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PRODUCTION OF WROUGHT IRON DIRECT FROM ELECTROLYTIC IRON

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Fig. 1.

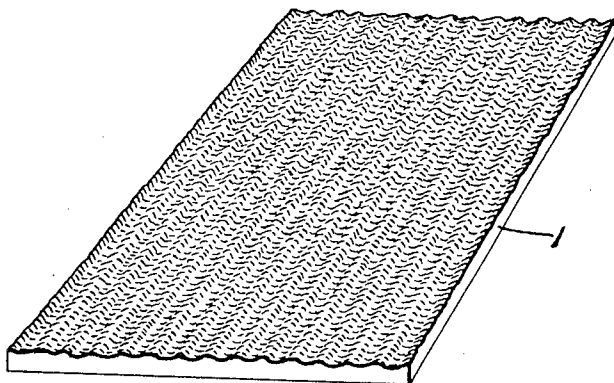


Fig. 2.

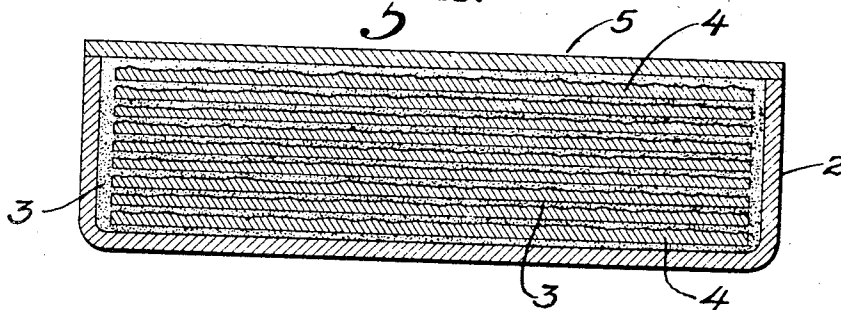
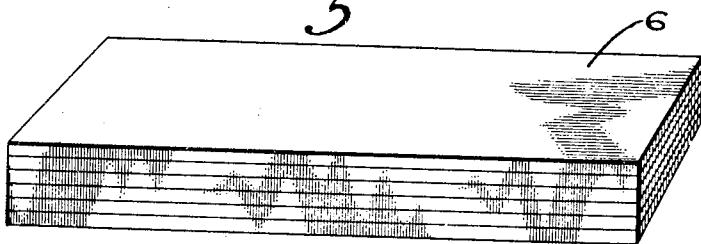


Fig. 3.



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PRODUCTION OF WROUGHT IRON DIRECT FROM ELECTROLYTIC IRON.

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This invention relates to the production of wrought iron direct from electrolytic iron. In a co-pending application filed by myself and George H. West jointly, of even date herewith, there is disclosed a process for the making of pure iron from broken or powdered electrolytic iron cathodes.

My present invention has for its object to make wrought iron articles of a special high grade direct from electrolytic iron cathode sheets without breaking the same into smaller particles. By eliminating the breaking-up step, I reduce handling costs, and also reduce the danger of contamination by oxygen and other gases, because such gases are given a greater chance for action the greater the surface exposed. My present invention also possesses other unique advantages, notably the production of wrought iron sheets, plates, or other objects made up of substantially continuous laminæ of pure iron and slag. The advantage of slag laminæ is well recognized in wrought iron because these reduce the conduction of electric currents which cause electrolytic corrosion; but in wrought iron as produced by present processes, such slag laminæ are broken and irregular, whereas in the wrought iron produced by my present process the laminæ are substantially continuous and regular. Furthermore, the relative thickness of the iron and slag laminæ may be changed at will and the slag laminæ may be substantially eliminated if desired.

A further object of my invention is to eliminate the intercrystalline cracks which are characteristic of electrolytic iron cathode sheets and to build up large iron objects, as for example, billets, bars, pipe, skelp, etc., by welding and working the original cathode sheets with suitable fluxes or deoxidizing additions, or both; and in carrying out this object I may start with one or several cathode sheets.

I am aware of the fact that it was heretofore been proposed to produce iron sheets by rolling electrolytic iron plates after they have been stripped from the cathode starting sheet, but I have found that iron produced in this way will seldom be sound, because it will usually contain intercrystalline cracks which are coated with oxide or other compound which prevents the iron from becoming welded. I am not aware of any prior method capable of producing sound, merchantable iron by welding together separate

electrolytic iron cathode sheets. The finished articles have been made up by reducing in dimensions the single cathode sheets as deposited.

In the accompanying drawing I have shown by way of illustration the different stages of the present process and product.

Fig. 1 shows an electrolytic iron cathode sheet in perspective.

Fig. 2 shows a transverse cross-section of a bundle of sheets assembled in an annealing box.

Fig. 3 represents a rolled sheet with exaggerated representation of laminæ.

The electrolytic iron cathode sheets 1, Fig. 1, when stripped from the cathode are about $\frac{1}{8}$ "- $\frac{1}{4}$ " thick but may be as thick as 1". The side which adhered to the cathode is smooth but the side on which the deposit was made is rough. Sheets may be of any desired size, but 24" wide by 30" long is a convenient size. The sheets when stripped are brittle, and should be handled with care.

2 is an annealing box of nichrome or similar material which has inside dimensions about $\frac{1}{2}$ " larger all around than the cathode sheets, and is about six inches deep. One of the cathode sheets is carefully placed on the bottom of the box smooth side down. The surface of this sheet is then dusted with a fairly pure form of powdered iron ore so as to substantially fill the depressions on the surface and make a fairly smooth bedding for the next sheet. Mill scale can be mixed with the iron ore so as to bring up the iron oxide content. A considerable variation in the quantity and quality of the iron ore is permissible, depending on the results desired, and it may be omitted entirely or some prepared form of slag materials may be used to replace it in whole or in part. In producing laminated wrought iron the end sought is to produce slag laminæ which will have substantially the same chemical properties as those slags occurring in the best grades of wrought iron.

The slag laminæ must not be so thick as to cause an actual separation of the sheets, but reliance is placed for a sufficient metal-to-metal contact to result in a homogeneous product upon the numerous ridges and mounds which occur on the rough side of the sheet, and which will come into welding contact with the smooth face of the sheet above when the whole is passed through the rolls in a subsequent step of the process;

and upon the pure iron which is reduced from the iron oxide, as described later, and which tends to cement the sheets together.

I can also mix with the powdered material such substances as powdered manganese, silicon, etc., or any other pulverized metal which may be depended upon to assist in de-oxidation of the iron, in which event the oxides formed will become part of the slag

laminæ.

When the sheets have been placed in the annealing box as described, the marginal spaces are filled with iron oxide and the cover is put on the box. The transverse section then appears as Fig. 2, in which 3 is the powdered material 4 is the cathode sheet, 5 is the cover of the annealing box.

The annealing box is then put in a furnace having a reducing atmosphere and the temperature raised as quickly as possible to about 1832° F. and held at this temperature for about one hour. At this temperature the hydrogen which is driven off from the cathode sheets causes a reduction of the iron oxide between the plates, leaving a pure carbon-free iron mixed with the slagging and other added ingredients. The same reduction may also be assisted by the reducing atmosphere in the furnace, which penetrates into the boxes to some extent, or by the addition of metallic deoxidizers, or hydrogen or illuminating gas introduced into the boxes.

The furnace is now cooled while maintaining a reducing or substantially neutral atmosphere, and the bundles of sheets are carefully removed from the annealing boxes. The bundles may now be sheared longitudinally to form more convenient sized billets.

The next step is to heat the billets to a welding heat in a furnace which preferably has a neutral or reducing atmosphere. In the case of pure iron such welding heat is between 2650° F. and 2700° F. While at this temperature throughout their mass, the billets are removed from the furnace and quickly passed through rolls, which completes the welding process.

The preferable method is to continue the reduction of the billets in a direction perpendicular to the laminæ, so that eventually a sheet or pipe skelp is produced, similar to 6, which is formed of a series of substantially regular laminæ of iron and slag.

My process permits of forming such sheets or pipe skelps of practically chemically pure iron—more pure than is possible by any known process—and as the iron exists in laminæ it will be readily seen that the product possesses a unique degree of resistance to corrosion, making it highly suitable for manufacture of pipe and sheets. In addition, my process permits of creating in the iron laminæ a wide range of alloys of differ-

ent chemical and mechanical properties, by diffusion into the iron during the heating and welding, of the desired alloying ingredient.

I have also found that in a certain modification of my process it is possible to do away with the annealing step, and to combine both heating steps into one. This is done by adding sufficient deoxidizer, such as powdered silicon, or ferro-silicon, powdered ferro-manganese, or powdered aluminum, to the oxide of iron which is placed between the electrolytic iron sheets, together with a slight excess of the deoxidizing metal to take care of any superficial oxide of iron which may occur on the surface of the sheets. This mixture of iron oxide and powdered metallic deoxidizer is placed between the electrolytic iron sheets as described above, several sheets being piled one on top of the other, and the whole being then secured in a bundle by any suitable means, as for example by binding with wire. This bundle is then placed in a furnace, preferably having a neutral or reducing atmosphere and heated as rapidly as possible to welding heat, or to high enough heat as to cause reaction between the iron oxide and the deoxidizing metal employed. This reaction will in itself generate considerable heat, particularly if the reducing agent be composed in whole or in part of powdered aluminum, and this heat supplementing the heat of the furnace will cause an effective welding of the sheets. The deoxidizer which is employed combines with the oxygen, forming a slag material. In some cases it may be deemed desirable to have the oxide mixture with the deoxidizer contain an excess of iron oxide, so that the slag material which is formed may form compounds with iron oxide, forming as for example ferrous silicates. This variation of the process has the advantage of doing away with the annealing step, and of cementing the sheets of electrolytic iron together with a pure oxygen-free iron combined with a certain amount of slag.

If desired the material which is placed between the sheets may be sand or similar slag-forming materials which are ordinarily used as fluxes in the welding of iron. Sand will form ferrous silicate with the iron oxides which are present at the high temperature of the process and these silicate substances will aid in the welding of the sheets. My invention contemplates the working of the sheets at or near welding heat by suitable mechanical means until a sound metal is produced. If the slag-forming or fluxing material, as for example sand with or without a little borax and without metallic deoxidizers, is employed to assist the welding of the iron by virtue of the formation of a fluid ferrous silicate slag which absorbs the iron oxide from the sur-

face of the cracks and the surface of the metal and thus permits these cracks to be welded into a sound metal, the addition of iron oxide between the sheets may be omitted. The object of the process in any of its modifications is to remove iron oxide as such from all surfaces within the mass, so that these surfaces may become welded together. This is accomplished either by forming a slag with the iron oxide or by reducing it to the metal by means of gaseous or metallic reducing agents. If the latter are employed slags are necessarily formed in situ which also combine with iron oxide.

For example, if silicon be employed, silica is formed; and this can combine with any more iron oxide present to form ferrous silicates which constitute a fluid slag at the temperatures employed. The working of the mass by rolling or hammering at or near welding heat is then depended upon to work the fluid slags which are formed into all cracks, thus permitting these to become welded.

My process is susceptible to many changes in detail without departing from the spirit of my invention, which I believe is fundamentally new in the art of making ferrous metals.

What I claim and desire to secure by Letters Patent is:

1. As an article of manufacture, wrought iron consisting of substantial laminations of electrolytic iron in cathode sheets, with intermediate laminae of slag.

2. The process of manufacture of wrought

iron from electrolytic iron, which consists in stacking sheets of the latter, and heating said stack to welding heat, and welding.

3. The process of manufacture of wrought iron from electrolytic iron, which consists in annealing stacks of electrolytic iron sheets in an inclosed space so that oxides of iron associated with the sheets will be reduced to metallic iron by the liberated hydrogen, then heating the stack to welding heat, and welding.

4. The process of manufacture of wrought iron from electrolytic iron, which consists in stacking sheets of the same and bedding between each sheet an oxide iron, then annealing the stack in an inclosed space so that the oxides of iron in the stack will be reduced by the liberated hydrogen, then heating the stack to welding heat, and welding.

5. The process of manufacture of wrought iron from electrolytic iron which consists in stacking sheets of the latter, bedding a slag forming material between each sheet, heating said stack to welding heat, and welding.

6. The process of manufacture of wrought iron from electrolytic iron which consists in stacking sheets of the latter, bedding a slag-forming material between each sheet which will form a fluid slag with the iron oxide present, heating said stack to welding heat and welding by application of mechanical pressure.

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