

UNITED STATES PATENT OFFICE

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STRAIN HARDENED MANGANESE STEEL AND METHOD OF PRODUCING SAME

No Drawing.

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This invention relates to the production of manganese steel having a portion or portions through which it encounters stresses in service hardened by subjecting them to strains which raise the capacity of the metal to resist abrasion and deformation.

It is well known that most metals and alloys can be hardened by cold working; in fact, this characteristic of metals was used fully employed prior to the days of modern science by races who hardened and sharpened copper and iron weapons by hammering, probably between two stones. This property in metals of taking on hardness under cold working, to-wit, by deforming the metal at a temperature below that at which spontaneous re-crystallization takes place, is usefully employed in many industrial operations today, for instance, in cold rolled, hard, and elastic wire, roofing sheets, and the like, and many other standard articles of commerce made of metals or alloys. It is even so pronounced that it becomes very objectionable in many industrial operations because of frequent heating of the metal to annealing temperature, which it necessitates in maintaining sufficient softness to prevent fracture during progressive deformation or rendering the metal suitable for forming by rolls, dies, or the like.

The hardening of surfaces of manganese castings by hammering or pressing, and thereby increasing their resistance to abrasion or stresses of impact, has also been known, being described, for instance, in Austrian Letters Patent No. 73,325, issued to Gebr. Bohler & Co., as well as being published elsewhere. 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 the phenomenon to the formation of amorphous metal at planes of flow; and still another states that hardening is due to breaking down of the original crystal space-lattice with the resulting interruption of flow planes. But no claim is made herein to the abstract idea of hardening manganese steel castings by this method, hence the rea-

sons for the phenomenon or the explanation of the results attained need not be dwelt upon.

What I have discovered is the fact that induced hardening is proportional to the degree of actual plastic deformation with respect to space-lattice distortion, or or to the number of flow planes produced 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, of whatever degree, has no effect in producing hardness. I have found also 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, caused by propagating flow over too large areas. As corollary to this, I have found that intensive working of quite small unit areas produces hardness of a degree impossible of attainment by treatment of larger unit areas, without at the same time rupturing the entire mass.

In my tests to determine proper size of unit areas which may be deformed without causing flow at the boundaries of such areas sufficient to cause internal shear, I have made a series of cast specimens of manganese steel of various shapes and dimensions from one inch cubes (1" x 1" x 1") up to approximately two inches by three inches by two inches (2" x 3" x 2") in size, and have deformed these specimens both by slowly applied pressure and by impact under a heavy drop hammer. I found that when the larger sizes were flattened out, either by pressure or by blows, before any valuable increase in hardness could be produced side flow of the mass as a whole took place to a degree which produced serious cracking. But when pressure or impact was applied to the inch cube (1" x 1" x 1") specimens, a uniform deformation and hardening occurred, some of the test blocks reaching an ultimate Brinell hardness of seven hundred and forty-four (744), which is far higher than has ever, within my knowledge, been attained by other researchers.

Having discovered that small areas can be cold worked to a far greater hardness than large areas, I employ this principle in the preparation of large manganese steel castings, by forming as a part of the large surface of the casting, a number of adjacent projections of such height and cross section, and so spaced with respect to each other that when, by pressure or impact applied by mechanical means or resulting from forces received by the casting when in service, all such projections are reduced in height by flattening, the resultant Brinell hardness exceeds the initial hardness of the same casting by more than three times; also the area of each projection increases through flowing outwardly until the inter-projection spaces are practically filled up, but the backing up mass of the casting as a whole is not stretched or deformed to any harmful degree, as often occurs in service or in mechanical peen hardening where plain flat surfaces are employed.

The higher the projections are with respect to the cross section dimension of the projection (up to about twice) the greater will be the amount of deformation and consequent hardening that can be induced. I have found that castings or projections up to one inch (1") in diameter or approximately one inch square (1" x 1") can be flattened one-half their initial height before shear fractures occur. This does not hold true, of course, for relatively short specimens or projections, because in the latter relative side flow required for necessary hardness would produce distortion too quickly, such flow would exceed the plasticity of the edges of the section, and shear would occur. Likewise, too great length relative to the sectional area of the projection will cause a tendency to buckle or compress unevenly.

I have found further in producing castings with wear resisting surfaces made up of separated hardened areas, as described above, that if distortion of the casting as a whole, or that portion of the casting which is contiguous with and supports the work-hardened surface, is to be avoided, the unit or individual area being hardened must not be greater in proportion to the section which backs it up, than the ratio which the ultimate strength of the alloy under compression, bears to its elastic limit under tension. If its ultimate compression strength is two hundred thousand (200,000) pounds per square inch, and its elastic limit is fifty thousand (50,000) pounds per square inch, which figures are approximately correct, then, for every square inch of surface hardened by plastic shear flow under compression, there must be available the equivalent of at least four square inches properly distributed to prevent a propagated flow throughout the whole casting section. It is thus evident that not only must the projections themselves be properly proportioned

and spaced, but their actual unit areas cannot exceed a rather definite ratio to the area of the base casting on a section through the projection.

In the preferred method of manufacturing castings according to my improved method, depressions in the mold or in cores provide the desired projections on the casting, and the latter, after heat-treatment of the casting in the known manner to bring it to the austenitic state and proper cleaning by grinding, sand-blasting, or otherwise, are one at a time pressed down to the desired proportion of their original height by hydraulic press, toggle press, or heavy drop hammer. When ready for shipment, the wear-resisting surface of the casting is sufficiently smooth for all practical purposes, because with the leveling of each knob, the corresponding increase in its area has practically filled in the spaces surrounding the individual projections until the surface of the casting appears as a relatively flat area seemingly made up of a large number of assembled polygons. The hardness of such a surface may be well above 700 Brinell, and this hardness proceeds to the full depth of the depressed projection, while the castings of which these projections form a part may be only about one hundred eighty to two hundred (180 to 200) hardness, but with all its original toughness and capacity to resist shocks remaining unimpaired.

For many uses where heavy impacts are encountered in service, it is not necessary to cold work mechanically by pressing down the knob-like projections before installing the object in its place of use. In certain types of ball mills, for instance, the castings may be installed with the projections as cast, in which case the hammering of the grinding balls, while in operation, will be sufficient to cause the required flattening out of each knob or projection.

I claim:

1. A shock resisting casting of manganese steel, characterized by having a tough, shock resisting, and load or stress carrying portion, and a harder shock resisting area supported thereby, and a part thereof comprising cold worked adjacent spaced knob-like projections and intervening portions of the casting cold worked by reaction from said projections.

2. The process of producing hard, shock-resisting surfaces on manganese steel castings, characterized by forming at the time of casting, upon a surface of the casting, a number of essentially equally spaced knob-like projections, heat treating the casting to bring it to austenitic state, and compressing the projections to a fraction of their original height and thereby increasing the resistance of the surface to deformation.

3. The process of producing hard, shock-resisting surfaces of manganese steel cast-

ings, characterized by forming at the time of casting, upon a surface of the casting, a number of essentially equally spaced projections surrounded by areas of the casting of less elevation, heat treating the casting to bring it to austenitic state, and compressing the projections to a fraction of their original height, and thereby increasing the resistance of the surface to deformation; the compression of the projections being continued to an extent which causes the surrounding inter-projection areas to be cold worked.

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

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