Dec. 20, 1932. C. J. SCUDDER 1,891,505

LOCOMOTIVE AXLE AND CRANK PIN AND METHOD OF CONSTRUCTING THE SAME

Filed Nov. 3, 1931

Fig. 1

Fig. 2

INVENTOR

Charles J. Scudder

BY

ATTORNEYS
My invention relates to construction of locomotive axles and crank pins and a more exact method of obtaining final heat treatments thereof, and has for its object the provision of construction and method thereof of the character designated which shall effectively greatly prolong the service life of axles and crank pins and greatly increase their initial strength.

A further object of my invention is to provide locomotive axles and crank pins which shall comprise an outer surface of ductile, resilient material suitable to resist bearing friction and rolling and chafing action of the journals, and a center portion of harder, tougher and stronger materials to more effectively resist torsional and bending strains.

A still further object of my invention is to provide a composite structure of the character described comprising an outer shell having ductile wearing properties suitable for exterior fit bearings, and an interior structure of a tougher, stronger, strain resisting, harder material, the whole having each part separately heat treated and afterward fitted together to form a unitary structure.

A still further object of my invention is to provide by a method of construction a composite locomotive axle and crank pin whereby to increase their wearing and enduring qualities and initial strengths which shall avoid certain inequalities of grain structure found in forgings of large diameters.

A still further object of my invention is to provide a method of constructing composite locomotive axles and crank pins whereby the separate parts entering into the composite structure lend themselves more readily to more reliable heat treatment than with such constructions as heretofore known in the art, whereby the metal entering into the construction is more exactly and evenly treated resulting in a more homogeneous undisturbed crystalline structure.

As is well known in the art to which my invention relates, locomotive driving axles and crank pins have always caused considerable trouble, due to failure after certain limited periods of service. These failures are usually brought about by exterior fractures or heat checks which work progressively inward and finally work their way through the entire axle or crank pin journal until failure occurs. Such failure with the locomotive in service is a serious one, sometimes entailing much greater damage than the breakage of the member itself and danger to the lives of the occupants of the locomotive and train.

To obviate such failures, it has become the practice of a number of railroads to place a definite age limit on axles and crank pins at which time they are removed from the locomotives and replaced by new ones, regardless of whether they show any evidence of weakness or failure or not. Other railroads have established a minimum diameter for these parts so that as soon as they wear down to the minimum diameter, regardless of their appearance, they are removed from the locomotive and scrapped.

It has heretofore been the practice to construct locomotive axles and crank pins from solid forgings. The axles may be as much as fourteen inches or larger in diameter and seventy inches in length. The crank pins may be as much as twelve inches or more in diameter and twenty-four inches in length. With such large forgings, the only metal entering into the structure which is adequately worked is that extending inwardly from the surface to a depth of two or three inches. The metal of the center of the forgings receives inadequate working and ruptures occur during the forging and tempering processes within the interiors of the large bodies of metal. Furthermore, the difficulties of suitably annealing and tempering such forgings are very great as it is practically impossible to heat the interiors to as high temperatures as the surfaces. With
an axle as large as thirteen inches in diameter, for instance, it is considered best practice to heat the axle for thirteen hours to bring it to the required temperature for annealing and a corresponding length of time is required for cooling and normalizing it.

It is accordingly apparent that a structure which combines the qualities of resiliency, ductility, and wearing properties suitable for the exterior, and tougher, stronger, strain resisting materials for the interior, the whole being heat treated to a more exact and uniform degree, is one which would give a much longer, more satisfactory, more durable service life, and is therefore more desirable.

In accordance with my invention, I attain the above much desired objects, by first forging an axle or crank pin from a solid billet of steel having qualities suitable for the exterior wearing surface. I then bore out a considerable amount of the interior portion which cannot be so effectively worked by before mentioned suitable for the interior of the axle. If the core is eight inches or more in diameter, I preferably bore out its center, removing from two to two and one-half inches diameter of the center thereof. This central core is then accurately also heat treated and preferably quenched in oil, drawn and cooled in the furnace in most approved manner. The time of heating and cooling will be proportionately the same as that for the exterior shell.

By way of illustration, the following sets forth in tabular form the heat treatment, chemical composition, and physical properties of the materials which I have found suitable in the construction of locomotive axles and crank pins as herein set forth. The data being given for the outer shell and the core respectively. It will be apparent, however, that these details may be varied in wide ranges without departing from the scope of my invention.

### Outer shell

<table>
<thead>
<tr>
<th>Material</th>
<th>Heat treatment</th>
<th>Chemical composition</th>
<th>Physical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel steel</td>
<td>Normalized and drawn. Cooled in the furnace.</td>
<td>Carbon: 30 to 32%</td>
<td>Yield point: 55,000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manganese: 0.9 to 1.0%</td>
<td>Tensile strength: 40,000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phosphorus: Max 0.045</td>
<td>Elongation: 22%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulfur: Max 0.045</td>
<td>Reduction of area: 60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silicon: 0.15 to 0.25</td>
<td></td>
</tr>
</tbody>
</table>

### Core

<table>
<thead>
<tr>
<th>Material</th>
<th>Heat treatment</th>
<th>Chemical composition</th>
<th>Physical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chrome-nickel steel</td>
<td>Oil quenched and drawn. Cooled in the furnace.</td>
<td>Carbon: 0.45 to 0.55%</td>
<td>Yield point: 110,000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manganese: 0.30 to 0.60</td>
<td>Tensile strength: 130,000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phosphorus: Not over 0.04%</td>
<td>Elongation: 15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulfur: Not over 0.045</td>
<td>Reduction of area: 55%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nickel: 1.5 to 2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chromium: 0.90 to 1.25</td>
<td></td>
</tr>
</tbody>
</table>

After the central core is forged, then bored if necessary, and heat treated as hereinbefore set forth, it is turned to tightly fit within the bored exterior or outer shell of the axle or crank pin. It is then fitted into the outer shell in a manner to form a unitary composite structure, by a hydraulic press or by shrinking in place, by the outer shell cooling from its heat treatment with the core inserted or by combination of these two, or by any suitable means known to the art.

In the drawing hereto annexed and forming a part of this application,

Fig. 1 is a view partially in section and partially in elevation, showing the locomotive driving wheel assembly of my arrangement having the improved axle and crank pin construction embodied therein; and

Fig. 2 is a cross sectional view taken along the line II—II of Fig. 1.

Referring to the drawing for a better understanding of my invention, I show a pair of locomotive driving wheels 10 mounted in
a frame 11. The driving wheels 10 are mounted upon an axle comprising an outer shell 12 and an inner core 13, both constructed as hereinbefore set forth. The axle is mounted in a driving box 14 having the usual bearing 16 therein.

Carried by each of the driving wheels 10 is a crank pin comprising also an outer shell 17 and an inner core 18, both constructed as hereinbefore set forth. The outer surface of the crank pin shell 17 is turned to provide bearing surfaces 19 and 21 for the locomotive rods, not shown.

The outer ends of the pins 18 are provided with portions for engagement with the usual crank arms in customary fashion. It is also preferable, after forging the inner cores 13 of the axle and 18 of the pin, to bore them out centrally as at 22 and 23 in order to detect flaws in the interior of the metal and also to facilitate the heat treatment thereof. With axles and crank pins of the sizes described, the amount of material removed may be as much as two inches diameter or over.

The shell and core of the composite arrangement described each has approximately one half the cross sectional area of the complete axle or crank pin and accordingly about one half the mass. The removal from the solid forgings of material having a lower physical value than the surface and replacing it with material refined to a higher degree, quenched and tempered to have higher physical properties than the portion removed from the initial bulky forgings, results in an increase of approximately 50% in strength for the composite structure over a similar size solid structure.

It will be apparent that the forging and heat treatment of the smaller sections comprising the shell and core of the composite structure may be more readily handled when tempered and quenched and treated in oil, such as is practiced by present day metalurgists, as it is well understood that high carbon alloy steels do not as satisfactorily quench in large as they do in small sections, and in this way effecting an improvement.

It will furthermore be apparent that by the use of my improved composite structure I provide one comprising an outside part of steel having properties that resist heat stresses, chafing and rolling action more readily and one having a higher ductility. The interior also being comprised of a core of steel which is not required to resist the heat stresses of the exterior, but has greatly improved physical properties over a heat resistant and disseminating steel when made in the solid, in the way of greater strength and toughness, the whole resulting in a composite structure having greater strength and longer life than heretofore been possible.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed, boring out the interior of the member, heat treating the hollow shell thus formed, forging a core to fit the hollow shell, and forcing the core into the hollow shell to form a composite structure, without further heating the shell.

2. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed, boring out the interior of the member, heat treating the hollow shell thus formed, forging a core to fit the hollow shell, heat treating the core, and without subjecting either of said parts to further heating joining the core to the hollow shell to form a composite structure.

3. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed and of a material adapted to withstand bearing friction, boring out the interior of the member to form a hollow shell, heat treating the hollow shell, forging a core for the shell from relatively tougher material than the shell, and fitting the core to the shell without further heating of the shell, in a manner to obtain a substantially solid composite structure.

4. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed and of a material adapted to withstand bearing friction, boring out the interior of the member to form a hollow shell, heat treating the hollow shell, forging a core for the shell from relatively tougher material than the shell, heat treating the core, and without further heating the core or the shell, fitting the core to the shell in a manner to obtain a substantially solid composite structure.

5. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed and of a material adapted to withstand bearing friction, boring out the interior of the member to form a hollow shell, heat treating the hollow shell, forging a core for the shell from relatively tougher material than the shell, heat treating the core, and without further heating the core or the shell, press fitting the core to the shell to obtain a substantially solid composite structure.

6. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed, bor-
ing out the interior of the member centrally thereof to remove substantially 50% of the material thereof, heat treating the resulting cylinder, forging a core for the heat treated cylinder, and without further heating the cylinder, tightly fitting the core into said cylinder.

7. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed, boring out the interior of the member centrally to remove up to 60% of the material thereof, heat treating the resulting cylinder, forging a core for the heat treated cylinder, heat treating the core, and without further heat treating the core or the cylinder tightly fitting the core into said cylinder.

8. The method of constructing locomotive axles and crank pins which consists in forging solid the member to be constructed and of a material adapted to withstand bearing friction, boring out the interior of the member centrally thereof to remove material ineffectively worked by forging, heat treating the resulting cylinder, forging a core for the cylinder of a relatively tougher material than the cylinder, boring out the core centrally thereof, heat treating the core, and pressing the core into the cylinder to form a composite structure.

9. In a device of the character described, an outer heat treated shell of relatively hard, ductile resilient steel, and an inner central core firmly mechanically united to the outer shell and comprising separately heat treated steel relatively tougher, stronger and harder than the outer shell.

10. In a device of the character described, an outer heat treated shell of relatively hard, ductile resilient steel, and an inner central core firmly united to the outer shell and comprising separately heat treated steel relatively tougher, stronger and harder than the outer shell, said inner core comprising approximately 50% of the total mass of the device.

11. In a device of the character described, an exterior shell of heat treated steel of relatively low carbon content and relatively low tensile strength, said shell comprising as much as 50% of the mass of the device and a central core rigidly joined to the exterior shell and of separately heat treated steel of a higher carbon content and higher tensile strength than the exterior shell.

12. In a locomotive axle, an exterior cylindrical shell of heat treated material having relatively high ductility and relatively high frictional resistance properties, and a separately heat treated cylindrical core rigidly joined to the outer shell having relatively greater tensile strength and higher yield point than the exterior shell.

13. In a locomotive crank pin, an exterior cylindrical shell of heat treated material having relatively high ductility and relatively high frictional resistance properties, and a separately heat treated cylindrical core rigidly joined to the outer shell having relatively greater tensile strength and higher yield point than the exterior shell.

14. A locomotive axle comprising a heat treated steel outer shell comprising not less than sixty percent of the mass of the axle and having a tensile strength of not less than 80,000 pounds and a yield point of not less than 55,000 pounds; and a central separately heat treated steel core rigidly joined to the outer shell and having a tensile strength of not less than 130,000 pounds and a yield point of not less than 110,000 pounds.

15. A locomotive axle comprising a heat treated steel outer shell comprising not less than sixty percent of the mass of the axle and having a tensile strength of not less than 80,000 pounds and a yield point of not less than 55,000 pounds; and a central separately heat treated steel core rigidly joined to the outer shell and having a tensile strength of not less than 130,000 pounds and a yield point of not less than 110,000 pounds, said central core being bored for heat treatment and having not more than 55 percent of its material removed.

In testimony whereof I affix my signature.

CHARLES J. SCUDDER.