

UNITED STATES PATENT OFFICE.

NORMAN B. PILLING, OF ELIZABETH, AND JOHN GEO. SCHOENER, OF BAYONNE, NEW JERSEY, ASSIGNORS TO THE INTERNATIONAL NICKEL COMPANY, INC., OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

WELDING ROD.

No Drawing.

Application filed December 5, 1927. Serial No. 237,979.

This invention relates to welding, and more particularly to the use of nickel and alloys containing nickel, such as Monel metal, in wire or rod form, where the parts to be welded form one electrode of an arc and the wire or rod which supplies the welding metal constitutes the other electrode.

The present application is in part a division and in part a continuance of our application Serial No. 63,555, filed October 19, 1925.

In casting a great many of the metals, it is found not sufficient to simply eliminate objectionable impurities, but advantageous to introduce in small amounts certain elements which have been found by experience to aid in insuring the elimination of blowholes and other unsoundness, and in securing a ductile and malleable weld metal.

In particular, nickel and alloys containing nickel are sensitive to the presence of certain elements, notably sulphur, which are detrimental to malleability, and it has long been recognized that a small content of magnesium is necessary in nickel and many nickel alloys in order to secure castings which are both malleable and free from porosity. In addition, it has been found desirable to provide for the presence of other elements, such as manganese, silicon and carbon, and to carefully hold such magnesium, manganese, silicon and carbon contents within certain prescribed limits.

One function of magnesium in nickel or a nickel alloy is to combine with the sulphur present, which as already noted, is believed to be an element which renders nickel and its alloys non-malleable, as little as 0.01 per cent of sulphur being sufficient to impair malleability. An amount of magnesium substantially equivalent to the sulphur content is required to make nickel and many of its alloys malleable. In addition to its affinity for sulphur, magnesium also has a great affinity for oxygen and nitrogen, combining with them to form stable compounds. The necessary magnesium content therefore bears a distinct relation to the sulphur content, and its allowable range of variation is not great. It is limited on the one hand by the minimum content required for sulphur, and on the other by the fact that an excessive content of magnesium is itself physically detrimental. The desirable magne-

sium content depends upon the composition of the nickel alloy involved but generally does not exceed .2 percent.

Much difficulty in the fusion welding of nickel and its alloys is, we believe, due to the adverse conditions under which fusion for welding is necessarily done, causing exposure of superheated liquid metal with a high proportion of surface area to the oxidizing attack of the atmosphere. In order to confine the fusion locally when welding, a high rate of heating is necessary, and this inevitably results in superheating the fused metal. In oxyacetylene welding the rate of heating is relatively moderate, and in addition the fused parts are protected to some extent from exposure to air by the gases of combustion. In the metallic arc, on the other hand, in which the work to be joined forms one electrode of an arc, and a filler rod, which is to supply the added metal to complete the weld, the other, the heating rate is much higher, and in addition, due to the almost complete absence of reducing elements, the fused surfaces of both the filler rod and the weld are fully exposed to the oxidizing action of the air at temperatures at which chemical action is very rapid.

When nickel or an alloy of nickel containing small but highly necessary proportions of reactive elements such as magnesium, manganese, silicon, carbon etc. is thus welded by fusion, there results a preferential diminution and loss of these elements, the most highly reactive elements disappearing first according to well-known chemical laws. The result of this is a reduction in content of any or all of these essential ingredients, or a disturbance of their mutual relations, such that the physical properties of the resulting solid metal are impaired, as by the formation of blowholes due to the liberation of dissolved gases, or embrittlement from the sulphur content. The resulting weld presents a weak and porous structure which has so little tensile strength and ductility as to limit its usefulness greatly. The behavior of malleable nickel or malleable nickel alloys in welding is thus quite distinct from that of ferrous metals generally and it is believed that the peculiar relation existing between nickel and the several elements present either as impurities or by design are determinative of this fact. As a result weld-

ing processes suitable for use with many ferrous metals fail when applied to the welding of nickel and its alloys.

We have discovered that we can largely or entirely overcome this trouble by associating with the filler rod, preferably as a coating or core therefor, a highly reducing metal of high boiling point, such as titanium, or a low-melting alloy thereof, such as a ferrotitanium. We have also found that the action is improved by the use, with the rod, of an associated metal which is of relatively low boiling point and which will form a reducing atmosphere around the arc when vaporized and tend to exclude oxygen from the region of highest temperature. Calcium is an example of such a low boiling point metal, and is preferably used in alloy form, such as calcium-silicon. Such calcium alloys are relatively stable and unattacked by atmospheric moisture and organic solvents, and may also be readily pulverized.

We consider one metal reducing as compared with another, when the first metal will displace the second from its combination with a third element or group of elements. As used herein, we define metals of high boiling point as being those which are not vaporized to any great extent from the molten weld metal at the welding temperature.

It has been found that, in general, best results are obtained when the titanium content present exceeds the calcium content. The preferred ratio is approximately three parts of titanium to one part of calcium, but this ratio is not strictly limited, as titanium contents ranging from 25% to 95% of the combined titanium plus calcium content have been found to be operable.

In practice we prefer to mix a pulverized titanium alloy and a pulverized calcium alloy and apply the same to the welding rod in paste or paint form. The commercial titanium alloys containing 10% to 30% titanium are found to be quite suitable for the purposes of this invention. We prefer the low carbon ferrotitanium as it can readily be reduced to powdered form. Calcium metal or the commercial calcium alloys containing 15% to 35% calcium, all of which are readily obtainable, have been found to be suited for the purposes of this invention.

As an example of preparing a Monel metal welding rod, we make use of low carbon ferrotitanium with a titanium content of about 25% and calcium-silicon containing about 25% calcium. Both of these alloys are brittle and can readily be ground to fine powder. After reducing both, separately, to 80-mesh powder, they are mixed to give a ratio of titanium to calcium of about 3 to 1. The mixed, dry powder is then incorporated into sufficient liquid binding material to enable it to be applied as a coating to the metallic rod, as by dipping or brushing. For this

purpose liquid shellac has given satisfactory results, although it will be obvious that the ground metals may be incorporated in plastic materials without departing from the scope of the present invention.

One good electrode coating contained the following elements, based on the composition of titanium and calcium alloys of currently available grades:

	Per cent by weight.	
Titanium -----	19	75
Calcium -----	6	
Aluminum -----	5	
Silicon -----	17	
Iron -----	53	80

The ingredients other than the titanium and calcium are believed to be relatively unimportant in the welding processes under consideration as long as care is taken to allow no known injurious element to be introduced. The coating may be added to the electrode in any desired proportion, the amount being dependent upon the size of the electrode. Preferably the titanium content aggregates from 0.1 to 10% and the calcium from 0.1 to 8% of the weight of the electrode, respectively. In general, electrodes of small diameter require a proportionately greater quantity than electrodes of considerable thickness, and it has been found that the sum total of the titanium and calcium in the coating should usually be greater than 0.1% of the weight of the electrode. Excessively heavy coatings are not detrimental, as the excess may be consumed by oxidation or it may pass into the weld. In the latter event, certain advantages are noted when titanium does pass into the weld, but this invention is not dependent upon the transfer of titanium values from the filler rod or its coating to the weld. It may be noted that as much as 5% titanium content may be present in nickel or nickel alloys without being physically detrimental.

The use of the coatings above described permits the fusion welding together of separate parts of malleable nickel or malleable nickel alloys such as Monel metal, without the loss of substantial amounts of the malleableizing element or elements. As a result, the finished weld, throughout its entire body, possesses excellent physical properties and the resulting fabricated article may be subjected to forging, hammering, drawing or bending, without endangering the integrity of the structure. The ductility of such a weld being thus assured, it follows that the finished product possesses substantially the same capacity throughout for being mechanically worked as characterized the initially malleable parts and the filler rod or wire.

While we have discussed the present invention with particular reference to the

conservation of magnesium and other desirable elements in malleable nickel and malleable nickel alloys, similar beneficial results have been secured in preserving the improved physical characteristics of nickel and nickel alloys which have been malleableized by the association therewith of other alkaline earth metals, notably, metallic calcium. The use of alkaline earth metals, such as calcium, for malleableizing nickel and its alloys has been disclosed by one of us in a copending application of Norman B. Pilling Serial No. 223,233, filed September 30, 1927, and entitled "Alloys and processes for improving workability of same."

While a theory of the invention explaining the action of titanium and calcium has been given, it is not considered that the value of this invention is dependent on its correctness, since considerable practical use has proven its usefulness and success.

It is to be understood that various changes may be made without departing from the spirit of the invention or the scope of the appended claims.

We claim:

1. A welding electrode comprising a metallic nickelous matrix malleableized by an alkaline-earth metal, and an associated coating including a titanium alloy and a calcium alloy, titanium aggregating from 0.1 to 10%, and calcium from 0.1 to 8% of the weight of the electrode, respectively.

2. A welding electrode comprising a metallic nickelous matrix malleableized by magnesium, and an associated coating including a titanium alloy and a calcium alloy,

titanium aggregating from 0.1 to 10%, and calcium from 0.1 to 8% of the weight of the electrode respectively.

3. A welding electrode comprising a metallic nickelous matrix malleableized by calcium, and an associated coating including a titanium alloy and a calcium alloy, titanium aggregating from 0.1 to 10%, and calcium from 0.1 to 8% of the weight of the electrode respectively.

4. A welding electrode comprising a malleable nickel or nickel alloy containing nickel, carbon, manganese and magnesium having associated therewith a coating comprising a titanium alloy and a calcium alloy having the titanium aggregating from 0.01 to 10 percent and calcium from 0.1 to 8 percent of the weight of the electrode respectively, by weight of the coating, the titanium alloy and the calcium alloy being maintained in cooperative relationship to each other and to the electrode by a shellac binder.

5. A coating composition for an electrode adapted for use in welding metallic nickelous substances, comprising a brittle alloy of calcium, and a brittle alloy of titanium intimately mixed and incorporated in a binder titanium aggregating 2 to 30 percent and calcium 0.5 to 25 percent by weight of the coating, the titanium content being from 25 to 95 per cent of the combined titanium and calcium contents.

In testimony whereof we have hereunto set our hands.

NORMAN B. PILLING.
J. GEO. SCHOENER.