Dec. 16, 1930. F. A. FAHRENWALD 1,784,865

METHOD OF STRAIN HARDENING MANGANESE STEEL

Filed Dec. 13, 1926

Fig. 1

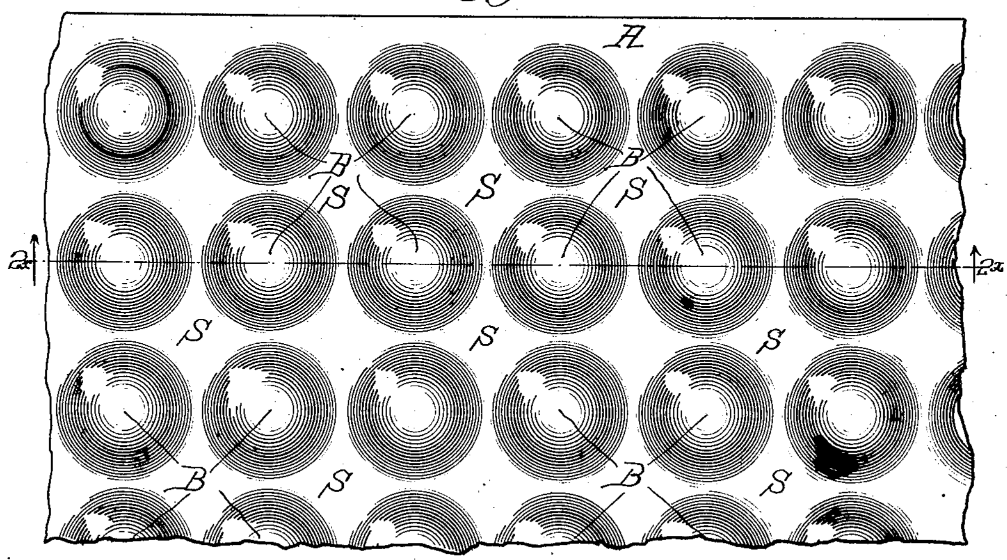


Fig. 2

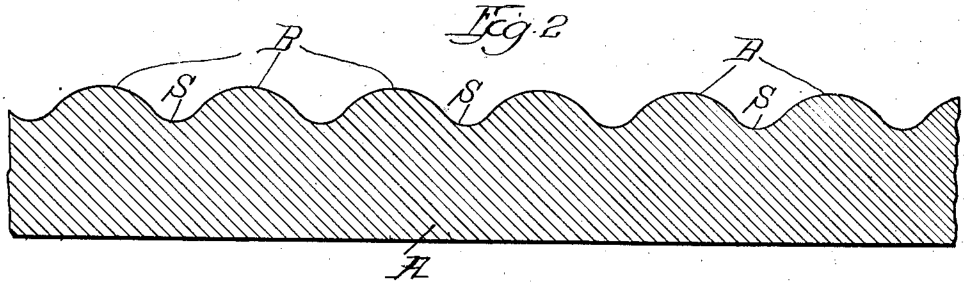
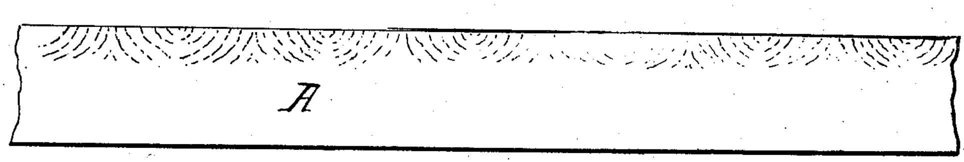


Fig. 3



Witness:

[illegible signature]

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UNITED STATES PATENT OFFICE

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METHOD OF STRAIN HARDENING MANGANESE STEEL

Application filed December 13, 1926. Serial No. 154,645.

This invention relates to the manufacture of articles of manganese steel, and particularly to a method of hardening portions of such articles to increase their resistance to abrasive forces and to deformation stresses encountered in service; also to an article resulting from the application of the method.

It is well known that most metals and alloys can be hardened by cold working or deformation at temperatures below those at which spontaneous re-crystallization takes place, and this phenomenon is usefully employed in many industrial operations today, for instance, in the production of cold rolled, hard, elastic wire, roof sheets, and other standard articles of commerce in which various metals and alloys are employed; in fact, the capacity in metals to harden under cold plastic deformation is so great that it becomes very objectionable in many metal-forming operations and necessitates frequent heating of the metal being worked, to an annealing temperature, to prevent fracture of the metal in progressive deformation, or to maintain softness to a degree which renders the metal responsive to rolls, dies, or other instrumentalities through means of which it is being worked.

A number of theories have been advanced to explain why metals and alloys harden when cold worked. One of these assumes the transformation of soft austenite to relatively harder martensite; another ascribes hardening to the formation of amorphous metal at the planes in which flow will be induced; still another states that the hardening is the result of breaking down the original crystal space lattice, with resulting interruption of flow planes. But the phenomenon of hardening, in itself, is not claimed to be of the present invention, and the reasons therefor are immaterial for purposes of explanation of the present invention.

It has long been proposed to harden the surfaces of manganese steel castings the better to adapt them to resist abrasive forces or impact stresses, but this has generally been practiced in a manner to develop over the entire surface to be hardened, a substantially uniform dimension of excess metal or a pad of metal, and depressing this pad until the excess metal has been retired within the desired ultimate surface of the work-piece.

I have discovered that induced hardening, or hardening by cold working, is proportional to the degree of actual plastic deformation with respect to degree of space-lattice, distortion, or to the number of flow planes produced in the mass per unit of volume; and that application of simple pressure alone, such as might be exerted upon a piece of manganese steel surrounded with liquid in a pressure chamber, in whatever degree, has no hardening effect. I have also found that the customary methods heretofore employed, such as pressing large areas of a casting or merely hammering relatively large surfaces, besides being relatively ineffective, introduce flaws into the treated casting, chiefly in the form of shear cracks, because of propagation of flow over the large areas. As corollary to this, I have found that intensive working of quite small areas or subdivisions of the total area to be affected, produces hardness of a degree impossible of production in larger sections treated all at once, without at the same time rupturing the entire mass.

Many efforts have been made to peen-harden surfaces of manganese steel castings, but these have usually comprised the simple process of repeated application of the hammer at shifting points in a manner to produce small indentations which collectively involve, eventually, the whole of the large flat surface; or they have comprised the pressing or pounding of elevated areas or pads corresponding in dimension to the section which it is desired to harden, with the result that a certain degree of hardness has been produced, measuring around 350 or in extreme cases even 400 (Brinell). But nearly always castings so treated suffer a spalling or flaking of the pressed areas due to shear cracks produced by the extreme pressure and excessive local shear flow in the castings at the boundaries of pressure areas.

In my copending applications, Serial No. 154,644, filed Dec. 13, 1926, and Serial No. 177,878 filed Mar. 24, 1927, I have described new methods of developing desired intensive plastic deformation and thereby strain hardening manganese steel castings; the method described in the former of said copending applications consisting in forming, at the time of casting, on those areas of the manganese steel castings which are subjected to heavy wear or stresses in use, a number of essentially equally spaced projections which, after heat treatment of the casting and while the casting is in a cold state, are compressed to a fraction of their original height, though preferably not depressed to a degree sufficient to form a continuous flat surface; while that described in the latter of said copending applications consists in pressing into the heat treated casting, while in a cold state and at spaced intervals, a tool with a rounded end, the curvature of the rounded end of the tool being preferably on a radius less than one fourth of the thickness of the casting at the point of treatment, and the depth of depression being preferably less than this radius.

The invention with which the present application is concerned, while involving the broad principle of the invention set forth in the said copending applications, follows more closely the copending application first named, in that a number of equally spaced projections are formed upon the area to be hardened and compressed in the cold state, after heat treatment, but differs therefrom in detail and principally in the circumstance that the projections formed upon the surface to be hardened are of special form, to-wit, cast-on conchoidal elevations, or elevations any section of which would be arcuate in form, for instance, elevations that are spherical, spheroidal, or egg-shaped in contour, and which elevations are joined onto the general surface of the casting through means of a smooth sweeping curve; the process of hardening by depressing projections of this general character having been discovered to be much more satisfactory for certain applications of my new principle of producing deep seated, hardened, wear-resisting surfaces.

In order that the invention may be more fully understood, reference will be had to the accompanying drawing, in which—

Figure 1 is a surface view of a portion of a manganese steel casting formed with projections in accordance with the present invention.

Figure 2 is a section on the line $2x$—$2x$ of Figure 1; and

Figure 3 is an edge view of the work-piece or casting after the hardening process is completed, flow lines in the piece being suggested by the use of dotted lines.

According to the present invention, I produce a casting such as A, Figures 1, 2, and 3, in the usual manner, but in a mold so designed that it will produce upon the wear-resisting surface of the casting, elevations B spaced at proper intervals, on general contours, which elevations may be characterized as conchoidal elevations, or elevations of spherical, egg-shaped, or other contour, any section of which would be arcuate in form, and the merger of which with the general surface of the casting is through smooth sweeping curves S (Figures 1 and 2). After such a casting has been heat treated and preferably cleaned, its surface carrying the elevations described, is subjected to the action of a powerful press or heavy drop hammer capable of driving the elevations into the casting until the surface of the casting is approximately level. The excess material thus forced into the body of the casting acts in a manner similar to a rounded tool, as described in my copending application, Serial No. 177,878, causing the surface surrounding each individual elevation to rise slightly, in an annular area, to accommodate the metal that has been flowed into the mass. The plastic flow incident to the leveling of the elevations produces hardness to a very high degree, locally, which hardness gradually diminishes with the distance from the focus.

For a specific example, let it be assumed that the casting is formed with elevations of the kind described having a one inch radius, and that these elevations are raised about one fourth of an inch above the general surface, or above a plane that is intermediate of the salients of the elevations and the depressions between them; also that the elevations are spaced approximately one and one quarter inches apart. When a surface so developed with elevations is smoothed by depressing the metal of all the elevations into the body of the casting, the casting being made of ordinary commercial manganese steel, the work-piece will be found to have had its hardness raised to about 450 to 550 (Brinell).

Elevations of the shape and size described are such that when sunk into the casting, the flow produced by their depression is propagated deeply into the casting, and not merely to the extent of a fraction of an inch (for instance, one-sixteenth of an inch) as in ordinary process of hardening by cold working. In fact, the metal is caused to flow for a depth of from one half inch to one inch, as suggested by the broken flow lines in Figure 3, and the deep hardening so produced is such as to produce long life to the casting. Unless smooth curves are maintained in the merger of the elevations with the general surface of the casting, shear cracks will appear at points corresponding to those indicated by the letter S in Figures 1 and 2.

In designing the casting, the surface of which is to be treated in accordance with the present process, it is, of course necessary to select the dimensions of the casting so that the ultimate dimension effected by depressing the elevations into the mass will be that which is desired.

I claim:

1. The process of strain hardening manganese steel, characterized by forming upon a surface of the steel, spaced, conchoidal elevations, and after heat treatment of the steel, and while the steel is cool, depressing these elevations into the body of the casting.

2. The process of strain hardening manganese steel, characterized by the steps of forming the steel with a series of individual, spaced elevations of convex contour meeting the general surface of the steel in substantially smooth curves, and while the steel is cool depressing these elevations into the body of the casting.

3. The process of strain hardening manganese steel, characterized by the steps of forming upon a surface of the steel, elevations of convex contour, with spacing bearing a ratio to their radii greater than unity, with elevation above the ultimate general surface of the casting approximately one-fourth of their radii, and with smooth sweeping curves of merger between the elevations, and then while the metal is cool depressing the elevations with resultant raising of the intermediate merging curves until a substantially smooth surface is developed.

Signed at Chicago, Illinois, this 9th day of December, 1926.

FRANK A. FAHRENWALD.