Dec. 16, 1930. F. A. FAHRENWALD **1,784,866**

METHOD OF STRAIN HARDENING STEEL

Filed March 24, 1927

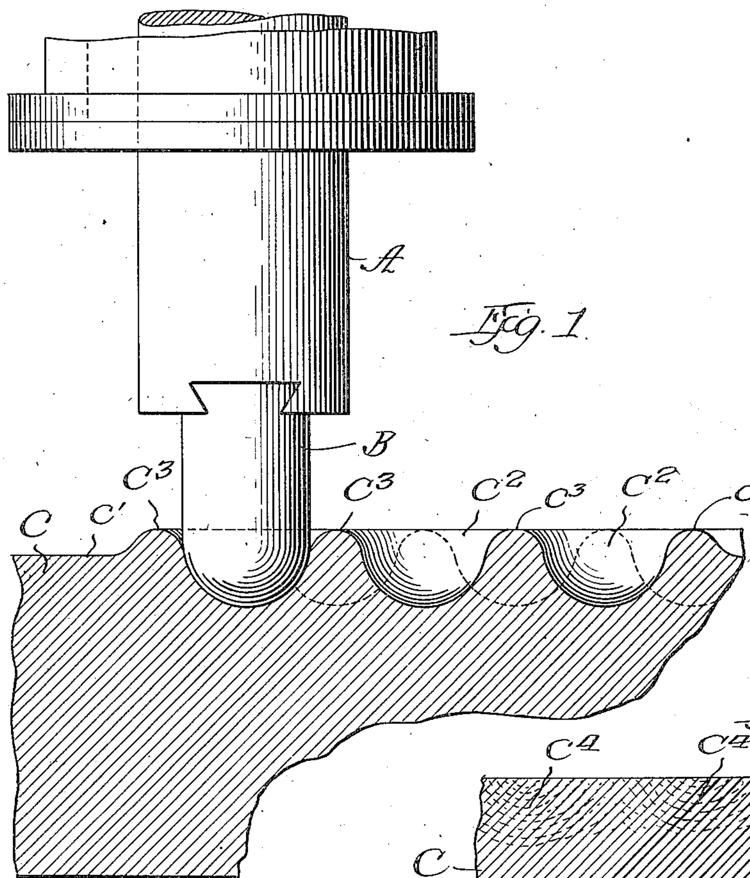


Fig. 1

Fig. 3.

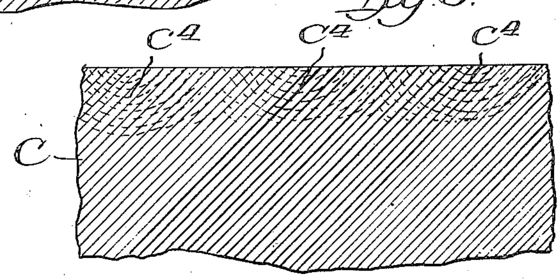
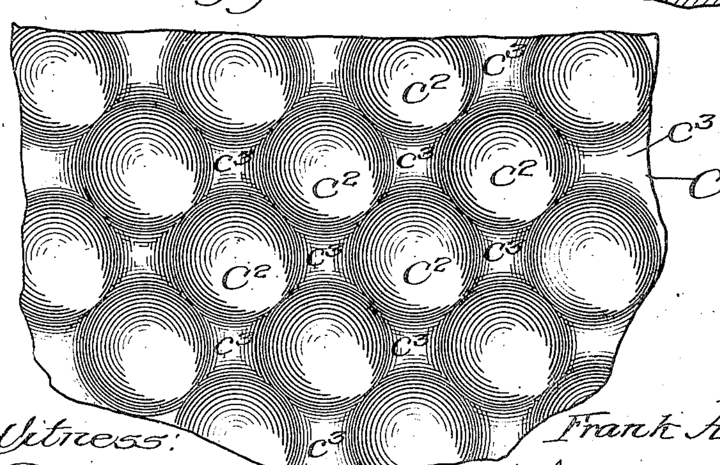


Fig. 2.



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UNITED STATES PATENT OFFICE

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METHOD OF STRAIN-HARDENING STEEL

Application filed March 24, 1927. Serial No. 177,878.

This invention relates to an improved method of hardening portions of steel castings, for instance, manganese steel castings, to increase their resistance to abrasion and deformation under stresses encountered in service, and particularly to hardening by localized cold working of the metal.

It is well known that most metals and alloys can be hardened by cold working, such method having been successfully employed from earliest times; and the property in metals of taking on hardness under cold working, to-wit by deforming the metal at a temperature below that at which spontaneous recrystallization takes place, is usefully employed in many industrial operations of today. It even occurs as an objectionable incident to some industrial operations and involves frequent heating of the metal to annealing temperature as a means of maintaining sufficient softness to prevent rupture of the metal during progressive deformation or in the treatments such as rolling, forging, and the like. Use of the cold working process in hardening manganese steel castings, and particularly by the hammering or pressing operation and with the effect of increasing the resistance of the castings to abrasion and other stresses, has also long been known.

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 is that it results from the formation of amorphous metal at the planes of flow; and still another is that the result is due to breaking down of the original crystal space lattice, with interruption of flow planes. But, inasmuch as no claim is herein made to the abstract idea of hardening manganese steel castings by the cold working process, the exact explanation of the phenomenon becomes unimportant.

What I have discovered is that induced hardening of manganese steel is proportional to the degree of actual plastic deformation with respect to space lattice, or to distortion, or to number of flow planes produced per unit volume, and that so-called densifying by static pressure or impact of whatever degree, has no real effect in producing hardness. I have also found that the customary methods, as employed to date, 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 the propagation of flow over too large areas. And as corollary to this, I have found that intensive working of quite small areas produces hardness to a degree impossible in large sections without at the same time rupturing the entire mass. Efforts heretofore expended in attempts to peen harden surfaces of manganese steel castings have comprised simple hammering over large flat surfaces in a manner to produce small indentations, or the pressing or pounding of relatively large pads, existing as single elevated areas covering the entire section which it was desired to harden. In this manner, surfaces have been produced with a skin hardness of around 350 to 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 induced in the casting at the boundaries of pressure areas.

These objections have been overcome by the procedure described and more broadly claimed in my application Serial No. 154,644, as well as the procedure described and more specifically claimed in my application Serial No. 154,645; but I have discovered that for some uses, deep seated hardening of wear resisting surfaces may be developed still more satisfactorily by a procedure which involves the development, in the mass of metal to be hardened, of an area of depressions such as will be formed by forcing deeply into the heat-treated casting, preferably while cold, a round-ended tool of relatively small diameter and causing the mass of alloy all around the tool to flow away and bulge up annularly to accommodate the displaced metal. The extent of area that is hardened will depend upon the extent of repetition of depression or the field of depression developed by the repeated application of the tool at properly spaced intervals; in other words, to develop a deep seated hardening effect over a desired area, it is necessary to repeat the impression of the round-ended tool a sufficient number of times, always maintaining an interval of spacing between the depressions which is properly related to the diameter of the tool and the depth of the depression produced thereby, and by so doing the entire area will become kneaded in a manner peculiarly suited to induce severe distortion and resultant great hardness.

The depth of the depressions and preferably the diameter of the tool which is pressed into the metal, will depend upon the thickness of the casting at the point of treatment, and the spacing of the indentations will, in turn, depend upon the diameter of the tool and the depth of its imprint. For instance, if a casting not less than two inches thick be pressed with a tool having an approximately hemispherical end, the curvature of which is on a half inch radius, and the depth of the depression be less than this radius, I have established by experiment that the hardness of the casting can be raised from an initial Brinell hardness of 200 to a hardness of 535 Brinell, which is far above any figure ever reached by previously known hammering or pressing operations. The spacing of the depressions will depend upon the reach of the depression in its plastic deformation, but I prefer to keep the spacing well within such limit when it is desired to develop hardness throughout the area of the treated region. For instance, the depressions may be given a spacing on some lines measuring from center to center a distance equal to twice the diameter of the pressing tool, and on other lines may be much closer together.

By way of illustrating a specific application of the invention, reference will be had to the accompanying drawing, in which—

Figure 1 is an elevational view of a work tool together with a sectional view of a workpiece used in the process of development of a field of depressions.

Figure 2 is a top plan view of the workpiece of Figure 1; and

Figure 3 represents, in section perpendicular to the plane of the hardened surface, a fragment of the work-piece.

A represents a plunger of a hydraulic press, and B a depressing tool appropriate for the procedure herein described. C represents a work-piece that is being treated by the tool B in accordance with the present invention, C′ indicating the original level of the surface being treated; C2 a series of depressions made by the tool B; and C3 the annular ridges or crests developed around the tool by the plastic flow of the metal displaced in forming the depressions.

In many cases a uniformly roughened surface such as would result from the process herein described is of material value in the finished article, for instance, to increase grinding effect or to prevent slippage. But if it be objectionable to have for the surface of the work-piece C the crater-like indentations and their defining rims resulting from the hardening method herein described, the condition may be relieved by grinding the surface of the work-piece to any extent, even to the extent of producing a level surface, as suggested in Figure 3; and even with the removal of unevenness, the range of plastic flow and deformation will still exist well below the resultant surface, as suggested by dotted flow lines C4 in Figure 3.

The verb "to press" used in its various forms in this specification is to be interpreted with its usual engineering significance and is not to be confused with the verb "to hammer," the effect of which is essentially percussive, extremely local in its application, and largely resisted by inertia of metal surrounding the point of impact, and is therefore different from the influence of pressure of a selected tool to which areas of the treated metal adjacent the actual area of contact can respond by flowing.

An important advantage arising from this method resides in the deep seated hardening effect induced as a result of a flow of the metal, plastically, in every direction from the rounded tool. In the method herein described, as well as in that described in my copending applications herein identified, distortion of the casting as a whole is avoided by imposing pressure or impact on individual areas small enough to insure confinement of the shear flow to small areas by the elastic strength of the surrounding metal.

I claim:

1. The process of producing work hardened manganese steel castings, characterized by the step of pressing into the heat treated casting, while the casting is cool, and at spaced intervals, a tool with a rounded end.

2. The process of producing work hardened manganese steel castings, characterized by the step of pressing into the working surface of the casting at intervals, a rounded end tool, the radius of rounding of the tool end being not greater than one fourth of the thickness of the casting at the point of treatment, the depth of depression being less than said radius, and the metal being cool at the time of said treatment.

Signed at Chicago, Illinois, this 14th day of March, 1927.

FRANK A. FAHRENWALD.