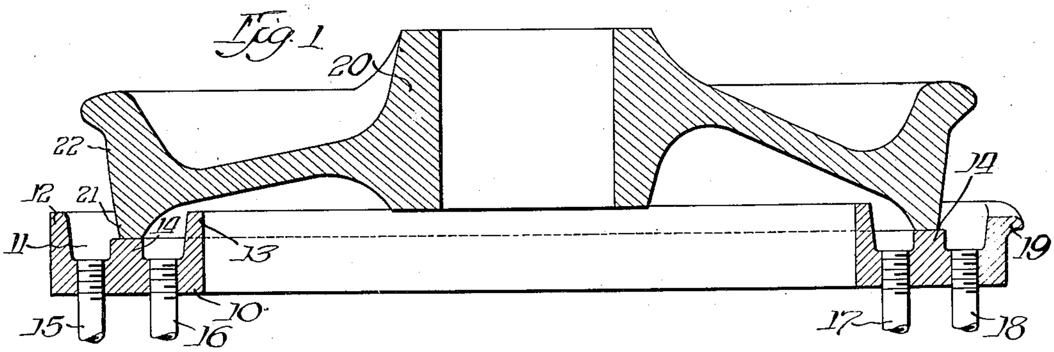
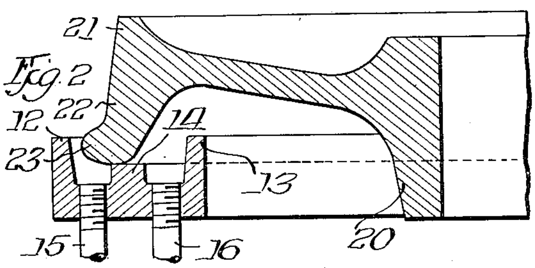
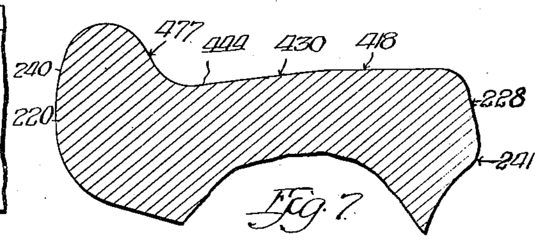
March 3, 1931. J. C. DAVIS 1,794,445

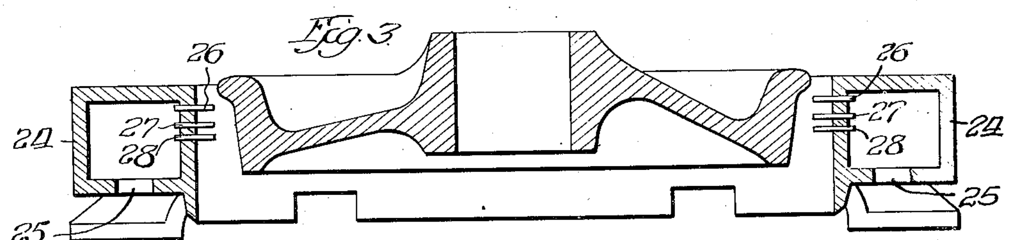
METHOD OF PRODUCING DIFFERENTIALLY TEMPERED METAL

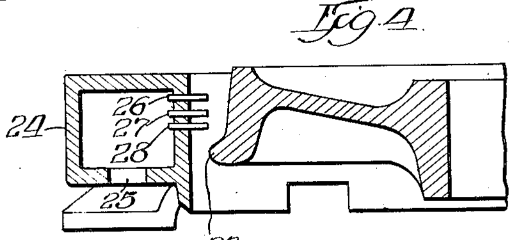
Filed July 27, 1925

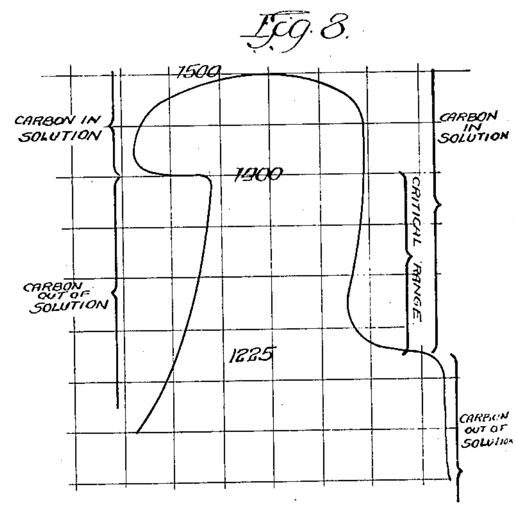


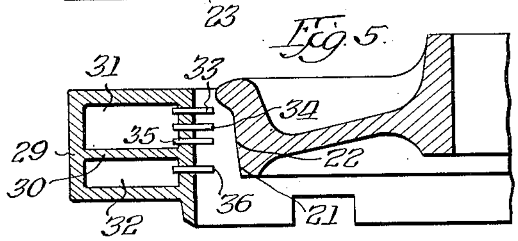


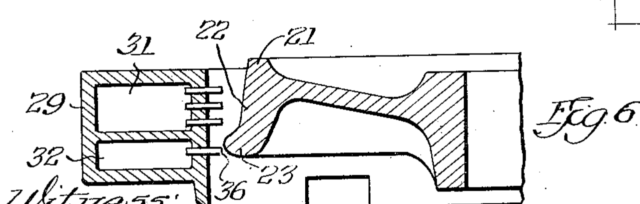












Witness:

Inventor

James Carey Davis

by attorney

Patented Mar. 3, 1931 1,794,445

UNITED STATES PATENT OFFICE

JAMES CAREY DAVIS, OF CHICAGO, ILLINOIS

METHOD OF PRODUCING DIFFERENTIALLY-TEMPERED METAL

Application filed July 27, 1925. Serial No. 46,255.

My present invention relates to the art of tempering in general, more particularly to the tempering of metal and specifically to the localized hardening of steel castings containing a modifying agent. Broadly considered, the invention comprehends an improved method for tempering, an apparatus for carrying out the tempering method and the resultant improved product.

While the invention has a broad field of usefulness for changing the state of various articles of different composition, I have found it of peculiar utility for producing cast steel car wheels containing manganese as a modifying agent, and I therefore find it convenient to describe the invention in connection with such product; it being understood that such limited fields of specific description are employed purely for purposes of an example of the utility of the invention in its several phases.

The principal objects of the present invention are the provision of an improved method of tempering and apparatus therefor whereby a continuous wearing surface may be treated by a local application of tempering fluids as compared with other portions of the wearing surface, to impart to the casting, particularly where a car wheel casting is made, a wearing surface which, throughout use, will resist the stresses encountered, and maintain its roundness with maximum degree in service.

In the attainment of the foregoing objects and certain additional benefits and advantages to be herein disclosed, I find it convenient to carry out my method by means of an apparatus, the embodiments of which are illustrated in the accompanying drawing. On inspection of this drawing, it will be observed that as above suggested, I have for purposes of convenience in disclosure and description illustrated an apparatus in form adapted for the treatment of a disc-like metallic casting, to wit: in the present case, a flanged cast manganese steel wheel, of a carbon content of say .32% to .38%.

The invention is peculiarly adapted for the treatment of such objects as will be manifest when it is considered that a great desideratum in the hardening of wheel treads is that such hardening be uniform in order that the wheel may wear both uniformly in service and not lose its circular character and at the same time that the hardening be localized to that portion of the tread and throat which is most usual in contact with the rail head in order that the rim of the wheel may wear uniformly and not become curved in cross-section in service.

To this end, therefore, it is most desirable that the outer surface of the flange of the wheel which ordinarily is quite of sufficient hardness without tempering, be not further hardened and similarly, that the outer marginal portion or heel of the tread which is opposite to the flange and receives much less wear owing to its relatively less contact with the rail head be left less modified and relatively soft, so that the wheel and tread in service will wear down uniformly.

It is likewise desirable that the web of the center of the wheel be left free from hardening and in its normal relatively soft state.

In my application, Serial No. 670,486, Patent No. 1,563,170, granted November 24, 1925, I have described a method and apparatus for obtaining a differentially hardened tread surface by shielding portions of said tread against the action of the tempering fluid. Though this process has certain advantages outlined in the application aforementioned, it has been found that aside from the necessity of the use of moving parts of the apparatus described and the necessity for manually or otherwise applying this shield to the article to be tempered, that the desired shielding effect is not obtained to the degree desired due to conduction of heat to the part of the article treated with which the shield must come into contact, or by reason of the tempering fluid finding its way to the article past the protecting shield.

The word "tempering" as employed herein, relates to changing the state of the metal treated, that it, it may apply to either hardening or softening or changing the relative state or condition of various portions of a single casting as will appear, the example illustrated and described being for the purpose of producing a casting of various degrees of hardening in a particular region thereof.

In the accompanying drawing, Fig. 1 is a side elevation taken in section of one form of my tempering apparatus;

Fig. 2 is a fragmentary view similar to Fig. 1, showing the treatment of another portion of an article;

Fig. 3 is a side elevation taken in section of an apparatus for projecting tempering fluid upon an article;

Fig. 4 is a fragmentary view of the apparatus shown in Fig. 3 for treating an article in a different position;

Fig. 5 is a further embodiment of the apparatus shown in Fig. 3;

Fig. 6 is a fragmentary view of the apparatus shown in Fig. 5 with the article in the reverse position;

Fig. 7 is a transverse sectional view of the wheel tread;

Fig. 8 is a carbon iron diagram showing the variation in temperatures and the state of the carbon.

In order to obtain a steel wheel having a differentially tempered tread portion, I initially subject localized portions of the tread and rim of a wheel casting which is still heated above the critical range to partially tempering action for a short period of time; and in my preferred embodiment where a steel wheel is to be tempered, the heel portion of the tread is treated with a tempering fluid until that limited portion has reached a temperature substantially below the critical range.

I have found that in the ordinary form of cast wheel, the heel portion will reach this condition in about from 10 to 15 seconds. After this initial treatment, the casting is removed from the influence of the tempering fluid for a period of time sufficient to permit the heat of the main body of the casting to re-heat the initial portion treated. Preferably this reheating is attained by conduction from the main body of the casting to the portion initially treated.

I have found that sufficient re-heating of the initially treated portion is obtained by the casting such as is herein preferably dealt with, in a period of about 30 seconds, and that this period of time is sufficient to overcome any structural changes which may have taken place at the initial quenching to render the heel portion unduly hard.

After air exposure or after the second step permitting the transference of heat by conduction from the main body of the casting to the portion initially quenched, the entire tread surface of the casting is then given a quenching treatment, rendering the inner surface of the flange, throat, and tread portions extremely hard, whereas the heel portion first treated will be found to be of such softness as will give best operating results in the preferred use herein described. The effect is similar to that produced by quenching the soft portions at lower temperatures.

I have found that quenching from 4 to 4½ minutes is sufficient to impart the desired hardness to the flange and tread areas and a softer effect is obtained at the heel portions or the portions which have been given initial quenching action.

For purposes of carrying out the process above described, I have found the apparatus shown in Fig. 1 to admirably serve the purpose.

Referring to Fig. 1, I have there illustrated a quenching apparatus which I have found to be particularly suitable for treating car wheels and as therein shown 10 is a pan having an annular depression, 11, defined by the upstanding walls 12 and 13 and having an intermediate pedestal 14 arranged concentrically with the upstanding walls 12 and 13. For supplying quenching fluid to this pan, I provide fluid conduits 15, 16, 17 and 18 arranged on either side of the annular grooves defined by the pedestal 14. There is also provided an overflow outlet 19 which may be located to give any desired depth of overflow.

The process is practised preferably as follows:—The casting, for example a car wheel, is treated while at a temperature which is above the critical range in a manner such as will be recognized to be the best practise in such cases, depending upon the chemical composition of the steel that is used. For giving the wheel the initial treatment, the quenching bath may first be prepared so as to have a constant level of quenching fluid. The wheel is then placed into the quenching pan, so that it rests upon the pedestal 14 exposing that portion desired to be treated to the quenching fluid, and in one embodiment of my invention the heel portion 21 is first immersed into the quenching bath. As has been previously described, the wheel is left in the quenching bath for a period of 10 to 15 seconds, where water is used as a quenching fluid.

Though I have described my preferred method of operation as carried out in constant level quenching bath, I may first position the casting upon the pedestal 14 and then gradually supply the quenching fluid for serving the initial quenching operation. This method of quenching will have the function which will be apparent as the discussion proceeds.

After this initial treatment the casting is removed from the influence of the quenching fluid to permit the re-heating of the heel portion 21 by conduction of the heat of the body of the casting which in practice I find is accomplished satisfactorily in about 30 seconds as is above described. Thereupon, the combined areas forming the initially treated heel portion 21 and the tread surface 22 is quenched, and where I use water as a quenching fluid, I have found that a period of from 4 to 4½ minutes will give excellent results.

The process above outlined may be either for initially treating the heel portion 21, or if desired, I may initially treat the flange portion 23 as shown in Fig. 2.

In this way, by a single heating of the casting, the separate parts may be quenched by a series of steps, the length of time necessary for carrying out the steps being sufficient to permit that change in temperature which will obtain best results upon subsequent quenching action.

In Fig. 3, I have illustrated a quenching bath for treating the combined areas of the wheel treated initially as above described, and this apparatus is preferably of a nature described in my application Serial No. 670,486 Patent No. 1,563,171, granted November 24, 1925 in which 24 is a casing adapted to receive quenching fluid from the inlet 25 and having a plurality of series of nozzles 26, 27 and 28 for projecting the quenching fluid, all this preferably in accordance with the apparatus described in my application aforementioned.

In Fig. 4, I have illustrated the apparatus above described in Fig. 3, but shown with the wheel in a reverse position, so that the flange 23 is downwardly directed and the heel portion 21 is upwardly directed, thereby permitting the quenching fluid to gravitate away from the heel portion 21 downwardly upon the flange portion 23.

In Fig. 5, there is illustrated a further embodiment of my invention in which 29 is a casing of the same general form as the casing above described and in my prior application previously mentioned. This casing is divided preferably horizontally by the partition wall 30 forming an upper chamber 31 and a lower chamber 32. These chambers are adapted to have separate quenching fluids fed from independent feeding means or conduits not shown in the drawing. The upper chamber 31 has a plurality of series of nozzles 33, 34, 35 similar to those shown in the embodiments illustrated in Figs. 3 and 4. The lower chamber 35 has a series of nozzles 36. By this form of apparatus, the process may be carried out as follows:—

The casting is taken up at the accustomed temperature for tempering and is then introduced within the confines of the tempering device 29, care being taken by suitable means to have it concentrically positioned with the general axis of the apparatus. The initial localized treatment is then given to the casting by means of a series of jets 36, the tempering fluid being directed against the heel portion 31 in the instance where the casting is positioned with the heel portion downwardly directed as shown in Fig. 5.

Upon the application of the tempering fluid 36 for a period of time, as above described, the flow of the liquid is discontinued for a period sufficient to permit re-heating of the initially localized area that has been treated, that is to say, to permit re-heating by conduction. Subsequently, upon the expiration of the period necessary to produce this effect, the jets 33, 34 and 35 are turned on to direct the quenching liquid upon the entire tread surface, or all the jets 33, 34, 35 and 36 may be turned on to have the combined tread surface 22 and heel portion 21 submitted to the quenching action.

The series of jets 33, 34, 35 and 36 are preferably arranged as in my application aforementioned so that the uppermost jet supplies a larger quantity of quenching fluid than the lowermost series of jets. In this way if desired the continuous surface exposed will be affected by a uniform amount of quenching fluid.

In the embodiment shown in Fig. 6 the casting may occupy a reverse position so that the flange portion 23 is downwardly directed and is first subjected to the initial treatment by the lowermost series of jets 36.

In Fig. 7 there is illustrated a section of the periphery of the cast wheel showing the effect of the differential tempering action in terms of the Brinnell hardness scale. Thus, it will be observed that those portions of the tread surface which are required to be toughest indicate the lower figures while those portions which receive the greatest wear have the higher figures. These may be made gradient from the outermost portion receiving the greatest shock to the innermost portion which is apt to receive the greatest wear in accordance with practice which will be obvious to those skilled in the art. By thus grading the hardness in accordance with the treatment above outlined, uniform wear will be had in use to retain perfect roundness of the wheel contour throughout all of the tread surface.

In Fig. 8 there is shown a carbon-iron diagram, the curves on which indicate the transitions of carbon in steel when subjected to heat, followed by cooling. The upper divergence of the curve, as laid upon the scale, indicates the approximate temperature at which the carbon content of the steel goes into solution with the iron. The lower divergence of the curve indicates upon the scale the approximate temperature at which the carbon goes out of solution with the iron, at which time pearlite is formed. It is known practice to quench steel to obtain hardness while the steel is at a temperature above the upper critical point, since in the application of a quenching medium, after the temperature has fallen below the lower critical point and the carbon has gone out of solution, only a comparatively slight hardening action results.

When steel has been heated to a temperature above the upper critical point and is then subjected to the action of a quenching medium, a very substantial increase in the hardness of the steel is established and it remains in such state until the re-application of sufficient heat to modify the said hardness. The critical points of steel are modified by variations in the chemical constitution of the steel, and therefore the curves on the carbon-iron diagram shown relate to a special composition of steel which I have found best suited to the production of the articles herein mentioned.

It is readily understood that the results obtained by me in producing a car wheel casting having a tread surface of harder characteristics than the localized initially treated surfaces having softer areas,—that is the heel portion or the outer tread portion,—can be and are ascribed to the fact that the heel or rim portion has been quenched at a temperature above the upper critical point, and would be as hard as the center of the tread portion were it not for the fact that the application of the quenching medium is of such short duration that the main body of the casting is not affected thereby, with the result that upon cessation of application of the quenching medium to said heel portion of the tread, there is a substantial reheating or return of heat by conduction to the said heel portion whereby the hardness thereof is substantially modified, even though the said reheating or return of heat increases the temperature of the heel portion to exceed the lower critical point as indicated on the diagram. The subsequent application of a substantial volume of water to the main tread portion of the wheel causes great hardness thereof, but previously to this application the heel portion has been brought below the thermal point at which the further application of water would confer great hardness.

The result of following the various steps of the procedure herein indicated is that I produce an integral car wheel whose main tread or wearing surface is of great hardness, and at the same time the heel or outside of tread portion of the rim is softer and more ductile, thereby establishing a car wheel structure which is much stronger under impact and which will wear more evenly in the regular service which it performs, than otherwise would be the case.

In the claims, where I refer to "continuous wearing surface of metal", I mean to include by the term that character of wear received by a rolling surface, such as a car wheel tread, throat and flange, which are simultaneously exposed to abrasion and compression, in rolling over the rails of the roadway and where I refer to a "uniformly wearing surface" I mean to include thereby the property of a continuous wearing surface to remain substantially of the predetermined contour, when exposed to the wear equivalent to a rolling surface of a car wheel.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent, is:

1. The method of tempering the continous wearing surface of a car wheel casting to impart uniformly wearing characteristics over the entire wearing surface which includes the steps of heating and maintaining the temperature of the same above the critical range, quenching a localized area of the peripheral surface by a plurality of series of streams of fluid arranged one above the other the topmost series having the largest volume of streams, omitting intermediate portions of the tread, withdrawing the quenching fluid and permitting reheating of the localized area from the main body of the casting and then quenching before the casting is cooled, below the critical range.

2. The method of tempering the continuous wearing surface of a car wheel casting to impart uniformly wearing characteristics over the entire wearing surface which includes the steps of heating and maintaining the temperature of the same above the critical range, quenching a localized area of the peripheral surface adjacent to the heel and flange by the application of a quenching fluid, omitting intermediate portions of the tread, withdrawing the quenching fluid and permitting reheating of the localized area from the main body of the casting and then quenching the entire peripheral surface before the casting is cooled below the critical range.

3. The method of tempering the continuous wearing surface of a car wheel casting to impart uniformly wearing characteristics over the entire wearing surface which includes the steps of heating and maintaining the temperature of the same above the critical range, quenching a localized area of the peripheral surface adjacent to the heel by the application of a quenching fluid, omitting portions of the tread intermediate the heel and flange, withdrawing the quenching fluid and permitting reheating of the localized area from the main body of the casting and then quenching the entire peripheral surface before the casting is cooled below the critical range.

In testimony whereof, I have hereunto signed my name this 6th day of July, 1925.

JAMES CAREY DAVIS.