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PROCESS OF HARDENING METALLIC SURFACES.

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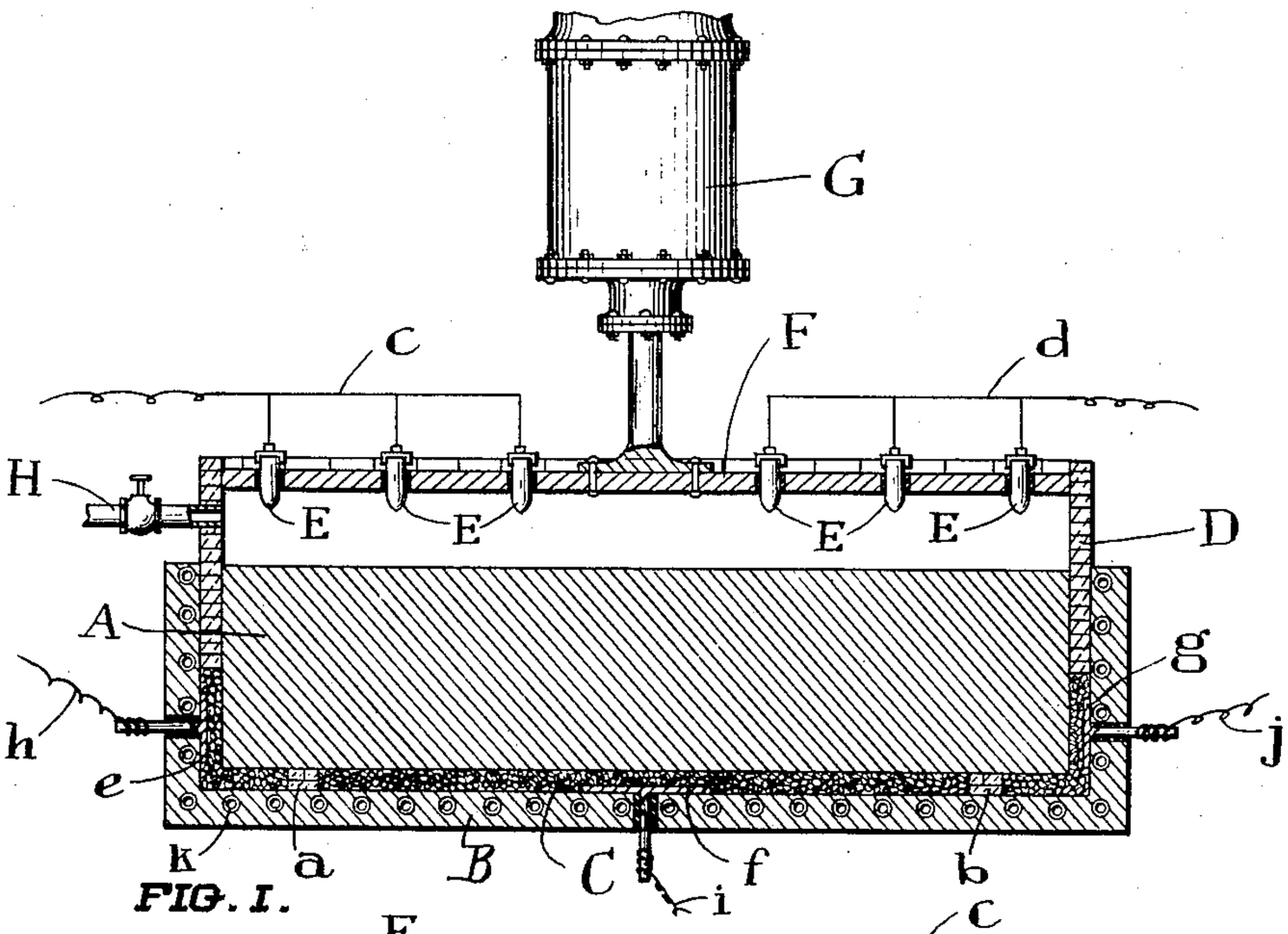

FIG. 1.

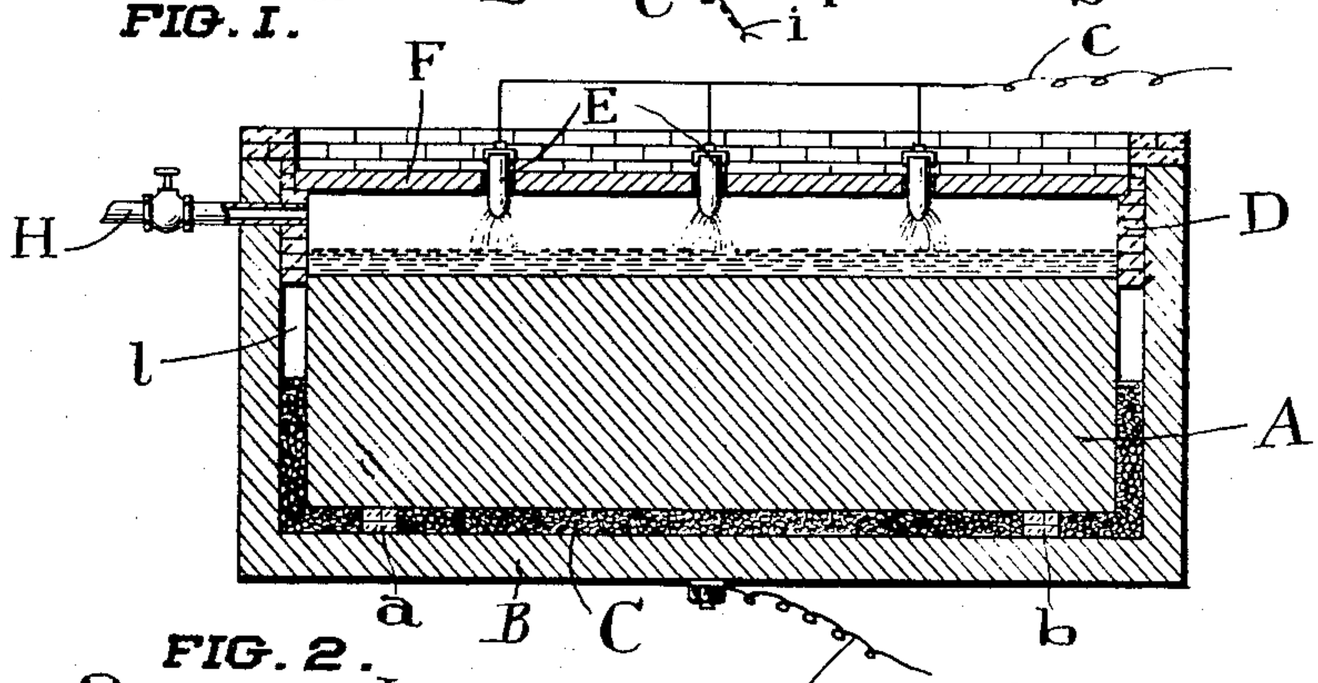

FIG. 2.

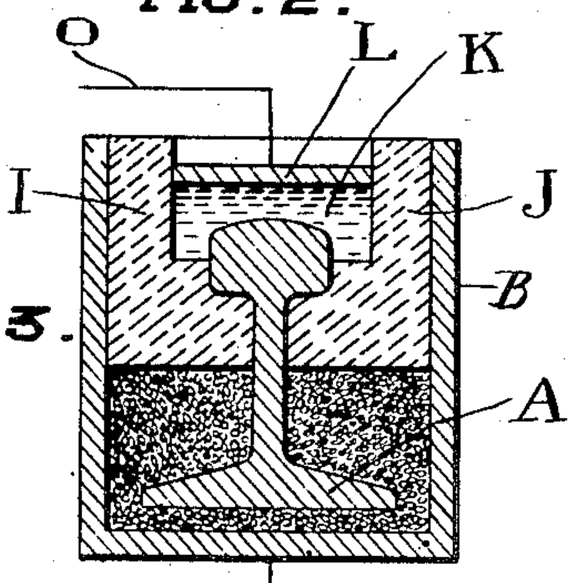

FIG. 3.

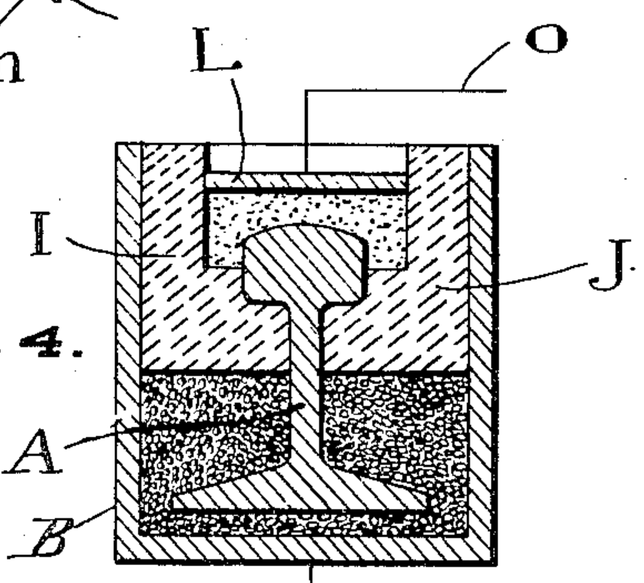

FIG. 4.

WITNESSES

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PROCESS OF HARDENING METALLIC SURFACES.

966,121. Specification of Letters Patent. Patented Aug. 2, 1910.

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To all whom it may concern:

Be it known that I, JAMES HENRY REID, of Newark, in the State of New Jersey, United States of America, have invented certain new and useful Improvements in Processes of Hardening Metallic Surfaces, of which the following is a specification.

This invention relates to improvements in processes of hardening metallic surfaces, and the objects of the invention are to provide a simple and efficient process by means of which an increased degree of surface hardness may be obtained in a minimum time and also to combine with the said process, a method of gradually annealing or softening the metal below the surface in proportion to the distance therefrom, thereby forming a hardened surface with a gradually softened or annealed backing.

The invention is applicable with great advantage to the manufacture of armor plates, rails and car wheels, as in these it is desirable to have an extremely hard surface in combination with a gradually softened backing, whereby the metal may be utilized to the greatest advantage to resist the stress.

In the manufacture of armor plates as at present carried out, various cementation processes have been employed, which consist, in general, of heating the plate in contact with a mixture containing carbon, and in some cases the back of the plate has been cooled. It is also known to separately apply hardening material to the surface of the plate through the medium of an electric arc directed thereagainst. In these, however, while the surface is hardened, the backing is left unaffected and there is liable to be a more or less sharp separation between the hardened and unhardened plate.

According to the present process, the change from the hardened to the unhardened plate is graduated thereby securing maximum efficiency, and in the case of armor plate, offering the greatest possible resistance to the passage of the projectile.

In carrying out the process, the plate or other article is bedded in suitable granular conducting material, such as hematite, magnetite or carbon in the form of coke, a bath of hardening substances is formed on the surface and an electric current passed through the bath, plate or article and bed. The granular material offering resistance to the flow of the current is raised in temperature, heating the lower part of the plate and annealing the same, while the hardening materials contained in the bath, which may be vanadium, tungsten or molybdenum, combine with the surface to harden the same.

It may here be observed that the word "bath" as employed in the present specification is intended to cover the application of hardening material in any form to the surface, whether applied directly or through the medium of a liquid, gaseous or solid conveyer. I have found, however, that a fluid bath, either liquid or gaseous, is more desirable, as the hardening elements can be more uniformly distributed through the same.

The process is described in detail in the accompanying specifications and drawings together with various apparatus which may be used to carry out the same.

Referring to the drawings, Figure 1 is a vertical section through one form of apparatus for treating armor plate. Fig. 2 is a vertical section through an alternative form. Fig. 3 is a transverse section through a modified form adapted to treat rails to harden the tread surface thereof. Fig. 4 is the apparatus of Fig. 3 in which a bath of granular substance is employed.

In the drawings, like letters of reference indicate corresponding parts in each figure.

Referring, first, to the apparatus illustrated in Fig. 1, the steel plate A is located within a casing B of suitable conducting material, preferably metallic, and held in suspension therein, by suitable supports *a* and *b* of non-conducting material. The space around the bottom and part way up the sides of the plate is filled with a bed C of material adapted to afford resistance to the passage of an electric current and of such a character as will not carbonize the surface of the plate, when raised to the annealing temperature during the carrying out of the process.

It has been found that hematite, magnetite or carbon in the form of coke, or a mixture of these substances is the best material to employ to form the bed, but it is evident that many other substances exist, which possess the necessary properties.

The bed extends about one-third or one-half way up the sides of the plate and the

remainder of the sides are protected from the heat by a surrounding band of heat insulating character. In the embodiment illustrated in Fig. 1, this band is formed of a wall D of fire brick preferably externally glazed.

Above the plate A a plurality of electrodes E are provided, suitably supported as from a plate F and insulated therefrom. In the embodiment illustrated in Fig. 1, means are provided for forcing the plate F downwardly to exert a pressure on the bath, which bath, in this case, may be in the form of gas. These means comprise a hydraulic piston and cylinder G of suitable and well known construction, connected to the plate F. A valved conduit H extends through the portion of the said wall above the plate to permit of the introduction of the gas or liquid adapted to form the bath at the top of the plate. The electrodes E are all united by suitable conductors *c* and *d*, which lead to one side of a dynamo, or other source of electrical power, the opposite side of which is placed in communication with the bed C. This may be accomplished by connecting the said source of power directly with the casing B, but, if desired, and as shown in Fig. 1, plates *e*, *f* and *g* may be provided on the inside of the casing, which are connected to conductors *h*, *i* and *j*.

To prevent over-heating of the casing B, water circulating coils *k* may be provided therein, the different parts of the coils extending around the heat insulating bands and the remainder of the sides being preferably, separately controlled.

In the form of apparatus illustrated in Fig. 2, the heat insulating band is in the form of a dead air space *l*, provided around the upper portion of the sides of the plate. The conductor *m* is connected directly to the casing B and the hydraulic piston and cylinder are omitted. The bath, shown in the form of a liquid, is introduced through the valved conduit H.

In the embodiment illustrated in Fig. 3, two blocks I and J of heat insulating material, such as fire-brick or fire-clay, are formed and adapted to extend around the upper part of the sides of the rail, and the inside of the upper part of the casing B, and being centrally recessed, whereby a basin K will be provided on top of the rail to receive the bath. The bath in this case, is shown in the form of a liquid and the cover L resting on the liquid forms one of the electrodes to which the conductor *o* is connected, the opposite conductor *p* being connected directly to the casing B.

The form of apparatus illustrated in Fig. 4 is the same as that shown in Fig. 3, only a granular bath is shown in place of the liquid one.

In carrying out the process, the plate or article is bedded on the electrical conducting and resisting material, the bath is formed on the surface and the current sent through the bath, plate or article and bed.

The resistance offered by the material forming the bed will raise the lower part of the plate to a moderate heat and care must be taken to always keep the temperature below the critical temperature of the particular steel being worked, whereby the absorption of any carbon by the steel will be prevented and its original properties will be untouched. To do this with ordinary steel, it is necessary that the maximum temperature should not go much over 560° C. and if there is a tendency for the plate to heat over this temperature, it will be necessary to use the water circulating coils illustrated in Fig. 1 to reduce the temperature. Should it become necessary to work a steel at a higher temperature than about 550°, it will be necessary in manufacturing the steel, to incorporate such materials as will raise its critical point below atmospheric conditions. This can be done by alloying the steel with vanadium, tungsten or molybdenum.

The bath on the surface of the steel to toughen and harden the same may be either in the form of a liquid, a gas or a granular or solid mixture, and will contain various hardening elements, such as nickel, chromium, vanadium, carbon, tungsten or molybdenum, either alone or in combination. The liquid or gaseous bath, however, is most desirable as it insures a more uniform distribution of the hardening elements.

The form of apparatus shown in Fig. 1 is that which would be best adapted for utilizing a gaseous bath applied under pressure, such as carbon monoxid. If this gas were used under pressure, the electric current passing through it would form arcs on the surface of the steel and would cause the gas to give up carbon to the steel, thereby hardening and toughening the same.

The liquid bath may be formed of a carbon carrying oil and may contain various hardening metals before specified or salts of them. The hardening bath might also be formed by placing the hardening elements on the surface of the steel prior to the passage of the electric current and on passage of the same arcs would be formed on the surface of the steel fusing or heating hardening elements and thus incorporating them with the surface of the steel.

The temperature of the steel will generally, be a maximum at the surface in contact with the hardening bath, being raised to this temperature either through the direct heat of the electric arc, or through the bath, the temperature of which is raised by the arc playing on it or the electric current passing through it. From the surface being hardened, the temperature gradually decreases

to the opposite surface in contact with the heated bed of material, whose temperature is below the critical temperature of the steel as herein explained.

The process is continued in operation until the steel has been deemed to have absorbed sufficient of the hardening materials and the electric current is then shut off and the steel preferably, allowed to cool gradually thereby providing against the tendency to change its physical properties.

The intensity of the action can be regulated by the density of the current and by the period of exposure. The hardening and toughening of the plate will be gradual, working from the surface downward and the depth of hardening can be controlled by the heat of the material of which the bed is formed.

By this method, a plate or article will be obtained which will be extremely hard and tough on the surface, but will become more ductile and malleable and possessing a greater degree of elasticity as the back of the plate is reached.

The means for exerting a pressure shown in Fig. 1, may be used with a liquid or solid as well as a gaseous bath, the effect being to force the hardening element into the metal and facilitate their amalgamation. It might also be observed that when the granular or solid form of bath is used, it is not essential that the arcs should actually fuse the hardening elements, as experience has shown that absorption will take place on the part of the steel, even when the temperature is considerably below the fusing point. It will therefore, be understood that the bath of hardening elements might simply be heated by the passage of electric current or by the arcs directed against the same.

What I claim as my invention is:—

1. A process of treating metallic surfaces which consists in applying a fluid bath containing hardening elements to the surface and passing an electric current through the fluid bath and the plate, said bath being in a fluid state before the current is applied.

2. The herein described process of hardening metallic plates or articles, which consists in bedding the plate or article in granular conducting material, applying a hardening bath to the exposed side of the plate or article while insulating the bath from the bed, and passing an electric current through the bath, plate or article, and the bed.

3. The herein described process of treating metallic plates or articles which consists in embedding the plate or article in granular conducting material, applying a bath to the surface containing hardening metals and passing an electric current through the hardening bath, the plate or article, and the conducting material.

4. The process of treating previously formed metallic plates or articles which consists in bedding part of the plate or article in a material which affords resistance to the passage of the electric current and which will not combine with the metal of the plate or article, applying treating substances to the surface of the article and passing an electric current through the treating substance, plate or article and bed of resistant material.

5. The herein described process of treating metallic plates or articles which consists in bedding the bottom and part of the sides of the plate or article in material adapted to afford resistance to the passage of an electric current and to be heated thereby the said material being of such character as not to combine with the plate or article, applying a bath containing hardening materials to the exposed surface of the plate or article, suitable insulation being provided on the sides of the plate or article between the bath and the bed, and then passing an electric current through the bath, the plate or article and the bed.

6. The herein described process of treating metallic plates or articles which consists in embedding the plate or article in granular conducting material which will not combine with the metal of the plate or article, applying a hardening bath to the surface and passing an electric current through the hardening bath, the plate or article and the conducting material.

7. The herein described process of treating metallic plates or articles which consists in embedding the plate or article in hematite, applying a hardening bath to the surface and passing an electric current through the hardening bath, the plate or article and the conducting material.

8. The process of treating a metallic surface to harden the same, which consists in applying a hardening bath under pressure to the surface and passing an electric current through both the bath and plate or article being treated, whereby both the bath and plate or article will be heated by the passage of the current.

9. The herein described process of treating metallic plates or articles which consists in embedding the plate in electrically conducting and resisting material, applying a bath to the surface containing hardening metals, and passing an electric current through the hardening bath, the plate or article and the conducting material.

In witness whereof I have hereunto set my hand in the presence of two witnesses.

JAMES HENRY REID.

Witnesses:

RUSSEL S. SMART,

WM. A. WYMAN.