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METHOD OF FORMING HEAT RESISTANT FERROUS ALLOYS

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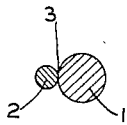


FIG. 1.

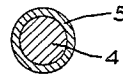


FIG. 2.

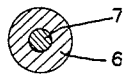


FIG. 3.

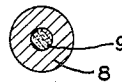


FIG. 4.

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METHOD OF FORMING HEAT RESISTANT FERROUS ALLOYS

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17 Claims. (Cl. 219-10)

This invention relates, as indicated, to methods of forming ferrous alloy heat and oxidation resistant coatings, facings and articles.

Aluminum has heretofore been added to certain ferrous alloys in appreciable amounts up to about 20% in order to improve the electrical and magnetic properties or oxidation or heat resistance of such alloys. For these purposes, the amounts of aluminum exceed the amounts usually used for deoxidation purposes. For electrical uses, the ferrous alloys usually contain in addition to aluminum and iron, nickel, cobalt or tungsten, in varying amounts. For oxidation resistance at elevated temperatures, the alloys usually contain chromium and/or cobalt, in addition to iron and aluminum. For heat resistance, the alloys usually contain chromium and/or nickel and/or silicon, in addition to iron and aluminum.

The following are examples of alloys used as electrical resistors:

|               | 1        | 2        | 3        |
|---------------|----------|----------|----------|
|               | Per cent | Per cent | Per cent |
| Chromium..... | 20       | 25       | 37.5     |
| Aluminum..... | 5        | 5        | 7.5      |
| Cobalt.....   |          | 3        |          |
| Iron.....     | Balance  | Balance  | Balance  |

The following are examples of alloys used for heat resistance purposes:

|               | 1        | 2        | 3        | 4        |
|---------------|----------|----------|----------|----------|
|               | Per cent | Per cent | Per cent | Per cent |
| Chromium..... | 12-14    | 7-15     | 18       |          |
| Aluminum..... | 4.5      | 2-6      | Up to 3  | 3-7      |
| Nickel.....   |          |          | 8        |          |
| Silicon.....  |          |          |          | 6-9      |
| Carbon.....   | 0.12     | 1.00     |          |          |
| Iron.....     | Balance  | Balance  | Balance  | Balance  |

Owing to the fact that the aluminum is usually incorporated directly into the molten alloy, as when the molten alloy is still in the ladle, it is usually difficult to fabricate or forge the alloy into finished products, since the alloys are usually brittle. For this reason, it is preferred, in most instances, to cast the alloys in substantially finished form.

While the cause for this brittleness and difficulty in forging or otherwise plastically deforming the alloy is not definitely known, it is believed to be due, to some extent at least, to the fact that the aluminum, when incorporated in the alloy in the manner described above, forms aluminum oxide inclusions at the grain boundaries, and that these inclusions so interrupt the con-

tinuity of the material as to render it brittle in varying degrees.

We have discovered that this brittleness can be eliminated or minimized to a great extent, and the alloys rendered forgeable and otherwise workable by first producing the ferrous alloys, minus the aluminum, in the form of weld wire or weld rods, and incorporating the aluminum in the fused alloys resulting from the fusion of such weld wire or weld rods, such fusion being usually incident to arc welding or gas welding. In other words, we propose to start with the ferrous alloys such as described above, but in solid form and devoid of the requisite aluminum content, and then add the aluminum, in the desired proportion, to the pool of metal resulting from the fusion of the ferrous alloy, the aluminum being preferably added to the fused ferrous alloy simultaneously with the fusion of the latter.

The aluminum may be added to the ferrous alloys in varying ways, among which the following may be mentioned.

Aluminum wire of any desired thickness may be attached to the weld wire or weld rod, so as to be fed to the arc simultaneously with said ferrous alloy wire or rod. The thickness of aluminum wire will depend upon the percentage of aluminum desired in the finished alloy. This method is particularly desirable in cases where heating equipment, such as oil stills and the like, are to be faced or coated with the aluminum-containing oxidated or heat-resistant ferrous alloy. The aluminum wire, in such case, may be

(a) Attached to the weld wire or rod by means of suitable clips or other fastening means,

(b) Attached to the weld rod or wire by means of a coating which envelopes both wires, and which may be an arc welding coating of any well-known type,

(c) Enclosed as a core in the ferrous alloy, which in that case, will be of tubular form,

(d) In tubular form, enclosing the ferrous alloy, which, in that case, constitutes a core.

The aluminum wire, in all of the above instances, may be of any desired cross-section.

The aluminum may also be incorporated as a powder inside a tube or tubing of the ferrous alloy, which is fed to the arc, but in that case, care must be observed to prevent melting of the powder at a greater rate than the ferrous tube or tubing.

Moreover, the aluminum may be incorporated in powder form, in the arc weld coating with which the weld wire or rod is usually provided.

Figs. 1, 2, 3 and 4 illustrate cross-sections of weld rods embodying our invention.

Examples of weld rods embodying some of the foregoing ideas are illustrated in the accompanying drawing, wherein

Fig. 1 is a transverse cross-sectional view of a ferrous alloy weld rod 1 having a rod or wire 2 of aluminum attached thereto at 3;

Fig. 2 is a transverse cross-sectional view of a ferrous alloy weld rod 4 having a coating 5 of aluminum on said rod;

Fig. 3 is a transverse cross-sectional view of a hollow ferrous alloy weld rod or tube 6 having a core 7 of aluminum therein, and

Fig. 4 is a transverse cross-sectional view of a hollow ferrous alloy weld rod or tube 8 having a core 9 of powdered aluminum therein.

Other methods of incorporating the aluminum in the ferrous alloy are by spraying the aluminum, either as a powder, or as molten aluminum from a spray gun, into the arc, or by pouring molten aluminum into the arc. In all cases, however, it is necessary to accurately gauge the amount of aluminum added, so as to correlate this amount with the rate at which the ferrous alloy is melted by the arc, and thereby insure that aluminum, in the desired percentage, is present in the final alloy.

As previously stated, the foregoing methods are also applicable to acetylene or gas welding.

Instead of applying the invention to the facing or coating of articles in the manner described, it may also be used in the formation of heat-resistant articles by casting in molds or dies. In such case, the arc will be formed directly over the mold or die, and the molten ferrous alloy and aluminum permitted to run into such mold or die.

Facings, coatings and articles formed in this manner exhibit excellent properties, are free or substantially free from brittleness, and are strong, forgeable and otherwise workable. Moreover, by the practice of the present invention, it is unnecessary to resort to melting in or under a vacuum.

While we are not entirely certain of the reasons for the improvements in the properties of the final deposited ferrous alloys, we believe that this may be partially attributed at least to the fact that the atmosphere about the arc in arc welding as well as about the deposited metal in gas welding is usually a protected atmosphere created by a number of different conditions with which those skilled in this art will probably be familiar, and that this atmosphere prevents the oxidation of the aluminum as it is incorporated in the ferrous alloy.

Various changes may be made in the details of the methods which have been described, without departing from the scope of the invention, as defined in the appended claims.

We claim:

1. The method of applying a coating of a heat resistant ferrous alloy containing aluminum to an article which consists in feeding a wire or rod of the ferrous alloy minus the aluminum to an electric arc formed between the wire and the article, and simultaneously feeding aluminum in regulated amounts to such arc, aluminum being fed in such amount in relation to said wire or rod as to form more than 2% of the coating.

2. The method of applying a coating of a heat resistant ferrous alloy containing aluminum to an article which consists in feeding a wire or

rod of the ferrous alloy minus the aluminum to an electric arc formed between the wire and the article, and simultaneously feeding aluminum wire or rod to said arc, aluminum being fed in such amount in relation to said wire or rod as to form more than 2% of the coating.

3. The method of applying a coating of a heat-resistant ferrous alloy containing aluminum to an article, which consists in feeding a wire or rod of the ferrous alloy minus the aluminum but having a wire or rod of aluminum attached thereto to an electric arc formed between said wires or rods and the article, the aluminum being in such amount relative to the first-named wire or rod as to form more than 2% of the analysis of the coating.

4. The method of applying a coating of a heat-resistant ferrous alloy containing aluminum to an article, which consists in feeding a hollow rod of the ferrous alloy minus the aluminum, but containing a core of aluminum to an electric arc formed between said rod and core and the article, the aluminum being in such amount relative to the rod as to form more than 2% of the analysis of the coating.

5. The method of applying a coating of a heat-resistant ferrous alloy containing aluminum to an article, which consists in feeding a rod of the ferrous alloy minus the aluminum, but having a coating of aluminum thereon to an electric arc formed between said coated rod and the article, the aluminum being in such amount relative to the rod as to form more than 2% of the analysis of the coating.

6. The method of applying a coating of a heat-resistant ferrous alloy containing aluminum to an article which consists in applying a wire or rod of the ferrous alloy minus the aluminum to the article, progressively melting said wire or rod to form a deposit on the article and simultaneously feeding aluminum in regulated amounts to the molten metal, aluminum being fed in such amount in relation to said wire or rod as to form more than 2% of the coating.

7. The method of applying a coating of a heat-resistant ferrous alloy containing aluminum to an article, which consists in feeding a rod of the ferrous alloy minus the aluminum, but having an arc welding coating thereon which contains the aluminum to an electric arc formed between said coated rod and the article, the aluminum being in such amount relative to the rod as to form more than 2% of the analysis of the coating.

8. A weld rod consisting of a rod of a heat-resistant ferrous alloy, and an aluminum rod attached to said first-named rod, the amount of aluminum in relation to the alloy being in excess of 2%.

9. A weld rod consisting of a heat-resistant ferrous alloy, and a coating of aluminum on said rod, the amount of aluminum in said coating being such that the fusion of the rod and coating will form a deposit containing more than 2% aluminum.

10. A weld rod consisting of a heat-resistant ferrous alloy, and a coating on said rod containing aluminum, the amount of aluminum in said coating being such that the fusion of the rod and coating will form a deposit containing more than 2% aluminum.

11. A hollow weld rod consisting of a heat-resistant ferrous alloy, and a core of aluminum in said weld rod, the amount of aluminum in said

core being such that fusion of the rod and core will form a deposit containing more than 2% aluminum.

12. A hollow weld rod consisting of a heat-resistant ferrous alloy, and a core of powdered aluminum in said weld rod, the amount of aluminum in said core being such that fusion of the rod and core will form a deposit containing more than 2% aluminum.

13. A weld rod comprising a rod of a ferrous alloy, and aluminum associated with said rod in an amount such that when the rod and aluminum are fused as by welding, the resultant alloy will contain aluminum in an amount in excess of 2%.

14. A weld rod comprising a rod of a ferrous alloy, and aluminum associated with said rod in an amount such that when the rod and aluminum are fused as by welding, the resultant alloy will contain aluminum in amounts from about 2% to about 7.5%.

15. A weld rod consisting of a rod of a ferrous alloy, and an aluminum rod attached to said first-named rod, the amount of aluminum in relation to the ferrous alloy being such that

fusion of the two rods will produce a heat-resistant ferrous alloy containing from about 2% to about 7.5% aluminum.

16. The method of applying a coating of a heat resistant ferrous alloy containing aluminum to an article which consists in feeding a wire or rod of a ferrous alloy to an electric arc formed between the wire and the article, and simultaneously feeding aluminum in regulated amounts to such arc, the aluminum being fed in such amount in relation to said wire or rod as to form more than 2% of the coating.

17. The method of applying a coating of a heat resistant ferrous alloy containing aluminum to an article which comprises progressively melting a wire or rod of a ferrous alloy to form a coating of such alloy upon the article, and simultaneously feeding aluminum in regulated amounts so as to form a part of said coating, the aluminum being homogeneously distributed through said coating and being fed in such amount in relation to said wire or rod as to form more than 2% of the analysis of the coating.

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