UNITED STATES PATENT OFFICE.

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METHOD OF UNITING IRON OR STEEL WITH EACH OTHER AND WITH OTHER METALS.

No. 885,668. Specification of Letters Patent. Patented April 21, 1908.

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To all whom it may concern:

Be it known that we, EVAN LLEWELYN DAVIES, a subject of the King of Great Britain, mining-engineer, and WILLIAM GEORGE CLARK, also a subject of the King of Great Britain, machinist, both residing at Wessels Nek, in the Colony of Natal, have invented a certain new and useful Improved Method of Uniting Iron or Steel with Each Other and with Other Metals, of which the following is a specification.

This invention which is an improvement on the method described in the specifications to British patent No. 10763 of 1899, relates to a method of welding iron or steel with each other or with other metals such as copper or its alloys, silver or gold or their alloys, and to the composition of fluxes to be employed in connection with such processes, the object of the invention being to obtain a more complete adhesion of the metals to one another than has so far been accomplished.

The improved method will be described with reference to the coating or welding of steel sheets with a film or coating of copper of any desired thickness, but it is to be understood that it may also be applied to the coating of any kind of iron plate, tube or wire with other metals than copper or with copper or other alloys, and also to the uniting of iron or steel plates or bars with each other or with plates or bars of copper or other metal or alloy.

The iron or steel plate to be coated is heated to a temperature which should be considerably above that of the melting point of the coating metal, and when possible approximately that of the boiling point of the coating metal, such a temperature under usual conditions entailing the conversion of any iron oxids on its surface into the black oxid, and is placed in a suitable mold in a furnace in which it is maintained at about the same temperature. In this furnace, in suitably formed hearths, there are kept in the melted condition supplies of a flux, the composition of which will be hereinafter described, and of copper or other coating metal. The lining of the copper bath hearth should be of a neutral or a basic brick, while the character of the lining of the flux bath may vary and would determine to some extent the character or proportions, or both, of the flux constituents. The mold containing the iron plate is then partly filled with liquid flux, preferably covered with a layer of carbon in suitable form, such as ground charcoal, the iron oxid on the plate combining with flux and leaving a clean iron surface.

The separation of the iron oxid and its chemical combination with the flux may be facilitated by the use of scrapers or rakes passed over the surface of the iron plate and agitating the flux. The melted copper is then admitted to the mold and being heavier than the flux takes its place, so that the liquid copper becomes covered with the layer of flux thus preventing to some extent the oxidation of its surface when exposed to an oxidizing atmosphere. The melted copper is thus brought into intimate contact with a clean iron surface at a welding heat, and an intimate union of the copper and iron is obtained, this being facilitated and a homogeneous distribution effected by the use of scrapers or rakes as above described, or by other suitable means of agitating the layer of melted copper. The mold containing the coated plate upon its withdrawal from the furnace may be covered with a sheet of metal to prevent access of the air as far as possible during cooling.

Since it is practically impossible in carrying out the process in a furnace with an oxidizing atmosphere to prevent the oxidation of the copper to some extent, it is important that the copper used should be what is known as slightly over poled, or in that condition of brittleness which requires oxidation to bring it back to the tough condition. Should the heating furnace used not have an oxidizing atmosphere it may be unnecessary to use over poled copper.

When it is desired to coat both surfaces of the plate, it is practically necessary to use two furnaces, in one of which copper is kept molten in a bath having a magnesite or other basic lining, while the other furnace is used to raise the plate to the temperature of the molten copper or such a higher temperature as may be necessary to allow for the unavoidable fall of temperature in bringing the plate and the molten copper into contact. This latter furnace also contains on its hearth a bath of the particular flux used in the process in a molten condition, and the plate on being taken from the furnace is first immersed in this bath whereby its surface is cleaned and covered with a film or molten flux, and is then placed in a suitable mold of magnesite clay or ordinary foundry loam, which has been previously heated to as high

a temperature as it will stand by a gas flame or other suitable means. The molten copper is then run into the mold and, displacing the film of flux comes into intimate contact with the clean surface of the iron at a welding heat and rigidly adheres thereto.

In a modified method of carrying out the process and one which obviates the difficulty experienced by the fact that the liquid copper more or less readily permeates the lining of the copper bath hearth, more particularly if ordinary silica bricks are used for this purpose, the plate to be coated is formed with its edge which may previously have been reduced in thickness, upwardly turned, preferably through an angle of 90° at least, and liquid or solid flux is poured or sprinkled over the surface to be coated and the coating metal is added in the molten condition or in small pieces distributed over the surface, no mold being required. Sufficient flux should be added to cover completely the copper or other coating metal when melted and the copper used should be over poled if the furnace to be used has an oxidizing atmosphere. The flux and copper are melted in heating the plate as rapidly as possible to an oxidizing temperature, which may be done in any suitable furnace.

One result of the herein described process of coating steel with copper is that both the steel and the copper of the coated plate are thereby considerably hardened. The flux which is used for the above purpose usually consists of silica, carbonate of soda and borate of soda, in about equal proportions, to which is added a small quantity which may amount to 4 per cent. or thereby of the total quantity of flux, of sodium phosphate or bone ash, the phosphorus serving to increase the fluidity of the copper, and thus preventing pin holes. At the same time the proportions and even the constituents may vary, as for example by the omission of the sodium borate or the substitution for the carbonate and borate of soda of other carbonates and borates and the proportions given above are by no means the only proportions which may give good results, such variations depending upon the character of the metals to be welded and the composition of the lining of the flux bath if such is used. The silica and carbonate of soda by themselves form a fusible silicate which has the property at the working temperature of dissolving the iron oxid, and the sodium borate is added chiefly for the purpose of dissolving any copper oxid which may be formed, or in conjunction with carbon which is added to the flux elements, preferably in the form of ground charcoal, to reduce or to prevent the formation of such, thereby reducing waste of copper.

When wire or thin strip metal is to be coated this is heated to an oxidizing temperature and then drawn through a vessel having a suitable neutral or basic brick lining containing the molten copper and divided into two parts by a depending partition which, however, does not extend to the bottom of the vessel, so that the wire or strip can be drawn through the molten metal under the partition. On the entering side for the wire or strip, the surface of the copper is covered with a flux, such as described above, which is in the liquid state, while on the emerging side of the vessel, the flux covering consists usually of sodium carbonate and sodium borate with the addition of powdered carbon, but the composition of this flux may vary in accordance with the constitution of the lining of the containing vessel, the only condition to be fulfilled being that the surface of the copper bath will be protected from oxidation. On passing out of the furnace the wire or strip may be cooled by passing through a stream of water and afterwards annealed or otherwise treated as may be desired.

When tubes are to be coated these may be treated in a similar vessel the tubes being caused to enter the vessel transversely and to revolve by running down an incline. Or two or more vessels may be used, the first of which contains molten flux in which the tube is first immersed, the second bath containing the molten coating metal and being situated at a lower level at the end of an incline down which the tube rolls from the flux bath, while the third bath, if such is used, is at a still lower level and contains molten flux of a similar nature to that in the first bath. The tube continues to roll through the molten metal in the second bath in which it is partially immersed and becomes uniformly coated therewith, and from which it passes or is transferred to the third bath in which it is temporarily immersed for the removal of dirt from the metal surface.

The rolling of the tube is maintained by means of an inclined plane or otherwise after it leaves the bath until the coating metal has become solidified. When coating iron or steel with gold or silver or alloys thereof or of copper, the same fluxes are employed but the proportions may be somewhat varied to suit the temperatures required for the various coating materials, the essential condition being that the flux is in a fluid condition at the welding temperature.

If the plate or other article to be coated is rusted or pitted it is advisable before treating it as hereinbefore described to dissolve the rust by treating with suitable acid and to remove the inequalities if any by rolling or other suitable means so as to obtain a smooth surface.

When it is desired to weld iron or steel with themselves or each other as for example to weld hard tool steel on a mild steel bar, the parts to be welded are raised to the oxidizing

temperature of iron and are then plunged into a bath of flux maintained at the same temperature and containing silica and carbonate of lime in about equal proportions. The flux dissolves any oxid on the surfaces to be welded, which by immersion in the flux are brought to a white heat, thus enabling the welding to be effected on bringing the two steel bars together quickly on withdrawal in the ordinary way.

We claim:

1. The herein described method of uniting iron or steel with each other or with copper gold or silver or their alloys which consists in heating the surface of the iron or steel considerably above the melting point of the metal with which it is to be united, removing the iron oxid by a suitable flux and bringing the uniting metal heated to a corresponding temperature into intimate contact with the surface of the iron while the temperature is maintained, substantially as described.

2. The herein described method of uniting iron or steel with each other or with copper gold or silver of their alloys which consists in heating the surface of the iron or steel considerably above the melting point of the metal with which it is to be united, immersing the iron or steel surface in a suitable flux to remove the oxid, and displacing the flux from the iron or steel surface by bringing the latter into intimate contact with the metal with which it is to be united in a mold, the temperature of the mold and of the said metal having been previously raised to a temperature considerably above the melting point of said metal, substantially as described.

3. The herein described method of uniting iron or steel plates with copper, gold or silver or their alloys which consists in heating the iron or steel considerably above the melting point of the metal with which it is to be united and in removing the iron oxid by a suitable flux and bringing the metal with which it is to be united into intimate contact with the iron by adding the said flux and metal, the latter in small pieces to a mold formed by upturning the edges of the plate, while the temperature of the latter is maintained, substantially as described.

4. The herein described method of uniting iron or steel with each other or with copper, gold or silver or their alloys, which consists in heating the surface of the iron or steel approximately to the boiling point of the metal with which it is to be united, removing the iron oxid by a flux containing approximately equal quantities of silica and an alkali carbonate and a small quantity of sodium phosphate, and heating the metal with which the iron or steel is to be united to a corresponding temperature and bringing the metal into intimate contact with the surface of such iron or steel while the temperature is maintained, substantially as described.

5. The herein described method of uniting iron or steel with each other or with copper, gold or silver or their alloys, which consists in heating the surface of the iron or steel approximately to the boiling point of the metal with which it is to be united, removing the iron oxid by a flux containing approximately equal quantities of silica and sodium carbonate and a small quantity of sodium phosphate, and heating the metal with which the iron or steel is be united to a corresponding temperature and bringing the metal into intimate contact with the surface of such iron or steel while the temperature is maintained, substantially as described.

6. The herein described method of uniting iron or steel with each other or with copper, gold, or silver or their alloys, which consists in heating the surface of the iron or steel approximately to the boiling point of the metal with which it is to be united, removing the iron oxid by a flux consisting of silica, sodium carbonate, and sodium borate in about equal proportions with the addition of a small quantity of sodium phosphate, and heating the metal with which the iron or steel is to be united to a corresponding temperature and bringing the metal into intimate contact with the surface of such iron or steel while the temperature is maintained, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

E. LLEWELYN DAVIES.
W. G. CLARK.

Witnesses:
C. L. HOPKINS,
JOSEPH WILLARD.