Dec. 10, 1935. F. MÜLLER 2,023,818

COATED STEEL ELECTRODE FOR ARC WELDING

Filed Jan. 5, 1935

Fig.1

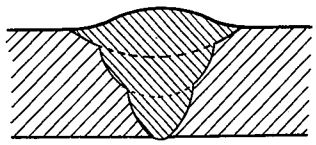


Fig.2

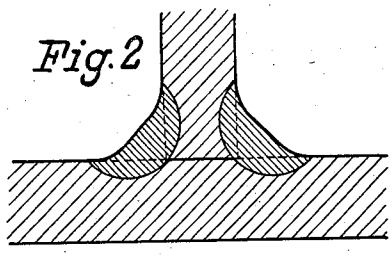


Fig.3

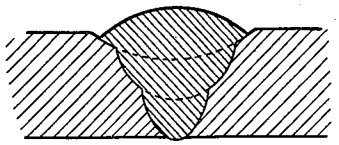


Fig.4

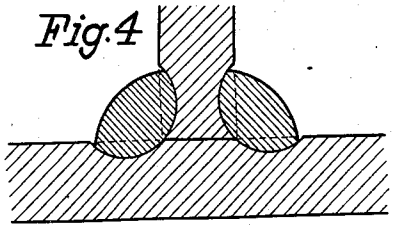


Fig.8

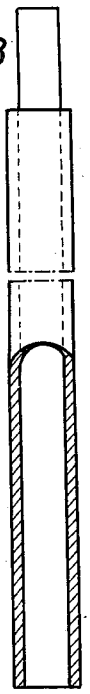


Fig.9

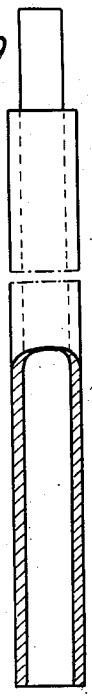


Fig.10

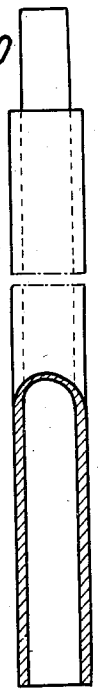


Fig.5

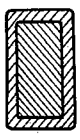


Fig.6

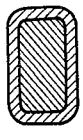


Fig.7



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COATED STEEL ELECTRODE FOR ARC WELDING

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Application January 5, 1935, Serial No. 511
In Germany August 9, 1932

6 Claims. (Cl. 219—8)

The present application forms a continuation in part of my copending application Serial No. 671,247, filed in the U. S. Patent Office on May 15, 1933, for "Coated steel electrodes for arc-welding".

If arc welding is carried out by means of electrodes made from steel wire that is not coated, oxygen and nitrogen from the air will be taken up by the molten steel which will thus be rendered brittle and red-short. It has been proposed to prevent the detrimental action of the air by coating the electrodes, but the results have not been satisfactory to a sufficient degree. It was found that the usual coatings transfer harmful ingredients to the steel such as oxygen which, for example, passes from the easily reducible oxides of the coating consisting of iron oxide out of the liquid slag into the molten steel and burns up carbon and other ingredients of the steel, such as iron, whereby strength is reduced and red-shortness as well as a considerable formation of pores in the weld are brought about. Carbon dioxide sometimes has a similar effect. Absorption of nitrogen from the air, which is the main cause of the brittleness of welds, is not prevented by the known coatings or only to an insufficient degree.

According to the invention, a coating mass is used which in the molten state forms a slag that is perfectly neutral relative to steel so as to exclude the detrimental action mentioned. The coating must be free from substances capable of passing oxygen or other impurities to the steel, such as easily reducible oxides or other ingredients which can give off carbonic acid.

However, the slag must not only prevent the transfer of oxygen but possess also the capacity of removing oxygen that is already bound from the material to be welded, i. e., it should have an effect resembling pickling. The slag must be capable of dissolving layers of oxide still adhering to the edges of the work owing to incomplete cleaning or forming anew near the arc on account of heating and of the precipitation of spurting or evaporating parts. The coalescence of the molten electrode steel and the heated work edges will be considerably facilitated and accelerated thereby so as to insure a purely metallic connection and good flowing for producing a gradual transition between the work and the seam. In order to bring about or further such conditions, it is advisable to employ slag that is sufficiently thin and capable of thoroughly wetting the steel. It will then uniformly spread over the pool without local accumulations and shut off the work from the air while insuring a smooth surface of the weld and favoring the coalescence of molten material and work under the protecting slag cover which thoroughly wets both parts.

The invention is illustrated, by way of example, in the accompanying drawing, in which Figures 1 and 2 show gradual transitions between a weld and workpieces, owing to thorough wetting; Figs. 3 and 4 show transitions having a notch effect, owing to the use of poorly wetting slag, and reducing durability; and Figs. 5, 6 and 7 show plan views and 8, 9 and 10 corresponding elevations in part section of an electrode having a steel core possessing a square or elliptical cross-section.

It is desirable that cooling of the glowing steel take place slowly, though this involves the risk that the substances kept away during welding enter subsequently. Sufficient protection is therefore needed in this process too. By a suitable selection of the coating substances it can be brought about that during solidification between the steel and the slag cover a layer of gases is formed which partly rise from the steel and partly form in the slag itself and are held by the surface of the slag, which solidifies first in the open air. These gases form an insulating layer for the glowing steel and retard the cooling thereof still more than could be done by the slag cover. Retarded cooling can, within certain limits, replace normal glowing of the weld which thus will disclose satisfactory toughness even without subsequent treatment, so that a favorable distribution of thermal stresses due to cooling takes place.

Exhaustive experiments have shown that a coating having as a basic sustance a paste consisting of the purest possible magnesium silicate and water glass in combination with deoxidizing ingredients, such as ferromanganese and silicic acid, which are either rich in carbon or mixed therewith, will form a slag which complies with the requirements stated. When this coating mass melts, oxygen entering from without or taken up by the base forms with the deoxidizing ingredients and the mass of the coating material ferrous or manganese silicates or similar compounds which will impart to the slag the capacity of melting at quite a low temperature, of being thin and of thoroughly wetting the iron. The additions must be large enough in quantity to insure the formation of low stages of oxidation and to exclude high stages, particularly the formation of the stage of oxidation of iron, so that the slag will contain protoxide only.

At a coating thickness sufficient for supplying

the requisite amount, the slag, owing to the properties mentioned above, will spread uniformly over the entire pool without local accumulations, shut off the pool from the air and prevent it from absorbing atmospheric oxygen and nitrogen. Oxygen coming from without is taken up by the deoxidizing ingredients, but only such compounds are formed which are unable to give off oxygen to the welding material. The amount of deoxidizing constituents is so regulated that even the slag contains an excess thereof, and the slag has therefore the pickling effect upon the base, because it is capable of reducing iron oxide while forming the protoxide step. The ferrous oxide thus produced will be dissolved by the slag while silicate develops. In this way the favorable physical properties of slag are produced without adding iron oxide silicates, as is necessary with respect to the known coating masses.

The fact that the deoxidizing constituents contain carbon, such as ferromanganese, or that carbon is added thereto brings it about that, during solidification, between the steel and the slag cover a gas layer is formed, since the ferrous oxide produced during the process reacts on the carbon while forming carbon monoxide. These gases represent an excellent insulating layer for the glowing steel.

Furthermore, constituents may be incorporated with the coating mass, which will enhance the quality of the melted down steel by alloying. It has also been found that the effect of the additions is particularly favorable if their concentration decreases from the inside towards the outside. In order to attain this object several coating layers may be superposed one upon the other, so that the inner layers preferably contain the additional substances.

In the manner stated not only oxygen can be kept away from the weld, but the absorption of nitrogen by the molten steel may be essentially decreased also. From a number of observations it may be deduced that the absorption of nitrogen by the steel is favored by the simultaneous presence of oxygen in the arc atmosphere and practically stopped by the reduction or complete removal of the oxygen.

It has further been found suitable to provide the electrode with a core of steel made from purest crude iron and produced in an acid open hearth furnace, the core having preferably a rectangular or elliptical cross section, as shown in Figures 5 to 7.

In coated steel electrodes of the kind described it is sometimes desirable to decrease the amount of deoxidizing constituents contained in the coating to avoid too much alloying of the ingot steel with these constituents. The deoxodizing constituents absorb the oxygen from the air during the melting process, reduce if necessary the oxides of the base and thus act as protector against the transmission of oxygen to the melting material. Owing to the relatively slow reaction between the liquid melt and the oxygen in the arc atmosphere, it is impossible to keep the surroundings of the heated places completely free from oxygen if the deoxidizing additions are present only in small amounts, and even if their quantity is so large that the reducing agents can take care of the oxygen that has passed into the fluid steel, they are unable to render the nitrogen harmless that has passed over into the steel.

In order to exclude completely the oxygen in such cases and thereby practically avoid also the absorption of nitrogen, it is advisable to employ other means for binding the oxygen. It has been found that the object aimed at may be attained by providing on the surface of the electrode coating a coat of combustible substances. Particularly suitable in this respect are substances which when heated, owing to evaporation or decomposition, will form combustible gases and vapors capable of quickly absorbing the atmospheric oxygen. Experiments have shown that it would be wrong to embed the combustible constituents inside the coating mass, since they would cause considerable porosity in the weld, and that it is best to place them in the outer coating layer and in relatively small amounts.

Uniform distribution of the electrode coating can be effected if liquids or substances dissolved in liquids serve as combustibles. One may also use a suspension of combustible substances in liquids. For example, it has been found to be particularly advantageous to employ varnishes as coating material which may be mixed with soot by stirring. This mass is then applied to the coating by immersion or brushing. If the proper consistency has been chosen a thin or somewhat thicker layer will adhere to the surface. The depth of penetration can be regulated by using a coating mass made so as to be only weakly porous. The liquid will then enter the pores, so that a certain depth effect is produced.

For such electrodes preferably a core of steel is used produced from purest crude iron in an acid open hearth furnace and thus free from impurities which will enter the steel under other manufacturing processes and which cannot be removed therefrom. Such impurities have a detrimental effect upon the quality of the weld, though they are present only in so small a quantity that the usual analysis cannot detect them.

A particularly severe test of the proper structure of the steel is the notched bar test.

The basic mass of the coating consists preferably of a paste of the purest possible magnesium silicate with water glass to which silicic acid has been added. Good, soft ingot steel in rolled condition has an impact resistance of 15 to 30 m. kg. per sq. cm. An arc weld produced by non-coated electrodes of soft carbon steel shows during the notched bar test an impact resistance of only about 1 m. kg./sq. cm. The known coated electrodes produce to a large extent welds that are just as brittle as bare wire, only a few disclosing about 5 to 10 m. kg./sq. cm. tenacity but are more or less large-pored and thus inferior.

Electrodes according to the invention produce welds having an impact resistance of approximately 20 m. kg./sq. cm., and if properly made are free from pores; moreover, their tensile strength can be made equal to that of the foundation material by suitable alloy constituents. The extensibility is so great and uniform that a bending angle of 180° is regularly attained even at the greatest thicknesses of the basic material found in practical operation. Compared with the known electrodes for arc welding, the electrode according to the invention represents a considerable advance, since in many instances it is of essential importance for the safety of highly stressed structural parts that the welds are as equivalent to the basic material as possible not only in strength but in tenacity and extensibility also.

It has been observed that in electrodes of the kind described, especially if the composition of the varnish has been properly chosen, a large

amount of gases will develop, which will prevent the admission of atmospheric constituents.

The above description is identical with the one in the parent application Serial No. 671,247.

In the following, the full description for the production of the electrodes is given:

The electrode coating comprises an inner steel core and a coating which mainly consists of the purest possible magnesium silicate and waterglass. The core may be made of a steel which has been melted from the purest charge in an acid open hearth furnace. The coating mass or material may contain deoxidizing ingredients with or without alloying ingredients. It may consist of two layers, the inner layer comprising magnesium silicate, waterglass and deoxidizing or alloying ingredients while the outer layer is composed only of magnesium silicate and waterglass. If only a homogeneous coating is used, it may comprise, for instance, 10% ferromanganese, with 50% manganese and 10% carbon content, 70% magnesium silicate and 20% waterglass.

If it is a question of two coatings, the inner coating is composed, for instance, of 10% ferromanganese, 70% magnesium silicate and 20% waterglass and the outer coating consists, for instance, of 75% magnesium silicate and 25% waterglass. The alloying of the weld may be effected with chromium, copper, molybdenum, nickel or silicon. In this case, the corresponding coating contains ferrochromium in such an amount that the entire coating contains up to 35% chromium, or copper in such an amount that the entire coating contains up to 20% copper, or molybdenum as ferromolybdenum in such an amount that the entire coating contains up to 5% molybdenum, or nickel so that the entire coating contains up to 15% nickel, or silicon as, for instance 50%, ferrosilicon so that the entire coating contains up to 10% silicon.

The above mentioned alloy constituents may be combined as desired, the percentage content of each individual metal not being higher than indicated therefor and the total of the percentage contents of all added metals not being higher than the highest percentage content which has been indicated above for one of the actually added metals.

It is in some cases advantageous to add a small amount of silicon dioxide to the coating mass. 10% silicic acid may be added.

I claim:

1. A coated electrode for electric arc-welding, comprising a steel core and a coating mass composed of technically pure magnesium silicate, waterglass and with addition of deoxidizing and alloying agents, consisting of about 70% technically pure magnesium silicate, and about 20% waterglass, about 10% deoxidizing and alloying constituents, the coating mass being free from mixture elements which are adapted to transmit impurities of the oxygen type to the iron.

2. A coated electrode according to claim 1 in which the coating mass contains addition of silicon dioxide in such an amount that the said coating contains 10% silicon dioxide.

3. A coated electrode for electric arc-welding, comprising a steel core and a coating mass composed of technically pure magnesium silicate, waterglass and with the addition of deoxidizing and alloying agents, consisting of about 70% technically pure magnesium silicate, about 20% waterglass, about 10% deoxidizing and alloying constituents with carbon, the coating mass being free from mixture elements which are adapted to transmit impurities to the iron.

4. A coated electrode for electric arc-welding, comprising a steel core and a coating mass composed of technically pure magnesium silicate, waterglass and with the addition of deoxidizing and alloying agents, consisting of about 70% technically pure magnesium silicate, about 20% waterglass, about 10% ferromanganese with 50% manganese and 10% carbon content, the coating mass being free from mixture elements which are adapted to transmit impurities to the iron.

5. A coated electrode for electric arc-welding, comprising a steel core and two superposed coatings, the inner coating being composed of technically pure magnesium silicate, waterglass with the additions of deoxidizing and alloying agents consisting of about 70% magnesium silicate, 20% waterglass and 10% ferromanganese and alloying constituents, the outer coating being composed of technically pure magnesium silicate and waterglass, consisting of 75% magnesium silicate and 25% waterglass, the coating masses being free from mixture elements which are adapted to transmit impurities to the iron.

6. A coated electrode for electric arc-welding, comprising a steel core, which has been melted from the purest charge in an acid open hearth furnace, and a coating, composed of technically pure magnesium silicate, waterglass with additions of deoxidizing and alloying agents, consisting of about 70% technically pure magnesium silicate, and about 20% waterglass, about 10% deoxidizing and alloying constituents, the coating masses being free from mixture elements which are adapted to transmit impurities of the oxygen type to the iron.

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