July 7, 1970 F. E. G. RAVAULT 3,519,781

ELECTROSLAG REMELTING AND WELDING PROCESSES

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FIG.1.

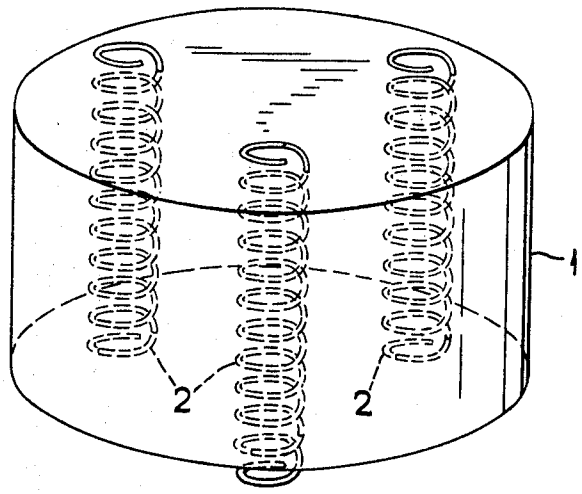
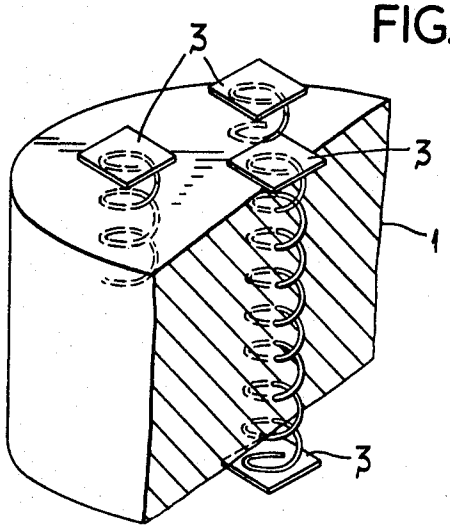


FIG.2.



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ELECTROSLAG REMELTING AND WELDING PROCESSES

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ABSTRACT OF THE DISCLOSURE

A starter tablet for use in the electroslag remelting and welding processes which is a block of a composition which comprises ingredients which react together exothermically when fired to yield a slag suitable for use in the said electroslag processes, wherein the block has within it, and projecting from it on opposite faces, metal springs which serve, inter alia, to improve electrical contact.

This invention relates to improvements in electroslag remelting and welding processes. It is of particular value in the electroslag remelting process and will be described with particular reference to that use. However it may also be applied to the closely similar electroslag welding process as herein later described.

The electroslag remelting process is a process for refining metals, particularly steel. In the process the metal to be refined is used as an electrode, the electrode is immersed at its end in a bath of molten refining slag contained in a water-cooled mould, and electrical current is caused to pass through the system. The mould usually consists of a hollow steel cylinder with a copper baseplate, and two components being separated by an insulating refractory gasket (e.g. asbestos). By reason of the electrical resistance of the system, due essentially to the slag component, heat is generated in amount sufficient to cause the tip of the electrode to melt. The molten metal falls through the molten slag layer in the form of droplets and thereby undergoes a cleansing action which reduces inter alia the sulphur and inclusion contents of the metal. The refined metal collects in the water cooled mould and is progressively solidified with a superior crystalline micro-structure to produce an ingot which possesses improved mechanical properties and is eminently suitable for subsequent rolling, drawing, forging and other working.

The slag used for the purpose may be of any composition which is suitable for the refining effect required, the principal restricting factor being that it must be electrically conductive to the correct degree so that its resistance to the electric current is responsible for producing the required heat. Usually, the composition of the slags has been based upon fluorspar, fluorspar/alumina, fluorspar/lime, fluorspar/magnesia, fluorspar/lime/alumina or fluorspar/magnesia/alumina systems with, possibly, minor additions of other substances intended to effect specific alloying or refining modifications of the metal. As the remelted metal collects in the mould and its level rises, a thin layer of the slag remains between the metal and the mould wall, conferring a very smooth surface to the ingot produced.

In terms of the type and quality of steel produced, the electroslag remelting process may be compared with the consumable arc or vacuum arc steelmaking method. It does, however, offer considerable advantages over the latter process, both economically by requiring lower capital and running costs and technically in that the ingots produced have superior surface quality, a lower sulphur content, a more uniform and finer grained structure and much improved hot-working ductility.

Nevertheless, the process suffers certain limitations which have proved difficult to overcome. The principal disadvantages arise from the difficulties in the starting procedure. It will be appreciated that it is not sufficient merely to place a quantity of powered slag in the mould, lower the electrode and expect a current to flow through it; considerable arcing occurs, possibly damaging the copper base-plate of the mould and certainly causing severe power "surging."

One technique for meeting this difficulty is to place in the mould a small quantity (e.g. an ounce or two) of a sodium or potassium nitrate/aluminum/iron oxide or nitrate/aluminum/magnesium mixture and lower the electrode on to it. Powdered slag is then poured into the space between electrode and mould wall, the electric power is switched on to trigger the reaction between the aluminum/magnesium and the nitrate and/or iron oxide. The exothermic reaction assists in melting a small quantity of the slag which then becomes conductive and the remainder is gradually melted. However, even this method needs a high starting current (much higher than the current for normal running of the process) and the electrical system has to be constructed in a way that it will withstand current surges without being damaged. As only a small quantity of slag is initially melted, it cannot rapidly attain the required running temperature whilst unmelted powder material continues to chill the slag pool. Thus, initially the slag is rather viscous and can contain lumps of unmelted material which are likely to become entrapped in any molten metal which is produced. In fact, it is quite usual to crop and discard the bottom 5% of the ingot produced because of its poor quality and high slag inclusion content.

Furthermore, the position of the electrode in the slag is usually automatically controlled so that it produces the required current density, i.e. when the resistance of the system changes the extent to which the electrode is immersed in the slag is automatically varied to compensate, so that a steady current density is maintained. With the violent current fluctuations resulting from the uneven melting of the slag, the electrode tends to move up and down in rapid oscillation in an attempt to stabilise the current density. This may result in the electrode touching the mould bottom and becoming welded thereto. In addition, it is often found that the powdered slag remains suspended above the liquid level and bridges across the annulus between electrode and mould wall. As the remelting process proceeds, the level of metal and slag rises in the mould and eventually the "bridges" are partly consumed. This causes intermittent cooling of the slag bath with consequent rises in viscosity. The usual effect is the production of an ingot with a corrugated surface, due to the formation of an uneven thickness of solidified slag on the mould walls.

In our copending application No. 634,737, the whole of the text of which is incorporated herein by reference, there is described a method by which the starting difficulties referred to above may be largely eliminated or overcome. In that application, there is described, inter alia a method for the production of refined ingots of steel or other metal or of welding two or more pieces of such metal together which comprises subjecting the steel or other metal to the electro slag remelting or welding process, characterised in that there is located in the region of the tip of the electrode of steel or other metal, before the electroslag remelting or welding process is initiated, a composition which comprises ingredients which react exothermically when fired and which burn to yield a slag which is suitable for refining the metal of the electrode.

On initiating the electroslag remelting or welding process by passing the electric current the exothermic composition is fired, generating the required molten slag. Additional slag-forming ingredients can then be added as required and will in turn melt to establish and maintain the required body of molten slag.

The firing of the ingredients may be effected by the provision of wires extending through the composition which protrude therefrom and make contact with the electrode and the base of the mould. When the current is initially switched on, these wires act as a resistance heating element. Thus, application No. 634,737 described starter tablets for use in the foregoing process which comprise a block of a composition which comprises ingredients which react exothermically when fired, characterized in that the said ingredients burn to yield a slag suitable for use in the electroslag remelting process, and the block has within it, and projecting from it on opposite faces, metal wires or rods. These wires or rods may be in the form of a comb or mesh within the body of the composition.

It has now been found that if instead of wire rods, or a wire comb or mesh, wire springs are inserted into the block with their ends protruding, certain advantages as compared with the blocks described in application No. 634,737 are effected.

According to the present invention therefore, there are provided starter tablets for use in the electroslag remelting or welding process which are blocks of a composition which comprises ingredients which react exothermically when fired to yield a slag suitable for use in the electroslag remelting process wherein the block has within it, and projecting from it on opposite faces, coil type, metal springs. The springs are generally separate from one another, but may be electrically connected together.

The coil type metal spring may be of spiral, helical or leaf type. Coiled type springs are preferred for reasons hereinafter explained.

The projecting ends of the springs enable good electrical contact to be made between the electrode and mould base through the springs since they take up any irregularities in either mould base or electrode and ensure good electrical contact. This electrical contact may be further enhanced by flattening the ends of the springs, and/or welding a metal plate thereupon.

The metal from which the springs, and plates if fitted, are made is selected having regard to the metal of the electrode. For example, in refining steel, steel springs are used, but when refining nickel alloys, springs made of e.g. Nimonic alloys may be employed.

An additional advantage of using coiled springs is that of the greater amount of wire in the body of the composition, and thereby a greater and more even generation of heat within the block during starting. Generally the springs when uncompressed will protrude 12 to 18 mm. from the face of the block. As indicated above the method of this invention may be adapted also to the electroslag welding process, e.g. as used for the welding of steel. In this process the weld metal is used as the electrode and instead of providing a mould as in the electroslag remelting process it is arranged that a cavity is formed between two opposite water-cooled shoes and two interspaced opposite metal elements which are to be welded together. The same technique of providing the molten metal from the electrode is used.

The invention is illustrated in the accompanying drawings, in which FIG. 1 shows a starter block according to the present invention, and FIG. 2 shows part of an alternative form of starter block according to the present invention.

Referring to these figures, the starter block **1** has embedded within it a number of spiral springs **2** the ends of which project from the face of the block. In the starter block partly shown in FIG. 2, each protruding spring end bears a metal plate **3**. Preferably, each starter tablet contains several springs. For use in the electroslag remelting process, cylindrical blocks 15 cm. diameter and 7.5 cm. in thickness having 5 or 6 springs embedded therein with their ends protruding from the circular faces about 12.5 mm., have been found to be very satisfactory.

Additionally, rectangular blocks of exothermic material, 90 cm. in length, 15 cm. in width, and 7.5 cm. in thickness, with 6 sets of springs (3 springs per set) embedded in the slab, have been used successfully for starting the electroslag refining process. This shape starter slab is particularly useful when large rectangular ingots are produced by the electroslag process from a multiple assembly of single electrodes.

The present invention includes not only exothermic starter tablets as described above, but their use in electroslag remelting and welding processes.

I claim as my invention:

1. A starter tablet for use in the electroslag remelting and welding processes employing an electrode, refining slag, a mold and electric current wherein said starting tablet is a block of a composition which comprises ingredients which react together exothermically when fired to yield a slag suitable for use in the said electroslag processes, wherein the block has within it, coil type metal springs which project from opposite top and bottom surfaces of the tablet, adated to make contact with the electroslag electrode and the mold base.

2. A starter tablet according to claim **1** wherein the ends of the coil type springs are flattened.

3. A starter tablet according to claim **1** wherein the ends of the coil type springs have metal plates welded thereupon.

4. A starter tablet according to claim **1** wherein the ends of the coil type springs, when unstressed, protrude 12 to 18 mm. from the face of the tablet.

5. In an electroslag remelting or welding process said process employing an electrode, refining slag, a mold and electric current, the use of a starter tablet which is a block of a composition which comprises ingredients which react together exothermically when fired to yield a slag suitable for use in the said electroslag processes, wherein the block has within it coil type metal springs which project from opposite top and bottom surfaces of the tablet, adapted to make contact with the electroslag and the mold base.

6. A starter tablet according to claim **1** wherein the coil type metal spring is a spiral type.

7. A starter tablet according to claim **1** wherein the coil type metal spring is a helical type.

8. A starter tablet according to claim **1** wherein the coil type metal spring is a leaf type.

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