Sept. 13, 1938. J. BRUNNER 2,129,671

METHOD OF MANUFACTURING WHEELS

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Fig. 1.

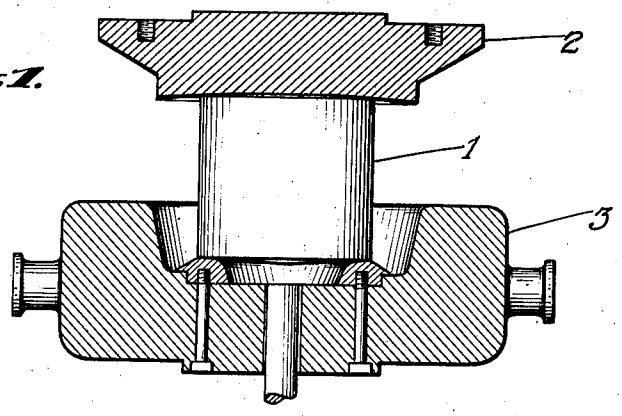


Fig. 2.

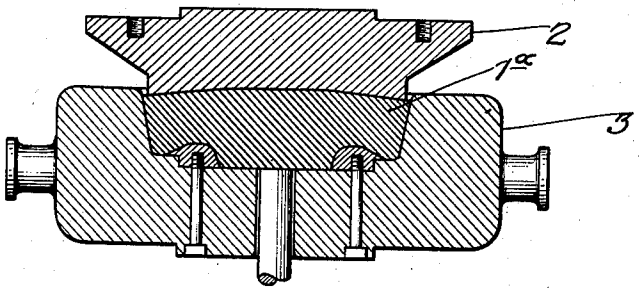
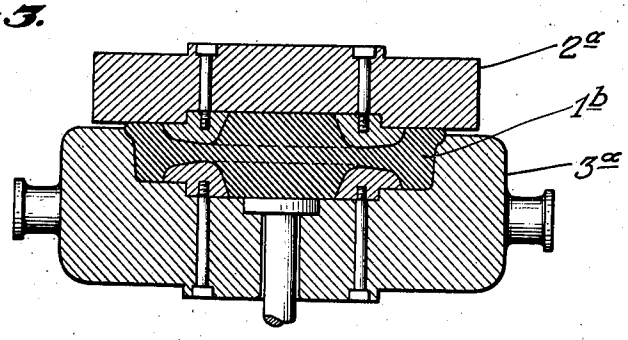


Fig. 3.



INVENTOR.
JOHN BRUNNER.
BY Mann & Lauber
ATTORNEYS

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Fig. 4.

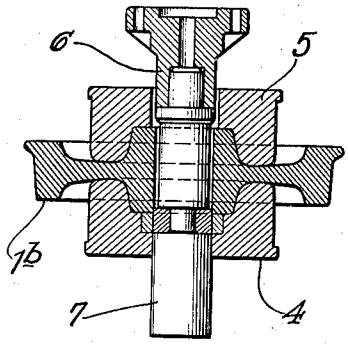


Fig. 6.

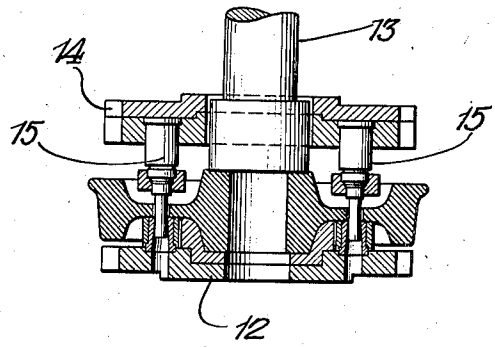


Fig. 5.

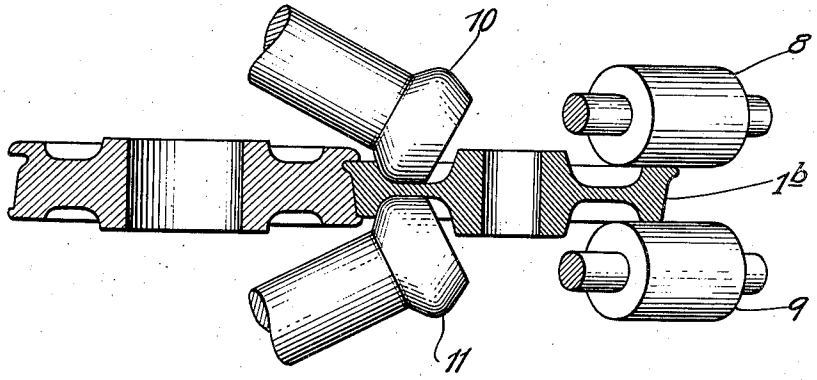
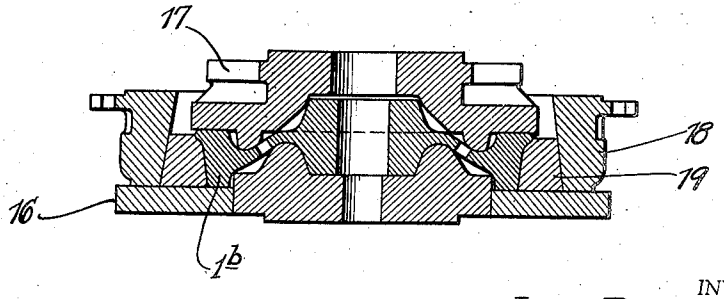


Fig. 7.



INVENTOR.
JOHN BRUNNER.
BY Adams & Rauber
ATTORNEYS

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Fig. 8.

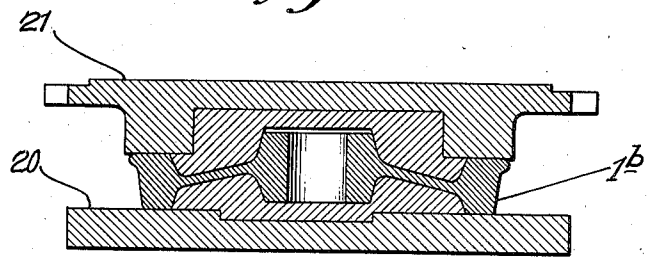


Fig. 9.

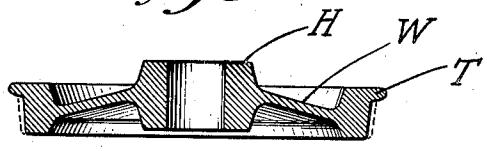
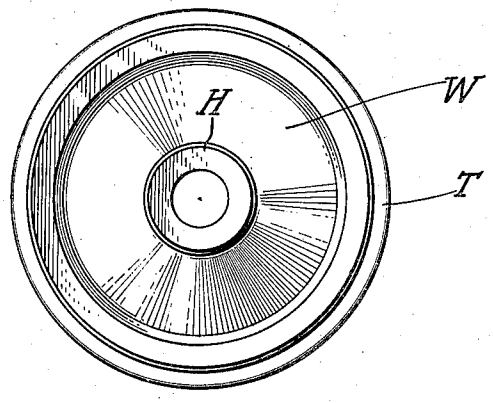


Fig. 10.



INVENTOR.
JOHN BRUNNER.
BY
ATTORNEYS

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UNITED STATES PATENT OFFICE

2,129,671

METHOD OF MANUFACTURING WHEELS

John Brunner, Chicago, Ill.; Cora M. Brunner executrix of will of said John Brunner, deceased

Application October 19, 1935, Serial No. 45,811

5 Claims. (Cl. 148—12)

This invention relates to wrought steel wheels and to a method of manufacturing the same to obtain thereby wrought steel wheels adapted for use under modern high speed service conditions.

One of the objects of the present invention is to provide an improved wrought steel wheel. Another object is to provide an improved method of forming said wheel. Still another object is to provide a method of heat treating a wrought steel wheel to improve its physical properties. Other objects and advantages will be apparent as the invention is more fully disclosed.

In accordance with the above objects I have devised an improved method of manufacturing wrought steel wheels of which the following is a full and complete description. In connection with the following description reference should be made to the accompanying drawings wherein:

Figs. 1 to 8 inclusive illustrate the several steps involved in the fabricating of a wrought steel wheel; and

Figs. 9 and 10 are sectional and side elevational views respectively of the finished wheel product thereby obtained.

Wrought steel wheels produced in accordance with the present invention are manufactured from steel having the following composition:—

Carbon	per cent	.35–.85
Manganese	do	.50–1.00
Silicon	per cent max	.40
Sulfur	do	.05
Phosphorus	do	.05

To this basic steel may be added, if desired, one or more of the following elements:—

Chromium	to 1.50%
Molybdenum	to .30%

If desired aluminum and titanium may be employed in the steel composition as deoxidizing agents and consequently may be present therein in residual percentages ranging from a trace up to about .05 per cent maximum.

In the manufacture of a wrought steel wheel from steel of the above identified composition a round ingot 1 is first produced either by casting a round ingot of desired diameter or by rolling an ingot into round blooms of the desired diameter. These ingots or blooms are then cut into unit lengths required in forming the wheels. These unit lengths are allowed to cool to atmospheric temperatures and the outer surfaces thereof are freed from scale and surface imperfections and prepared for mechanical deformation by pickling and chipping. The thus prepared unit lengths are then heated to a temperature approximating 1200° C. preparatory to mechanical deformation and the wrought wheel product is shaped therefrom.

Mechanical deformation of the ingot or bloom 1 to the desired wrought wheel product proceeds in a sequence of forging steps. The ingot is first placed between complementary dies 2—3 of a forging press (Fig. 1) and compacted therebetween into the shape 1^a indicated in Fig. 2. The specific structure and operation of dies 2 and 3 or of the dies hereinafter referred to form no part of the present invention and need not be further described.

The shape 1^a then is placed between a second set of complementary dies 2^a—3^a and compacted into the shape 1^b (Fig. 3).

The shape 1^b then is disposed in a punch press comprising a base 4, a hold down ram 5 and a punching ram 6 (Fig. 4) and the center hub opening for the wheel is made therein. Section 7 represents the metal removed by punching ram 7 in the forming of the said hub opening.

The temperature of the shape 1^b is again raised to about 1200° C. and the tread and web sections thereof are subjected to a rolling operation by the two sets of rolls 8—9 and 10—11 respectively (Fig. 5), operating simultaneously substantially as indicated.

From this rolling operation shape 1^b may be passed to a coning press (Fig. 8) or to a web punching press (Fig. 6) before passing to a coning press (Fig. 7). Web punching press (Fig. 6) comprises a base 12, a hold down ram 13 and punching ram 14 carrying a plurality of punch extensions 15—15, wherein the web section of shape 1^b is perforated as may be desired. When shape 1^b is subjected to a web-punching operating as in Fig. 6 it is usual to subject the shape 1^b to a coning operation wherein the web section is angularly displaced from the horizontal center line axis of the shape 1^b and the tread section of the wheel is displaced to bring the upper edge thereof in line with the center horizontal axis of the hub section of the wheel, substantially as indicated in Fig. 7. The coning press employed comprises a base 16, a coning ram 17 and a side or tread centering ram 18 which operates on annular die member 19 to set the tread on the periphery of shape 1^b. In operation coning ram 17 first is lowered to the position shown thereby angularly displacing the web and tread sections of the shape 1^b with respect to its hub section. Thereafter the

tread centering ram 18 is lowered which engages annular die member 19 forcing it against the periphery of the tread section and centering the same.

Where the web punching operation (Fig. 6) is omitted, shape 1b may be placed in the coning press (Fig. 8) and the web and tread sections thereof displaced with respect to the hub section substantially as indicated. In Fig. 6 shaped 1b is shown between base 20 and coning punch 21 of the said coning press.

The final wrought steel wheel product obtained from the shape 1b when mechanically deformed in coning press of Fig. 8 is indicated in Figs. 9 and 10 showing sectional and side elevational views thereof respectively. The hub, web and tread sections of the said product have been identified by the letters H, W and T respectively.

The thus fabricated wheel product, or the wheel product indicated in Fig. 7, at the conclusion of the series of forging operations above described have a temperature approximating 900° to 1100° C. The usual practice is to place the wheel upon cooling beds whereon they are allowed to cool to atmospheric temperatures, following which the wheels are machined and otherwise shaped to desired final configuration.

I have found, however, that the wrought steel wheels thus fabricated may be markedly improved in strength and resistance to wear, by subjecting the same to a heat treating and cooling process prior to the final machining operation, which process is designed to refine the grain structure thereof to eliminate most of the working and cooling stresses therefrom, and to prevent the formation therein of such cooling stresses tending to develop internal fissures and ruptures during the subsequent service life of the wheel.

In accordance with the present invention I permit the forged or wrought wheel to cool on the cooling bed only until the temperature of the heavier sectional parts thereof, such as the hub and tread sections, each have passed through the so-called "thermal critical range" but before any part of the wheel has cooled to a temperature as low as the so-called martensite forming temperature (about 400° C.) I reheat the entire wheel to temperatures slightly above the so-called "thermal critical range" and then permit the wheel to cool at a rate at least as fast as that occurring in freely moving air until all sections of the wheel have reached a temperature within the range 350° to 550° C. The wheels are then again reheated slowly to a temperature within the range 450° C. to 600° C. and then are placed under suitable covers or hoods wherein they are cooled at a rate slower than the normal rate in freely moving air down to approximate atmospheric temperatures (40° to 100° C.).

By the practice of the first step of this treatment process, I permit the steel composition in cooling following mechanical deformation to undergo transformation from austenite to ferrite but before the temperature has dropped low enough for martensite to form, I interrupt the cooling and reheat the wheel to a temperature just above the thermal critical range thereby again converting the steel structure to austenite. The austenite thus formed is relatively fine grained as compared to that present at the conclusion of the mechanical deformation operation.

I then permit this fine grained austenite to again pass through the thermal critical range at a rate approximating the normal rate for cooling in freely moving air, whereupon the fine grained austenite is converted or transformed back into fine grained ferritic structures. The fine grained structure thus obtained throughout the wheel is relatively stronger than the coarser grained or non-uniform grained structure ordinarily present in such wrought steel wheels in accordance with prior art practices.

To prevent the formation of any material amount of martensite with its accompanying hardening effects I interrupt the cooling of the wheel before any section of the wheel has cooled to temperatures as low as 350° C. Thereafter in order to provide for a suitable time interval within which all of the steel can undergo transformation into sorbitic structures, I reheat the wheel slowly to a temperature within the range 450° C. and 600° C. and hold the wheel at such temperature for such a time interval as will permit the steel to undergo substantially complete transformation into ferritic structures (sorbitic) other than martensite.

Thereafter, I permit the wheel to cool at a rate slower than the normal cooling rate in free air down to approximate atmospheric temperatures, which is adapted to permit the release of substantially all internal stresses and strains incident to the transformation of austenite into ferrite, or the reduction of the same to such a low order that during the subsequent service life of the wheel the development of internal fissures and cracks is substantially avoided.

The specific rate employed in the last cooling step is in part dependent with any given steel composition within the range above identified upon the size, shape and configuration of the wheel and the mass of its heavier sections, and selected to give a substantially uniform rate of cooling for all parts of the wheel so that cooling stresses between the heavier and lighter sections will not develop, and to give a minimum temperature gradient between the inside and outside of the said parts so that internal stresses and strains incident to such cooling gradient are substantially eliminated.

It is apparent that the specific mode of cooling to accomplish the purposes of the present invention, namely, (*a*) to refine the grain structure and (*b*) to remove rolling and cooling stresses, may be widely varied without departure from the present invention depending upon the steel composition and the specific wheel product obtained therefrom.

As a specific embodiment of the practice of the present invention, but not in any sense as a limitation thereof, I will describe the present invention as it has been practiced in the manufacture of wrought steel wheels for service on the super high speed trains of recent development. Such trains are constructed of light weight material and are streamlined for higher speeds ranging up to 120 miles per hour. The traffic stresses put on the wheels at these high speeds are tremendous and the frictional wear to which they are exposed are greatly in excess of normal conditions. It is highly essential that such wheels possess the maximum strength and ductility to resist such traffic stresses and that the tread sections thereof have the maximum wear resistance. Obviously, such wheels also must be substantially free from internal stresses and strains tending to subsequently develop internal cracks and fissures.

Preferably, the wheels are comprised of steel having the following composition:

Carbon	per cent	.40 to .75
Manganese	do	.50 to .90
Silicon	per cent max	.35
Sulfur	do	.04
Phosphorus	do	.04

At the completion of the mechanical deformation steps above described the wrought wheel product is at a temperature within the range 920° C. to 1065° C. This wheel is placed on the cooling bed and permitted to cool in freely moving air until the hub and tread sections thereof are within the range 400° C. and 700° C. At the normal rate of cooling in freely moving air steel of this composition should undergo transformation at a temperature approximating 720° C. All parts of the wheel, however, do not cool at the same rate, the heavier the section the slower the rate of cooling. Accordingly, the web section being the thinner section will cool more rapidly than the run or tread section and the hub section will cool still more slowly.

I therefore carefully watch the temperatures of the web and before this section cools as low as the martensite forming temperature I interrupt the cooling and reheat the wheel to temperatures slightly above the thermal critical range, which with the steel composition given approximates 800° C. to 850° C.

The reheated wheels are held at this temperature for a time interval at least sufficient to attain uniformity of temperature and they are again placed on the cooling bed and allowed to cool in freely moving air down to a temperature not lower than 350° C. and not above about 550° C.

In order to avoid marked temperature differentials between the tread, web and hub sections and to maintain the rate of cooling of each section substantially identical, I prefer to regulate the rate of air flow past the wheel through the use of an oven enclosing the said wheel from the atmosphere and provided with adjustable louvre means in the top and bottom of the oven to regulate the circulation of air therethrough over the wheel.

As the temperature of the wheel reaches the range 350° C. to 550° C., I again place the wheel in a suitable furnace and slowly heat the wheel up to a temperature within the range 450° C. and 600° C., the time interval of heating and holding at this temperature being at least approximating one hour and a half to two hours.

The wheel is then removed from the furnace and placed under a hood or cover wherein a cooling rate of approximately 50° per hour may be obtained. This cooling rate may be most conveniently obtained by regulating the rate of heat loss through the thermal insulation of the cover, as one skilled in the art may perceive, utilizing a pyrometer determination within the cover to determine the actual temperatures therein. The precise manner of effecting or obtaining this specific rate of cooling forms no part of the present invention. I permit the wheel to cool at this slow rate until the temperature approximates atmospheric temperatures (40° C. to 100° C.).

The thus cooled wheel is then ready for final machining to the required size and section. If desired such machining may be done under a cooling fluid to prevent the building up of excessive machining stresses. After machining the wheel may be annealed by heat-treating to temperatures approximating 400° C. to remove machining stresses. To avoid the introduction of cooling stresses the annealed wheel should then be cooled slowly at substantially the same rate hereinabove described.

The present invention having been broadly and specifically described, it is apparent that many adaptations thereof may be made without departure therefrom, and all modifications and adaptations of the same are contemplated as may fall within the scope of the following claims:

What I claim is:

1. The method of forming a wrought steel wheel which comprises mechanically deforming a blank work piece into said wheel at temperatures substantially above the so-called "thermal critical range" of the steel composition comprising said work piece, cooling said wheel at the normal rate in freely moving air through the said critical range down to temperatures appreciably above the martensite forming temperature, reheating the wheel to temperatures just above the said thermal critical range, again cooling at the normal rate in freely moving air through the said critical range, interrupting said cooling before any portion of the said wheel has reached the martensite forming temperature, equalizing the temperature of the wheel at a temperature within the range 450° C. to 600° C. and holding the said wheel at said temperature for a time interval adapted to produce substantially complete transformation of the austenite into ferrite structures other than martensite, and thereafter cooling the wheel down to approximate atmospheric temperatures at a rate slower than the normal rate in freely moving air which is adapted to maintain a desired temperature differential between the inner and outer portions thereof and between the different sized sections thereof effective to prevent the formation of a deleterious magnitude of internal stresses and strains in the cooled wheel product.

2. The method of claim 1, in which the temperature of mechanical deformation is within the range 900° C. to 1200° C., the minimum temperature of cooling for any wheel section during the first cooling step is 400° C., the temperature of reheating after said first cooling step is within the range 300° to 350° C., the rate of cooling during said second cooling step is regulated by control of the rate of air flow past the wheel to induce substantially uniform cooling between heavier and lighter wheel sections and the minimum temperature of cooling for any wheel section during said second cooling step is within the range 350° to 550° C., the time interval of heating and holding within the range 450° C. to 600° C. after said second cooling step is from one and one-half to two hours, and the rate of cooling in the third or last said cooling step approximates 50° C. per hour.

3. The method of manufacturing wrought steel wheels which comprises forming a blank work piece of a size and configuration adapted to be mechanically deformed into a wheel, heating the work piece to a temperature approximating 1200° C. and mechanically deforming the same to desired final size, shape and configuration without permitting the temperature of the said work piece to drop below about 900° C., cooling the thus formed wheel product in freely moving air to a temperature below the transformation temperature but above the temperature of martensite formation, reheating the wheel to temperatures approximating but above the upper critical temperature and holding the wheel at this tempera-

ture for a time interval adapted to obtain entire conversion of the ferritic structures into austenite, again cooling the wheel in freely moving air until all sections of the wheel are at a temperature within the range 350° to 550° C., reheating the wheel slowly to a temperature within the range 450° C. to 600° C. and holding the wheel at a temperature within this range for a time interval adapted to permit substantially complete conversion of the austenite into ferritic structures other than martensite and then cooling the wheel to atmospheric temperatures at a rate slower than the rate of cooling in freely moving air.

4. The method of manufacturing wrought steel wheels which comprises forming a blank work piece of a size and configuration adapted to be mechanically deformed into a wheel, heating the work piece to temperatures approximating 1200° C., mechanically deforming the heated work piece into approximate final size, shape and configuration without intermediate cooling of the work piece to below about 900° C., cooling the wheel in freely moving air until the temperature of the heavier sections thereof have been cooled to below the transformation temperature but before any section of the wheel has cooled to 400° C. reheating the wheel to temperatures above the thermal critical range, then again cooling the wheel in freely moving air until all sections of the wheel have reached a temperature within the range 350° C. to 550° C., and reheating the wheel slowly to temperatures within the range 450° C. to 600° C., holding the wheel at this temperature for a time interval adapted to permit substantially complete conversion of austenite into ferritic structures stable at the holding temperature, then cooling the wheel at a rate slower than the rate of cooling in freely moving air until a temperature at least approximating 40° to 100° C. is obtained.

5. The method of manufacturing wheels comprised of steel containing carbon .40 to .75%, Mn .50 to .90%, silicon .35% maximum, and sulfur and phosphorus each .04% maximum, which comprises mechanically deforming the wheel from a blank work piece to desired approximate size, shape and configuration at temperatures within the range 920° C. to 1200° C. without permitting cooling of the same to below this range, cooling the thus formed wheel product in freely moving air until the hub and tread sections thereof are within the range 400° C. to 700° C. and before the web section of the wheel cools to a temperature as low as the martensite forming temperature, reheating the entire wheel to temperatures within the range 800° C. to 850° C., holding the wheel at this temperature for a time interval adapted to convert the ferrite entirely into austenite and to obtain substantially uniform temperatures throughout, again cooling the wheel in freely moving air until all sections of the wheel are cooled to a temperature within the range 350° C. to 550° C., reheating the wheel slowly until all sections are at a temperature within the range 450° C. to 600° C. and holding the wheel at this temperature, the time interval of heating and holding being at least one and one-half to two hours, and cooling the said wheel at a rate of approximately 50° per hour until cooled to temperatures approximating 40° to 100° C.

JOHN BRUNNER.