cut ends of said conductors and filling a space between them and at least one pair of straight ducts within said body, each duct of said pair extending from the central duct of a respective one of said conductors outwards at an acute angle to the common axis of the conductors and communicating with one another.

14. A joint as claimed in claim 13 in which the ducts of said pair intersect one another at a place within the said metal body.

15. A joint as claimed in claim 14 in which each of said ducts is closed between the place where they intersect and the surface of the metal body.

16. A joint as claimed in claim 13 in which the ducts of said pair meet one another at the surface of said metal body.

17. A joint as claimed in claim 13 in which the ducts of said pair meet one another adjacent to the surface of the said metal body.

18. A joint as claimed in claim 13 in which each duct of said pair opens into a common recess in the surface of said body.

19. An electric cable joint comprising at least one joint as claimed in claim 13 and means insulating and enclosing same.

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