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(54) Method of electric arc welding or cladding and consumable electrode for use in such method

(57) The consumable electrode comprises a tube 55 containing a powder or granular fill 50. The ratio, by weight of the fill to the tube is greater than one-half but no more than two. The tube is non-circular and is shaped so as to be readily coiled yet has sufficient strength to be self-supporting and non-collapsible in normal use. Gas-shielded and submerged arc welding are referred to.

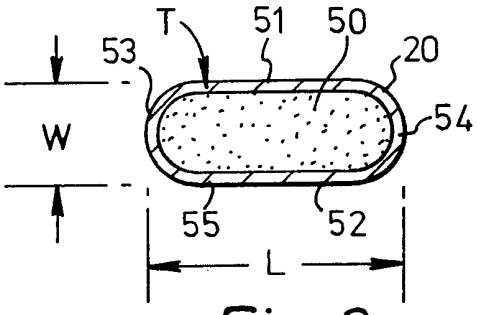

Fig. 3.

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

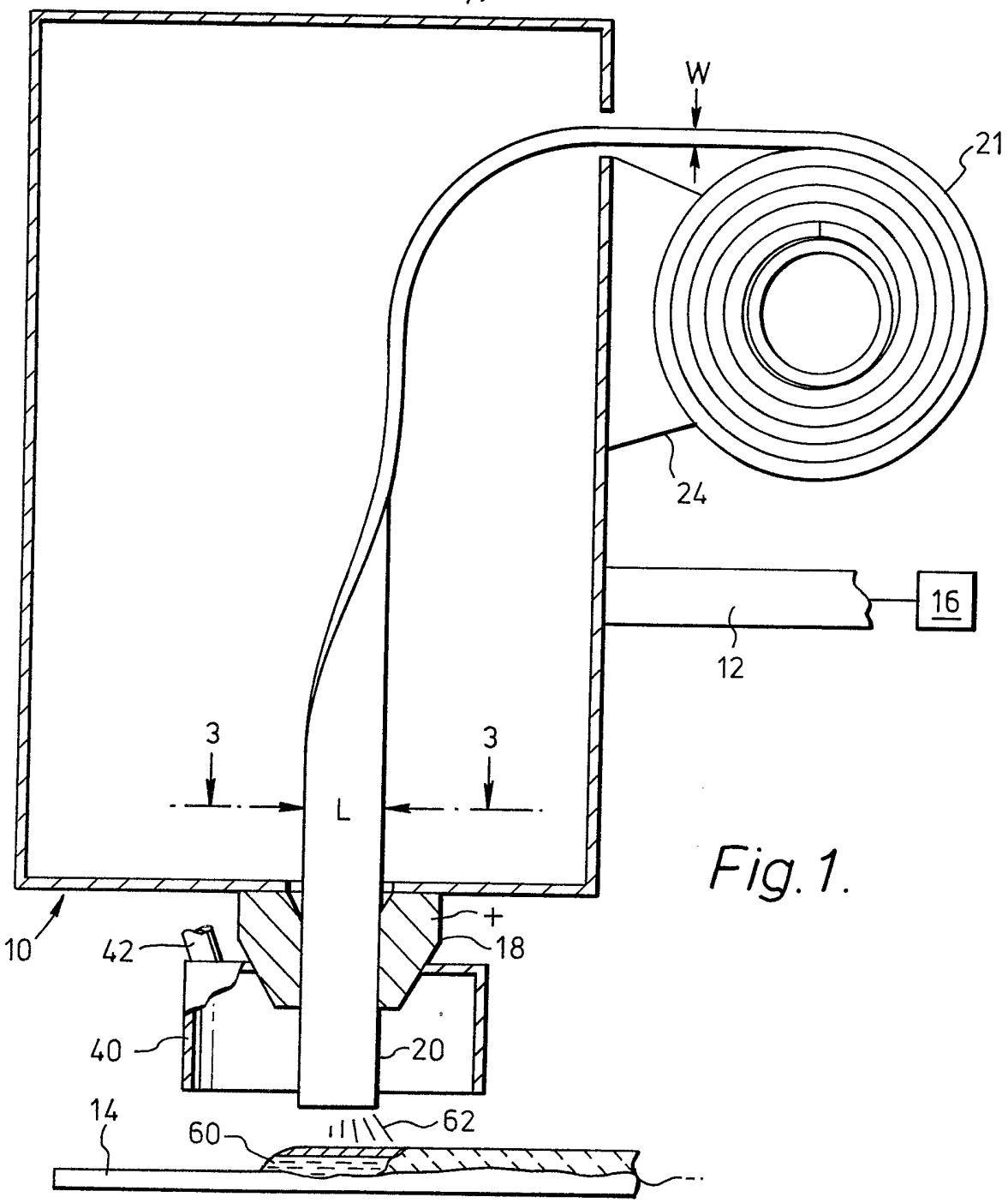

Fig. 1.

PRIOR ART

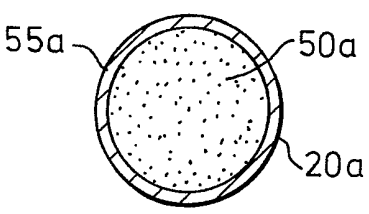

Fig. 2.

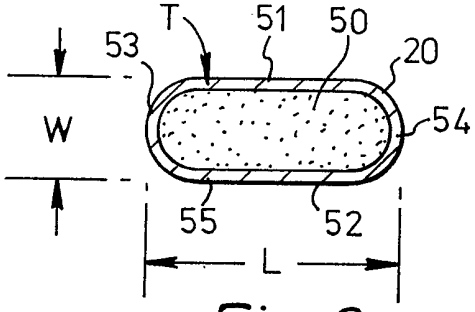

Fig. 3.

SPECIFICATION

Method of electric arc welding or cladding and consumable electrode for use in such method

This invention relates to a method of electric arc welding or cladding, and to a consumable electrode for use in said method.

In the art of welding the application of a deposition weld by an electric arc is commonly made in a number of ways. For instance, the technique of bulkwelding, by U.S. Patent No. 3,076,888 employs the combination in an electric arc of a consumable electrode and metal powder in measured amounts. The exact analysis of the combined electrode and powder is of importance in bulkwelding in determining the requisite puddle temperature and current, as well as the physical composition and qualities of the deposition weld.

The ductile tube method of arc welding is largely used for hardfacing. In this method, the welding arc is between the base metal, on the arc's lower end, and a consumable electrode comprising a metal tube containing a powder or granular metal fill, on the arc's upper end. The lower end of the consumable electrode melts and the molten mass falls and forms a puddle on the base metal which subsequently solidifies and forms a coating (i.e. cladding) on the base metal or a fusion weld at a joint. The analysis of the weld is controlled to close tolerances using automatic or semi-automatic welding equipment.

The rate of deposition of such a weld or cladding can be increased and the heat input to the base metal can be decreased by increasing the ratio, by weight, of powder or granular fill to tube in the consumable electrode. Conventional consumable electrodes for this purpose are of circular cross-section and less than one-fourth inch (6.35mm) in outer diameter. They are limited, though, to a low ratio of fill to tube because the wall thickness of the tube must be sufficiently great for the tube to maintain stiffness while being fed through automatic or semi-automatic welding equipment. The small diameter of the conventional tube, however, is required so that the tube may be conveniently coiled and bent through conventional equipment.

A higher ratio (by weight) of fill to tube has the advantages of producing a lower temperature puddle and a higher quality weld at a faster rate. Efforts to use a high ratio of fill to tube, however, using the conventional round tube have proved unsuccessfull. In particular, the required tube thickness necessary to obtain the relative amounts of fill and tube can be readily calculated knowing the density of the fill and tube. Ratios in the range of 0.5 to 2.0 are desirable. For example, to obtain a ratio of 1.5, using a steel tube with a density of 0.283 lbs./in.^{3} (3656kg/m^3) and a powder fill with a density of 0.132 lbs./in.^{3} (7838kg/m^3), a round 3/16 inch (4.76mm) diameter tube would be required to have a wall thickness of 0.011 inch. (0.28mm). Such a tube is unsatisfactory *inter alia* because its wall thickness is inadequate to maintain its shape without collapsing from the pressure of the rolls feeding the consumable electrode to the weld.

The present invention is directed to a method of electric arc welding or cladding which reduces at least some of the difficulties of the prior art methods. The invention provides for the production of welds and claddings through the use of consumable electrodes using higher ratios of powder or granular fill to tube than is permissible in conventional round tubes of the same diameter.

According to one aspect of the present invention there is provided a method of welding or cladding a surface by forming an electric arc between a consumable electrode and a surface to be welded or clad, wherein the consumable electrode comprises a tube which contains a powder or granular fill, characterized in that the tube is of non-circular cross-section and has a wall thickness 'T' such that the ratio, by weight, of the fill to the tube is greater than 0.5 but no more than 2.0.

Preferably, in cross-section, the tube has two substantially flat and substantially parallel longer sides which are joined by two substantially arcuate ends. In such an embodiment, advantageously, the distance between the outermost points of the two arcuate ends is approximately 1.5 inches (38.1mm), and the distance between the substantially flat and substantially parallel longer sides is less than o.25 inches (6.35mm).

Advantageously, the composition of the fill is different from the composition of the tube so that an alloy can be deposited by the method described.

The present invention also provides a consumable electrode which can be stored in coils and used in automatic welding or cladding apparatus, and which comprises a tube which contains a powder or granular fill, characterized in that the tube is of non-circular cross-section and has a wall of a thickness such that the ratio, by weight, of the fill to the tube is greater than 0.5 but no more than 2.0.

Preferably, in cross-section, the tube has two substantially flat and substantially parallel longer sides which are joined by two substantially arcuate ends. In such an embodiment the distance between the outermost points of the two arcuate ends is preferably approximately 1.5 inches (38.1mm), and the distance between the substantially flat and substantially parallel longer sides is preferably less than 0.25 inch (6.35 mm).

For a better understanding of the invention and to show how the same may be carried into effect reference will now be made, by way of example, to the accompanying drawings in which:-

Figure 1 is a partial, sectional side view of an apparatus using a consumable electrode in accordance with the invention;

Figure 2 is a cross-sectional view of a conventional consumable electrode; and

Figure 3 is a cross-sectional view of an embodiment of a consumable electrode in accordance with the invention.

Referring to Figure 1, reference numeral 10 generally designates a welding head which is supported by a boom 12 above a metal surface 14 which is to be welded. Attached to the boom 12 is an appropriate means 16 for moving the welding head 10 relative to the metal surface 14, either in a straight line or a

zigzag pattern, and with or without oscillation as desired.

Extending downwardly from the welding head 10 is an electrode nozzle 18 through which a consumable electrode 20 is pushed, and which serves as a means for establishing electrical contact with the consumable electrode 20. Also mounted on the welding head 10 is a supply, in the form of a coil 21, of consumable electrode 20, according to the present invention, which coil 21 is rotatably supported by coil supports 24. The consumable electrode 20 is fed from the coil 21 by rollers or other conventional means, (not shown).

Appropriately attached to the welding head 10 at the electrode nozzle 18 and surrounding the consumable electrode 20 is an optional shield 40 which maybe utilized to provide a gas shield around the consumable electrode 20 by introducing an appropriate shielding gas through gas inlet 42. The shield 40 may also be used for surrounding the consumable electrode 20 with flux to provide a submerged arc, if desired. An explation of gas shielding may be found in U.S. Patents 3,102,025 and 2,725,125. Additionally, the flux may be metered and supplied with granular materials, if desired.

Referring now to Figure 2, there is shown a conventional consumable electrode 20*a* which is round in cross-section. The conventional consumable electrode 20*a* comprises a tube 55*a* which encloses a fill 50*a* of powder or granular material. The ratio, by weight, of the fill 50*a* to the tube 55*a* is usually of the order of one-half weight of fill 50*a* to one of tube 55*a*. Also, the conventional consumable electrode, besides being round, has an outer diameter less than ¼ inch (6.35mm). For many applications it is desirable for the ratio (by weight) of fill 50*a* to tube 55*a* to be somewhat higher. However this is not practical using conventional consumable electrodes since *inter alia* the consumable electrode should be self-supporting, non-collapsible, yet coilable and of suitable dimensions for use with conventional automatic and semi-automatic equipment.

Referring to Figure 3, the cross-section of the preferred embodiment of a consumable electrode 20 according to the present invention is shown. The consumable electrode 20 comprises a tube 55 of metal which encloses a fill 50 of metal powder. The ratio, by weight, of fill 50 to the tube 55 is in the range of about one-half to about two. The preferred embodiment illustrated in Figure 3 is, in cross-section, substantially flat along its two longer substantially parallel sides 51 and 52 which are joined by two arcuate ends 53 and 54. The distance, L, between the outer most points of the arcuate ends 53 and 54, is approximately 1.5 inches (38.1mm). The distance, W, between the parallel sides 51 and 52 is less than 0.25 inch (6.35mm). The exact analysis of fill 50 and the metal forming tube 55 is first determined and then the desired ratio of fill to tube decided upon. The thickness, T, of the tube 55 is then calculated on the basis of the selected ratio using the densities of the fill 50 and the tube 55 and the precise shape of the selected embodiment of consumable electrode 20. The consumable electrode 20, in the preferred embodiment, is fed from the coil 21 at a predetermined rate. As seen in Figure 1 an electric arc 62 is formed between the metal surface 14 and the consumable electrode 20. The electric arc 62 melts the fill 50 and the tube 55 simultaneously and the molten matter falls onto the metal surface 14 forming a molten puddle 60 within the confines of the electric arc 62.

The electrode nozzle 18 shown at a positive potential and the metal surface 14 is negative, and can be supplied by conventional equipment of approximately 500 amp. capacity. Both positive and reverse polarity direct current, as well as AC, may be utilized with the present invention. In use, the welding head 10 is positioned over the metal surface 14. The means 16 is actuated to move the welding head 10 relative to the metal surface 14 and at the same time a drive mechanism, of conventional means (not shown), is engaged so that the consumable electrode 20 is fed from its coil 21 toward the metal surface 14 through the electrode nozzle 18. When the proper distance is reached, an electric arc 62 is struck between the consumable electrode 20 and the metal surface 14, which melts off the lower most portion of consumable electrode 20. The molten material falls upon the molten puddle 60 on the metal surface 14. In this manner, a bead 58 is formed as the welding head 10 is moved.

Illustrative of the use of this method, with a powder fill 50 having a density of 0.132 lbs./in.^{3} (3656kg/m^3) and a tube 55 (steel) having a density of 0.283 lbs./in.^{3}, (7838kg/m^3) to attain a ratio (by weight) of fill to tube of 1.5, consumable electrode of 1.5 inch (38.1mm) length, L, and width, W, of 3/16 inch (4.76mm) shaped in the manner of the preferred embodiment shown in Figure 3, would require a tube thickness, T, of 0.020 inch. (0.51mm) which is sufficient to ensure that the consumable electrode is self-supporting con-collapsible in normal use and coilable.

The tube 55 may comprise a metal or an alloy which can be formed into a tube. Similarly, the fill may comprise a metal or an alloy in powder or granular form. If desired the fill may also contain additives for facilitating the welding or cladding operation and/or improving the quality of the weld and/or cladding produced thereby.

For the avoidance of doubt the term 'cladding' as used herein includes such operations as hardfacing.

CLAIMS

1. A method of welding or cladding a surface by forming an electric arc between a consumable electrode and a surface to be welded or clad, wherein the consumable electrode comprises a tube which contains a powder or granular fill, characterized in that the tube is of non-circular cross-section and has a wall thickness 'T' such that the ratio, by weight, of the fill to the tube is greater than .50 but no more than 2.0.

2. A method according to Claim 1, characterized in that, in cross-section, the tube has two substantially flat and substantially parallel longer sides which are joined by two substantially arcuate ends.

3. A method according to Claim 2, characterized

in that the distance between the outermost points of the two arcuate ends is approximately 1.5 inches, (38.1mm), and the distance between the substantially flat and substantially parallel longer sides is less than 0.25 inch (6.35mm)

4. A method according to Claim 1, 2 or 3, characterized in that the composition of the fill is different from the composition of the tube so that an alloy can be deposited by the claimed method.

5. A consumable electrode which can be stored in coils and used in automatic welding or cladding apparatus, and which comprises a tube which contains powder or granular fill, characterized in that the tube is of non-circular cross-section and has a wall of a thickness such that the ratio, by weight, of the fill to the tube is greater than 0.5 but no more than 2.0.

6. A consumable electrode according to Claim 5, characterized in that, in cross-section, the tube has two substantially flat and substantially parallel longer sides which are joined by two substantially arcuate ends.

7. A consumable electrode according to Claim 6, characterized in that the distance between the outermost points of the two arcuate ends is approximately 1.5 inches (38.1mm), and the distance between the substantially flat and substantially parallel longer sides is less than 0.25 inches (6.35mm).

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