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METHOD OF BONDING ALUMINUM TO STEEL

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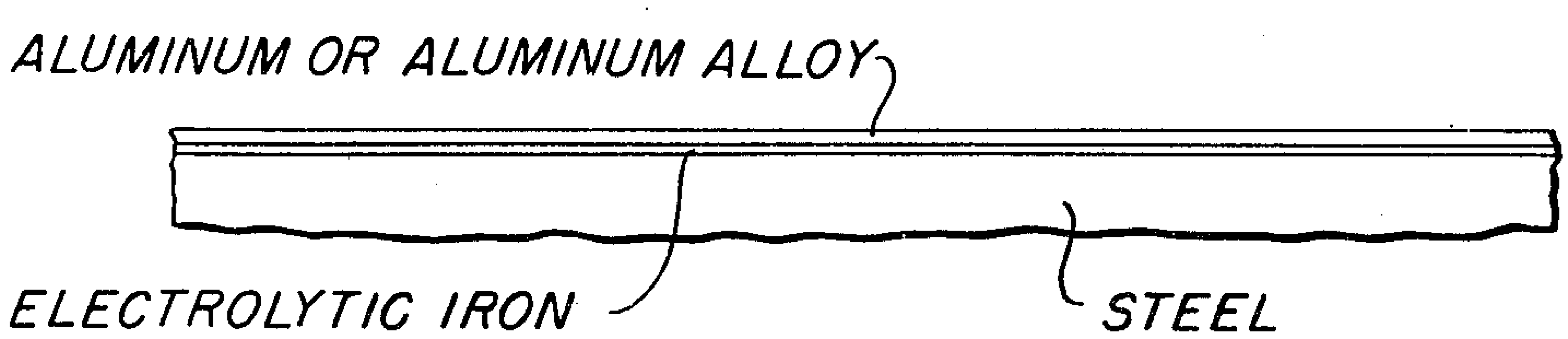

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METHOD OF BONDING ALUMINUM TO STEEL

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This invention relates to the cladding of steel with aluminum and aluminum alloys, and in the preferred method the steel is encased with aluminum sheet or foil in continuous strip.

Many methods have been proposed for cladding steel with aluminum, as by hot and cold rolling, and by dipping the steel, previously cleaned, in molten aluminum. However, there are many difficulties in such processes, particularly when hard aluminum alloys are sought as the cladding material, because the securing of a satisfactory bond between the steel and the aluminum alloy is very difficult.

My method is characterized by the provision of an interface between the two metals which consists of electrodeposited iron, carried by the steel, the deposit of the iron being sufficient to completely cover the entire surface areas of the steel which are to receive the cladding. Thus, a smooth and uniform deposit of pure electrolytic iron is employed for its bonding action, the iron being relatively soft and lending itself to the integral bonding of aluminum cladding and steel under heat and pressure.

The accompanying drawing illustrates diagrammatically the layers in the composite body.

As an example, steel strip of a desired thickness, as for example that permitting the strip to be wound into a coil, is run continuously through a series of tanks, the first containing a pickling or alkali cleaning bath, employing any of the customary solutions as practiced in the treatment of metals prior to electroplating. Thus, a pickling bath employing 10% hydrochloric acid solution may be employed. The second tank may contain washing elements for washing the steel strip, the latter passing to an electroplating tank where the pure electrolytic iron is deposited upon the steel strip.

Although there are many types of ferrous-plating solutions, with varying electrolytes and operating conditions, which may be employed, I prefer to use the method of making electrodeposited iron which is the subject of the Whitfield and Sheshunoff Patent 2,223,928 of December 3, 1940. The said method is desirable because it affords economical procedure by which films or layers of any desired thickness may be deposited upon the steel strip by relatively simple apparatus, the deposit having smooth surfaces free of pinholes. Briefly, the method is to circulate within a single tank-like cell an acid solution of ferrous salt, the solution being subjected to electrolysis between the steel strip as a cathode and a suitable anode, such as a cast iron anode plate within the tank, and from time to time increasing the ferric content of the ferrous salt solution to maintain the concentration of the solution such that it has ferric iron approximately 1% of the total iron content thereof.

In order to provide a continuous process the steel strip may be led through the tank back and forth about two vertical sets of supporting rollers, which rollers may be glass surfaced or provided with any surface not affected by the plating bath. From the plating bath the strip is led, in its continuous movement, to a washing station, followed by a drying station.

The rate of deposition of the pure electrolytic iron, the speed of the strip through the plating bath, and the length of travel of the strip in the bath are interrelated factors which determine the thickness of the electrolytic iron deposition. It is only necessary that the deposit be sufficient to entirely cover the steel strip with a smooth deposit of the electrolytic iron, and in many cases it will be sufficient to deposit a thickness of .0001'' for effective bonding of an aluminum alloy foil or sheet.

Upon the drying of the ferrous plated steel strip it will, in conditions of cold rolling, be ready to receive a web of aluminum foil, if one surface is to be clad, or two webs of such foil, if both surfaces of the steel strip are to be clad. By aluminum foil I mean more particularly foil of aluminum alloys difficult for the cladding of steel. In lieu of the foil, aluminum or aluminum alloy webs of a gauge thicker than that of foil may be employed as the cladding material. As an example, in the cold-cladding of the steel strip with its surfaces of pure electrolytic iron, the steel strip in its continuous movement from the drying zone, may be led between two spaced rolls of wound or coiled aluminum foil or sheet as the case may be, and the three, i. e. the steel strip and the two webs of aluminum foil or sheet may be brought between the contact rollers of a rolling mill, whereby through high pressure the bonding of the laminated structure is effected.

Ordinarily the bonding will be effected both under heat and pressure. To this end the strip of ferrous coated steel may, in its continuous movement, be led though a furnace and there subjected to a suitably high temperature, as for example 800°–900° F., preferably in a non-oxidizing atmosphere. Upon emerging from the furnace, the hot steel strip may be led to the hot rolls between webs of aluminum foil or sheet, for bonding under high pressure, customary with the reduction of aluminum plate into sheet. The composite structure leaving the hot roll will be reduced in thickness, and it can be further rolled to reduce thickness, coiled for further heat treatment, or cut into sheets for use or further heat treatment.

As an alternative, the steel strip leaving the ferrous plating, washing and drying stations may then receive the aluminum sheet or foil webs fed into surface contact with the electro-deposited surfaces of the steel strip and under substantial roll pressure for a light bond thereto. The composite structure in its continued movement may then be led through the furnace for heating, followed by hot rolling and treatment as before stated.

In a still applicable method the ferrous plated steel strip carrying the cladding sheets a foil, lightly bonded to the strip by roll pressure, may be loosely coiled by the usual coiling basket devices, and then transferred to the furnace for heating. Thus a stock of aluminum surfaced steel strip coils may be heated and made ready for the hot rolls.

In the use of the term aluminum herein, I include alloys which are predominantly aluminum.

It will be understood that the method is capable of wide variation in details. For example in the case of some types of aluminum alloy sheets, it may be desirable to first coat the alloy with commercially pure aluminum, so that the contacting faces in cladding the steel strip will be electrolytic iron and relatively soft aluminum, both particularly compatible with their carriers and with themselves. The method is obviously applicable to the aluminum cladding of steel plates and cut sheets in addition to strip.

The method also is applicable to the provision of a bonding film consisting of electrolytic iron directly upon sheets of foil of aluminum or aluminum alloys to be employed as cladding material. Either one or both faces of aluminum foil or sheet web may be plated with the electrolytic iron. In the first case the thus plated aluminum or aluminum alloy sheet or foil may be employed as the cladding material, that face carrying electrolytic iron being placed opposite to the steel strip or plate in the bonding operations. In the second case, where both faces of the aluminum or alloy foil or web is coated it will serve as a bonding medium to be placed intermediate the steel and

the aluminum or alloy cladding, as will be understood without further explanation.

As a still further variation a stripped web of electrolytic iron, obtained by the method of the Whitfield and Sheshunoff patent bond referred to may be used as the bonding material between the steel strip and the aluminum or aluminum alloy cladding.

Having described my invention, what I claim and desire to secure by Letters Patent, is as follows:

1. A method of continuously cladding steel strip with aluminum, which consists in feeding steel strip through an electrolytic iron plating bath and depositing relatively pure electrolytic iron thereon, continuing the movement of the strip through drying and heating zones, wherein the strip is raised to a temperature of from 800° to 900° F., and bringing aluminum in web form into face association with the steel strip followed by the step of hot rolling under reduction pressure and below the fusing temperature of aluminum.

2. The method of bonding sheet aluminum material to steel which comprises providing the steel with a surface of electro-deposited iron, placing a sheet of aluminum material against the electro-deposited iron surface of the steel, heating said assembly in a non-oxidizing atmosphere to a temperature of from 800° to 900° F., a temperature below the melting point of the sheet aluminum, and applying roller pressure to bond the sheet aluminum material to the steel.

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