(No Model.)

J. B. NAU.

METHOD OF MAKING METAL PLATES.

No. 490,451. Patented Jan. 24, 1893.

Fig. 2.

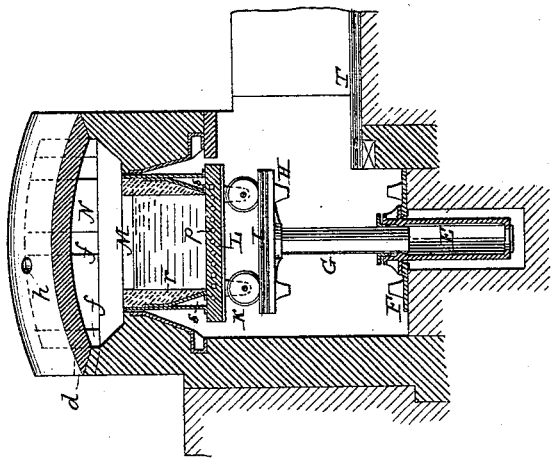


Fig. 1.

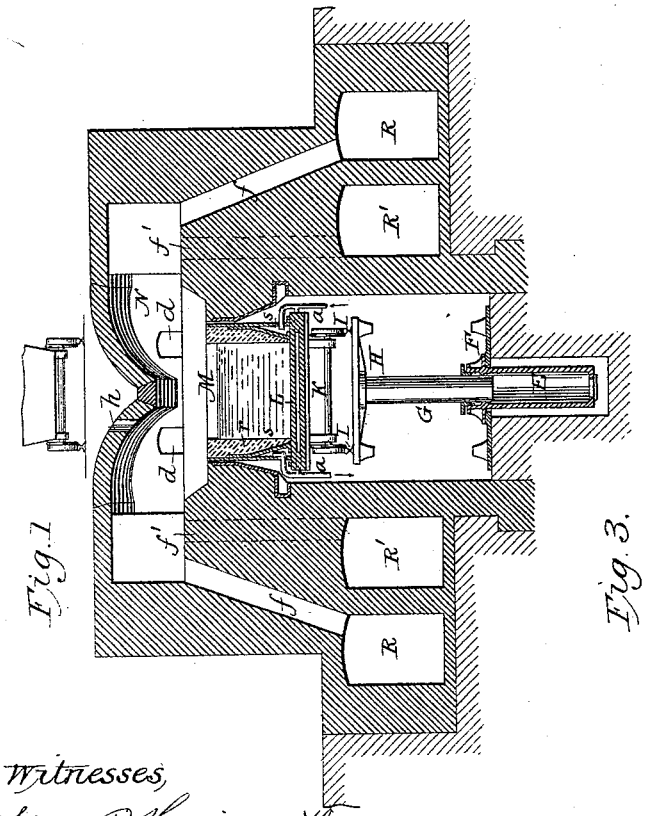
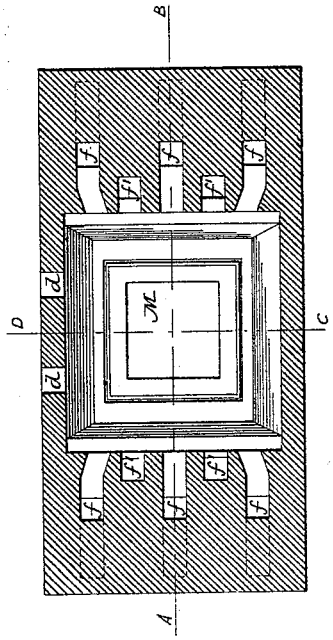


Fig. 3.



Witnesses,
Sidney P. Hollingsworth
Baltus D. Long.

Inventor,
John B. Nau
by his attorneys,
Baldwin, Davidson & Wright

UNITED STATES PATENT OFFICE.

JOHN B. NAU, OF NEW YORK, N. Y.

METHOD OF MAKING METAL PLATES.

SPECIFICATION forming part of Letters Patent No. 490,451, dated January 24, 1893.

Application filed January 11, 1892. Serial No. 417,765. (No specimens.)

To all whom it may concern:

Be it known that I, JOHN B. NAU, a citizen of the United States, residing in New York city, county and State of New York, have invented certain new and useful Improvements in Methods of Making Metal Plates, of which the following is a specification.

This invention has for its special purpose the manufacture of certain classes of metal plates, blocks or ingots, of whatever shape desired, that require different composition and different physical characteristics in different parts, as is the case with steel armor plate for instance.

In carrying out my invention, I introduce into the metal while molten in a suitable mold such element or elements, as for instance, manganese, silicon, carbon, titanium, chromium, tungsten, &c., or any other element or elements that it may be desired to introduce in some special side or part of the metal and not in other parts. If, however, the entire mass of metal be liquid when these additions are made, some of the elements added would descend into lower regions or planes of the mass where they are not intended to be incorporated. To avoid this I propose that such lower regions shall be brought to a semi-solid, pasty, or solid condition, while the surface and upper portion of the mass is more liquid; that is to say, the bottom or distant surface may be solid and the adjacent metal semi-solid or pasty in different degrees and as the upper surface is approached the metal is liquid: or the bottom may be more or less pasty and the mass gradually more liquid as the top is approached: or the top may be semi-liquid and the mass become more solid as the bottom is approached. To obtain these results means for cooling some parts of the metallic mass may be provided. By these means it will be possible to keep one part of the mold containing the metal at a lower temperature than other parts, by having it exposed to the air, or a forced current of air, or to water, steam, or any other cooling medium in order to cool the metal or solidify it in that particular part or zone; whereas other regions or zones may be kept liquid longer in order to obtain the desired effect above suggested. Thus, for instance, by cooling the bottom, and, if desired, other lower parts of the molds by air or any other cooling medium, this region of the metal will be solidified, whereas the zone immediately above and in contact with the solidified portion will be pasty and the upper or top zone will be liquid. In this state it will be possible to increase the percentage of carbon or manganese or titanium or tungsten or silicon or chromium or any other element or elements that it is desired to have in larger proportions in the liquid regions by making the ordinary addition of for instance, spiegel, ferromanganese, ferro-silicon, ferro-phosphorus, ferro-titanium, or ferro-chromium, or any other substance or substances that when introduced either in liquid or solid or gaseous form will incorporate the desired element into the liquid portion of the mass. Of course by so doing the upper portion of the metal which has been kept in the most liquid state will absorb most of the elements introduced, whereas that portion of the metal that is partly liquid or more or less pasty, lying between the liquid and solidified metal, will receive less of that element, or elements, and the solidified region will receive none of it. By this mode of operation, a gradual decrease of the percentage of the substance or substances that are introduced will be obtained from the most liquid to the solid regions. This gradual or uniform decrease of this element or elements will give a final piece, plate or ingot, the character of which will not be impaired by a sudden change in its composition in any zone or plane. The addition of these elements to a partly liquid, partly pasty, and partly solidified metal may be made to any previous compositions, such as ordinary Bessemer steel, or open hearth steel, or crucible steel, or liquid soft iron, or to metal obtained by any method and of any previous composition or nature.

It must be distinctly understood that I do not claim as my invention the mere addition of any recarburizing element or any other substance to a mass of metal liquid or solid in order to incorporate some outside elements into the metal and to give the product to be obtained certain homogeneous qualities, as I am well aware that such additions have been, and are daily made.

My invention on the contrary comprehends

a process, whose principal object is to obtain a product that is heterogeneous in its composition and physical characteristics, by the incorporation of other substances into certain defined zones of a metallic mass, which substances by their varying percentages in the different zones or parts of the metallic mass will impart to the metal different physical characteristics due to the different compositions in the different zones, these results being obtained by causing through any suitable means, the metallic mass to solidify or become pasty in some regions, whereas still other regions are kept liquid while desired substances are incorporated into or added to the mass. The liquid or pasty surface of the metal may if desirable or necessary be covered by suitable materials, to prevent undesirable action due to the contact therewith of the heating flame or products of combustion.

I wish it to be distinctly understood that I do not limit myself as to the time at which I intend to make this addition to the metal. They can be made at any moment after the metal has been cast with its already ordinary addition, if such there be, and before that part of the metallic mass that is intended to receive the further addition, has been left to solidify or become paste only. It can be made to metal which after having been cast and even cooled down, is made by the application of any means to be liquefied again to any depth in that region where the addition is intended to be made or even is made to be liquid again, entirely by the use of any known means, and then made pasty or solidified again in one part, whereas that portion of metal where the addition is to be made will be kept liquid or pasty through whatever means may be deemed best suitable to obtain and maintain this pasty and liquid state. I also wish to state that the mold employed may be of any shape and form, and that the addition or additions to the metal therein may be made after having removed the upper part of the ingot, should it be found that this part presents a hollow space or is generally unsound, as is often the case. After the removal of such a part, the remainder would receive the addition as has been described above.

To keep the upper part of the metal liquid, or even the whole mass, or even to liquefy already solidified metal I do not limit myself as to the means to be used, these means being only an accessory to the process and only employed to obtain the desired results.

The whole mass of metal can be kept liquid for a certain length of time, or only a portion thereof, whereas the remainder can be left to solidify, or a once solidified and already cooled down mass may be liquefied again entirely or partly by the application of any heat creating means, such as solid, liquid or gaseous fuel, or electricity, either separately or collectively, or also one or more of these means combined together. I also wish to state that should it be considered desirable that the ingot or plate or metal block should contain certain elements and have certain characteristics, on one side or end and other elements and other or different characteristics at the other end or side, for instance should it be desired to have tungsten or any other element or elements or compounds at one end or side and manganese or titanium or any other element or elements or compound at the other end or side, then the tungsten or any other element would be incorporated into the particular side or end, while that side or end is still liquid or pasty or when already solid, has been again made pasty or liquid through the application of any heat-giving appliance. After the incorporation of the desired element on this particular side, the manganese or titanium or any other element will be introduced into the other end or side of the plate which has been rendered pasty or liquid for that purpose after the first end or side has been solidified in its turn.

The furnace that I prefer to use to keep the upper part of the ingot liquid while the lower part is being solidified, is a furnace similar to the one accompanying these specifications.

In the drawings, Figure 1 represents a longitudinal vertical section on line A; Fig. 2 a vertical cross section on line C D; Fig. 3 a plan.

In the three figures similar letters represent similar parts.

E is a hydraulic cylinder located in the center of the foundation and supported by a cast iron plate F, bolted to the foundation.

G is a hydraulic piston supporting a horizontal plateau H to which are fastened two rails I. On these rails is run a car K mounted on four wheels. On the platform of the car rests the bottom L of the mold. This bottom is made of cast iron and inside of it is located a coil of iron pipes to receive water for cooling purposes. The top of the bottom of the mold may be lined with refractory material if judged necessary. On this bottom rests the mold M. This mold may be made of cast iron or wrought iron sheets bolted or riveted together. In the drawings the envelope is supposed to be made of wrought iron sheets. It presents at the lower end a double wall with a clear space between. This clear space is larger at the bottom and decreases to nothing at its upper end. On the drawings it is supposed to run to about the middle of the height of the mold. This space may be run however clear to the top of the mold between a double envelope. The purpose of the space is to cool the lower part of the ingot by a circulation of water or other medium in the space around the mold. The water may be introduced into the space by means of a pipe located at any point and run off in a similar manner. The coil in the bottom plate also receives its water through an inlet *a* and after having circulated through the coil, the water

is run off through another aperture. As this entire construction has to be raised at will, the aperture *a* as well as the other apertures are connected with any water conduit by means of rubber pipes or flexible or telescoping metallic pipes. The mold has an inside refractory lining *r*, thick at the top and reduced to almost nothing at the bottom. The thick part of the top will keep the heat a long time and consequently keep the metal in the mold liquid or semi-liquid at the top, while the lower thinner part of the refractory lining, allows the ingot to be cooled and solidified in this region. The whole is placed in a reveberatory furnace N of the ordinary type or any other type. The Siemens type is shown here.

R and R′ are the heat regenerators. R for gas, and R′ for air. The flues *f* and *f′* carry the heated gas and air to the furnace on one side and lead it off on the other side.

d d are two doors on one side of the furnace and may be placed on both sides.

h is a hole placed in the roof of the furnace, through which the liquid metal is cast into the mold M. Other holes may be placed in the roof above the mold, in order to measure, by plunging iron bars in the bath, how high the metal has been solidified.

T is a railroad track on which the truck runs, permitting the mold to be run into the furnace or taken away. When an operation is to be made, the piston G is down in the cylinder E, the car carrying the mold is pushed over the track T, on top of the plateau H, and then kept in place by whatever means may be used. Then the mold is raised to the position shown on the drawings. This mold is empty as yet. Heat is now applied to the furnace and the mold is heated inside by the reverberation of the flame to the right temperature, whereas both the bottom and the lower part of the mold are kept cooler by the circulating water. This cooling can also be begun immediately as just described, or sometimes after the metal has been cast into the mold. When the mold is sufficiently heated the liquid steel is poured through the hole *h* while heat is still being applied. This heat is kept up in order to prevent the surface of the metal from solidifying. When the lower part has been solidified to a sufficient height, while the upper part is kept liquid or semi-liquid, the desired addition may be made either through one of the doors *d* by means of a run or through the hole *h*. When the necessary reactions have taken place the heat is shut off in order to allow the metal to solidify to the top. To accelerate or maintain the complete and final solidification, the mold can be partly or entirely lowered, which action will bring it into a colder region. After complete solidification the car with mold and ingot is pulled out over the track T. The ingot is stripped of its mold and is now ready to be transformed into the desired shape either by rolling, or hammering or hydraulic pressure or any other means. The so obtained product will now be ready to be hardened, either in water or oil, or by any other means whatever if it is found necessary to harden it. A steel plate treated by the above described method, will constitute an article, which not only will have a different composition in the different zones, but on account of the gradual change in its composition, its physical characteristics such as hardness, or toughness, or malleability, &c. will also gradually change from one side to the opposite side, and whereas one side may be very hard and resistant the opposite side can be left very soft and yet remain very tough. During the casting of the metal into the mold and during its exposure to the heat in the furnace, the flame is preferred to be a reducing one in order to prevent any oxidation of the metal. The metal being exposed during the whole operation to the reducing flame, can only be improved in quality.

Though this is a description of a special furnace, I wish to state that any other furnace may be used as well as any other means adapted to carry out my invention, may be employed.

The pouring of liquid metal into an entirely heated up mold, exposed furthermore at its upper end to a very high temperature, whereas the lower end is made or allowed to cool down slowly and gradually from the lower regions toward the upper regions, has for effect that the metal will be kept liquid longest in the upper regions and the last portion of the metal to be solidified will be the upper surface region. By so doing not only will it be made possible to introduce other elements into this particular region of the metallic mass, but the formation of blow holes and especially the hollow space which is so often found at a small distance from the upper surface of otherwise sound ingots or blocks, will be completely avoided. A perfectly sound and dense block without honeycombed structure will be produced. Thus by this method a double end is obtaind, viz.: (1) a sound metallic block without blow holes or hollow spaces at the upper end, and (2) the possibility by making further additions as hereinbefore described of obtaining the desired heterogeneous product.

I claim as my invention:

1. The herein described process of producing heterogeneous metal blocks with different physical characteristics and different compositions in different zones, which method consists in causing the upper side or surface a mass of homogeneous iron or steel contained in a suitable vessel (and having its upper surface subjected to a high heat) to be liquid or semi-liquid and the bottom solid, then introducing into the liquid side additional material of different nature and composition which will unite with the original metal, thereby producing a block of heterogeneous metal whose composition and qualities will gradu-

ally vary from the liquid side through the pasty region to the opposite side, and then allowing the mass to solidify, as and for the purpose set forth.

2. The herein described process of producing heterogeneous metal blocks with different physical characteristics and different compositions in different zones, which method consists in causing the upper side or surface of a mass of homogeneous iron or steel contained in a suitable vessel (and having its upper surface subjected to a high heat.) to be liquid or semi-liquid, and the other side solid, then introducing into the liquid side additional material of different nature and composition which will unite with the original metal, thereby producing a block of heterogeneous metal whose composition and qualities will gradually vary from the liquid side through the pasty region to the opposite side, then allowing the mass to solidify, and then reducing the solidified mass into a plate of the desired thickness and dimensions, thereby obtaining a steel plate of heterogeneous character, gradually varying in composition from one side to the other, and then hardening the same by any known process.

3. The herein described process of producing sound heterogeneous metal blocks without honey combed structure and with different physical characteristics and different chemical composition in different zones, which method consists in causing the upper side or portion of a mass of liquid iron or steel contained in a suitable vessel to be exposed to a high temperature while the lower regions are exposed to a lower temperature, whereby a slow and gradual solidifying of the mass from the lower toward the upper region may be obtained, then when this upper region is still liquid or semi-liquid introducing into it additional material of different nature and compositions, which will unite with the original metal and produce a block of heterogeneous metal whose composition and qualities will gradually vary from the liquid side through the pasty region to the opposite side, then allowing the mass to solidify gradually and last in the upper surface, substantially as and for the purpose set forth.

In testimony whereof I have hereunto subscribed my name.

JOHN B. NAU.

Witnesses:
FRANK S. OBER,
EDWARD C. DAVIDSON.