A. C. CUNNINGHAM.

STEEL CAR AXLE AND METHOD OF MAKING THE SAME.

APPLICATION FILED DEC. 17, 1908.

938,827.

Patented Nov. 2, 1909.

2 SHEETS—SHEET 1.

Fig. 1.

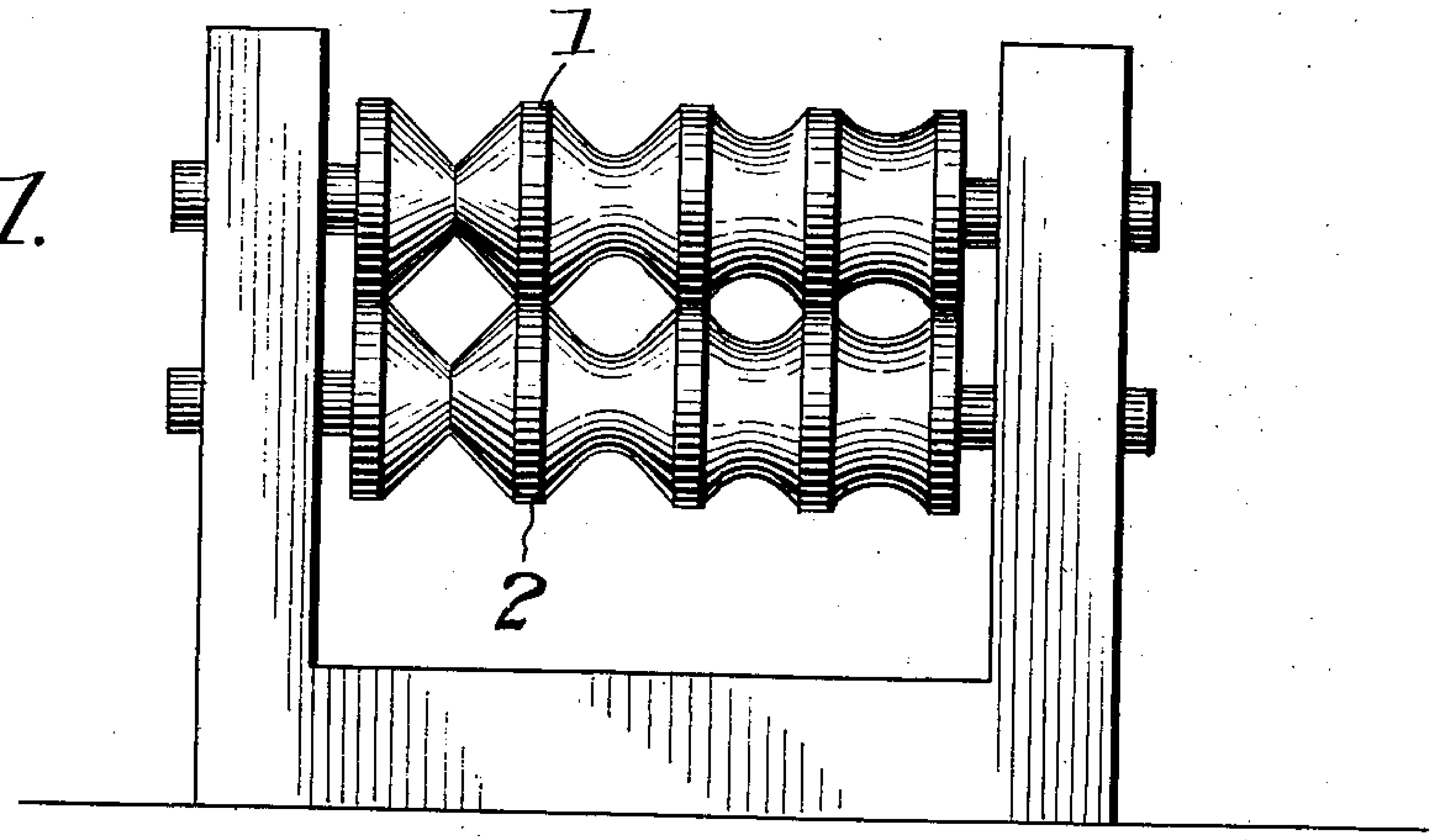
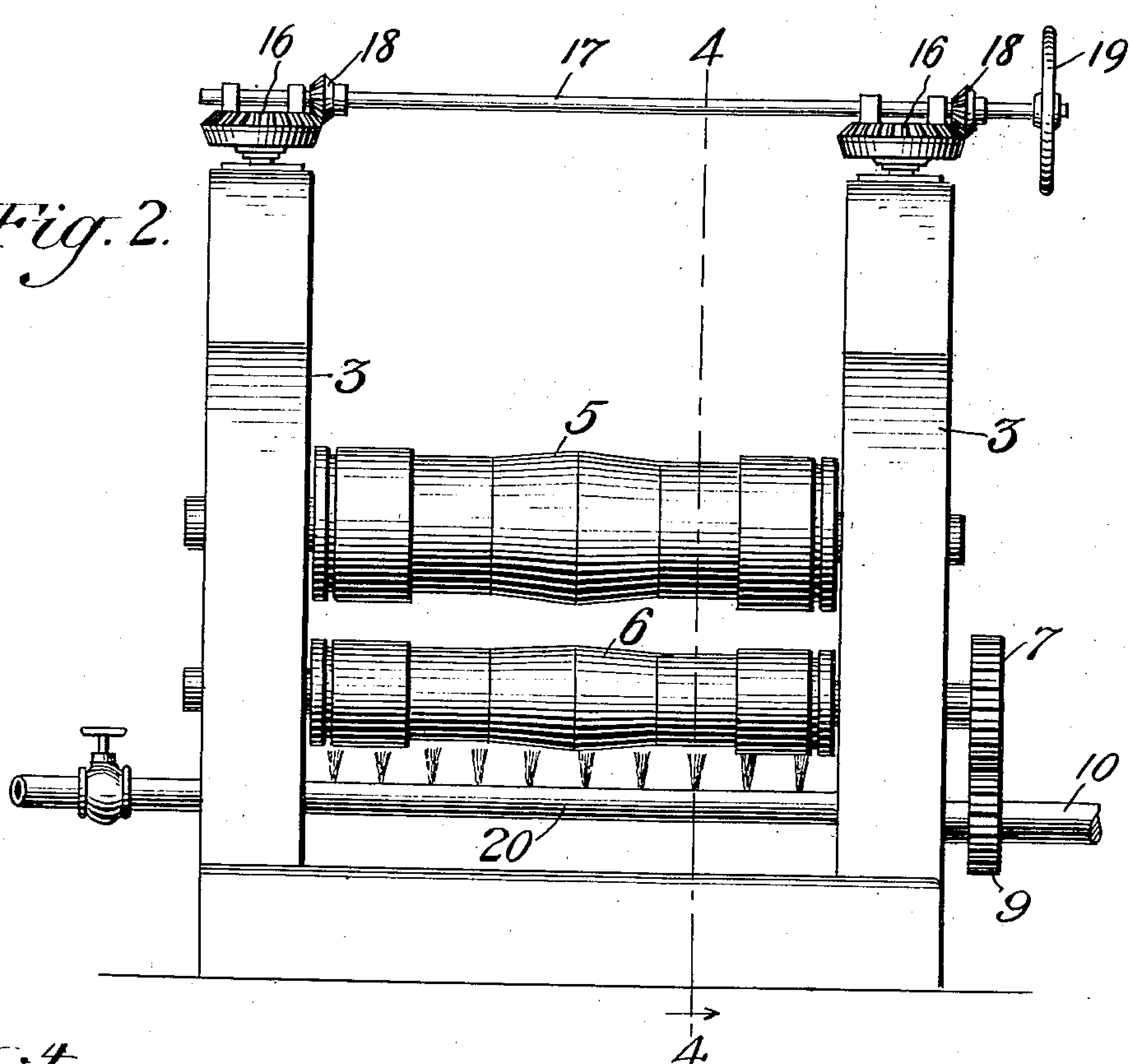


Fig. 2.



Witnesses.

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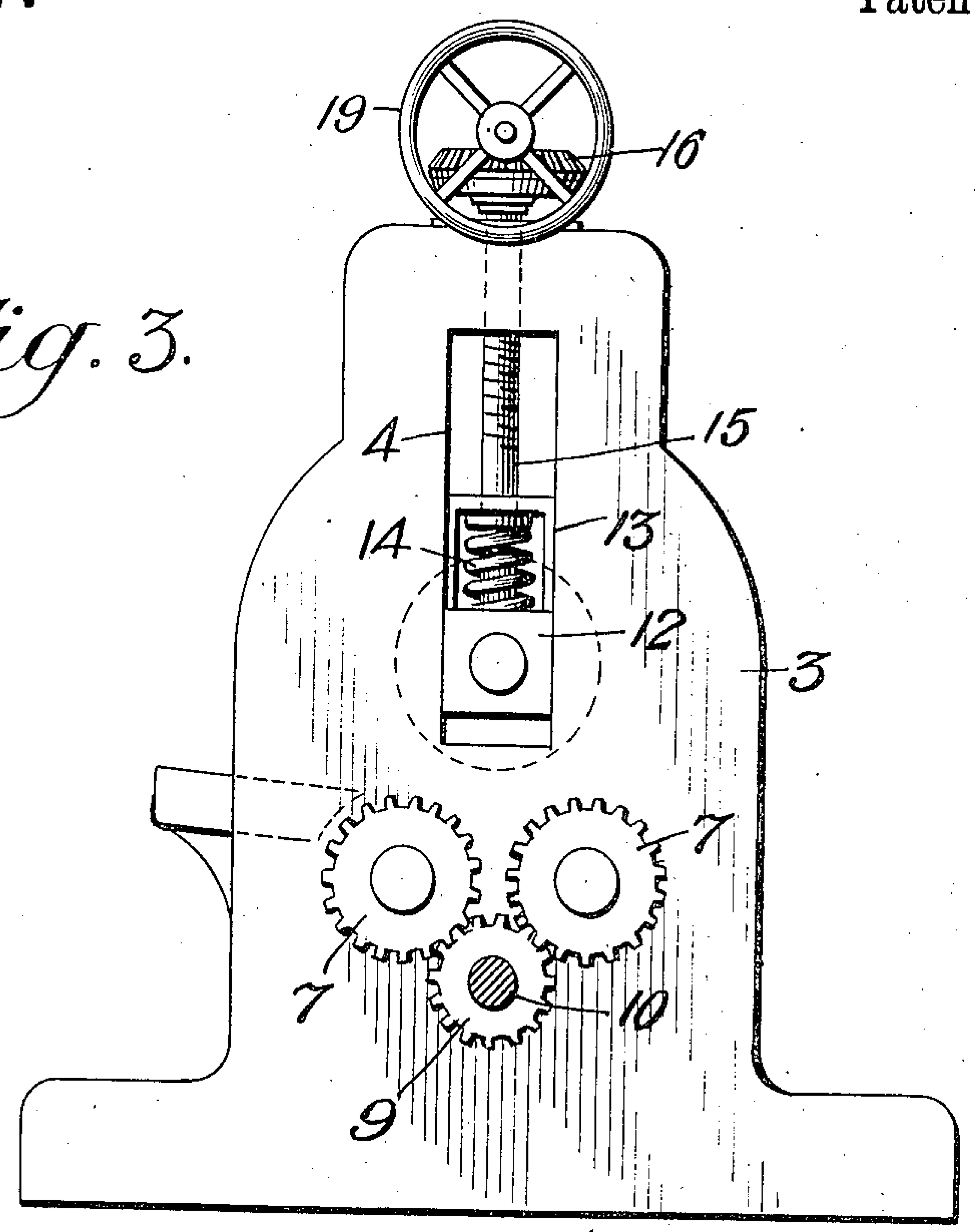

Fig. 3.

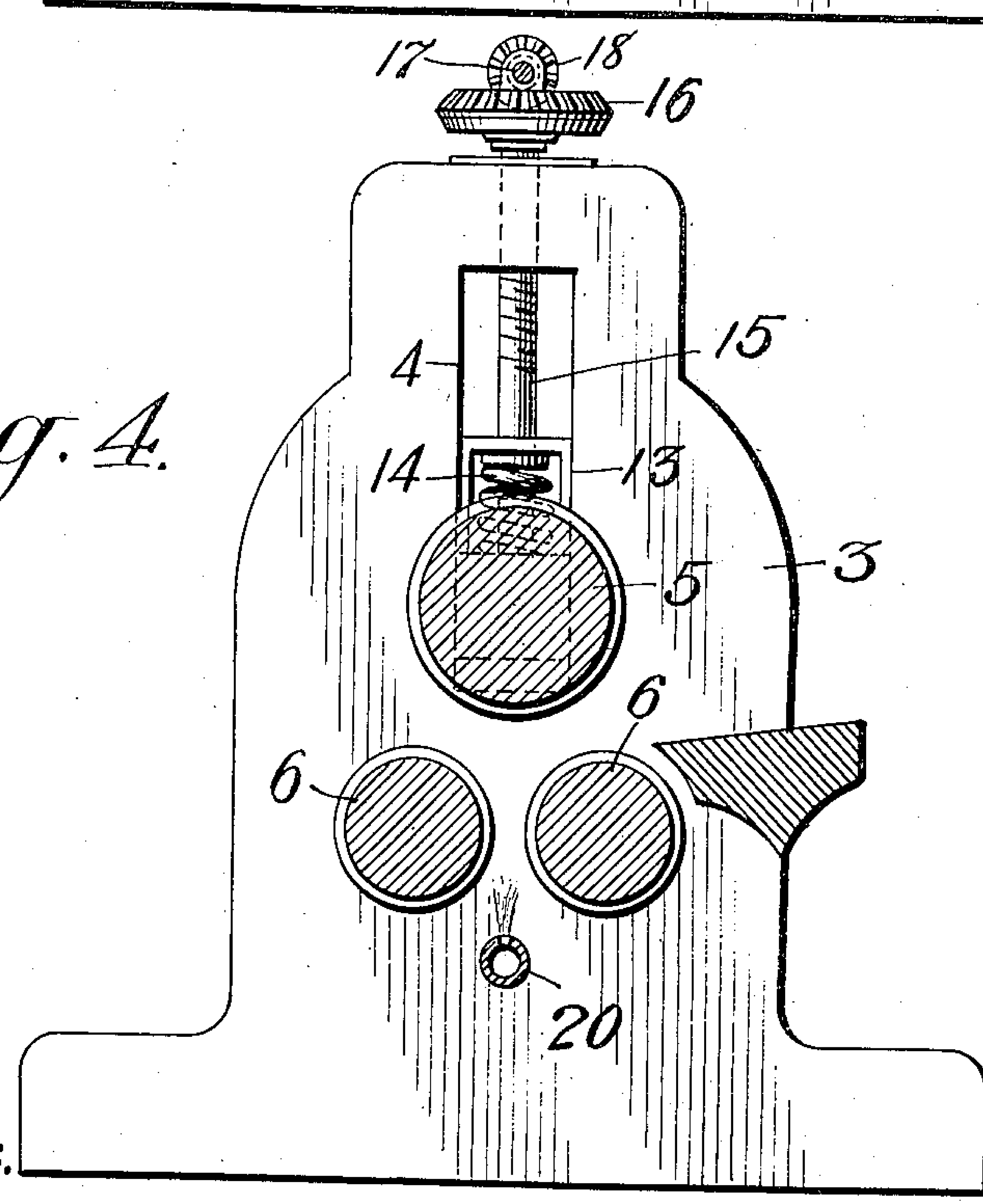

Fig. 4.

Witnesses.

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[illegible]

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UNITED STATES PATENT OFFICE.

ANDREW C. CUNNINGHAM, OF NORFOLK, VIRGINIA.

STEEL CAR-AXLE AND METHOD OF MAKING THE SAME.

938,827. Specification of Letters Patent. Patented Nov. 2, 1909.

Application filed December 17, 1908. Serial No. 468,091.

To all whom it may concern:

Be it known that I, ANDREW C. CUNNINGHAM, a citizen of the United States, residing at Norfolk, county of Norfolk, State of Virginia, have invented certain new and useful Improvements in Steel Car-Axles and Method of Making the Same; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The object of the invention is to produce steel car axles of great hardness, toughness, ductility and strength by a process of first rolling a billet longitudinally from a heated bloom to reduce the billet to an elliptical or flattened cross section and at the same time work and refine the grain of the steel as deeply as possible, and second, cross rolling the elliptical billet under gradually increasing pressure to reduce the same to circular cross section and thoroughly work or refine the grain throughout the body of the steel, whereby the texture is reduced to substantial homogeneity and uniform fineness of grain. In order to increase the hardness and strength of the finished axle, the latter is preferably tempered during the final cross rolling operation by applying a blast of cooling medium over the entire length of the axle thereby hastening the cooling of the latter while it is still subject to the agitating action of the cross rolling.

Steel axles for locomotives, cars and the like have been heretofore made by rolling or forging processes; the steel being first made into ingots, then forged or rolled into blooms, which are cut to appropriate lengths and the blooms finally rolled or forged into the approximate shapes of the finished axles. The most commonly practiced process of making axles is by forging, and this process is carried out by heating the bloom successively and forging one part at a time, the process being repeated until the axle is completely forged. The advantage of the forging process is that the hot steel is worked or refined deeply into its mass. The forging process is a slow and expensive one, as will be well understood, but it has maintained its favor in the art of making axles in that the working or agitation of the body of steel can be made to penetrate deeply and thus extensively refine the grain while the forging and cooling are being carried out.

One objection to the forging process arises from the fact that when an axle in the course of manufacture is forged by successive heating, the grain will not be uniform; the partial heating of the bloom, from which the axle is made, necessarily produces a varying grain, as it is difficult to maintain these partial heats uniform; one end or part of the bloom will have the highest temperature and from that part the temperature will gradually decrease into the adjacent portions, consequently the cooling also will not be uniform and even in the completely forged axle there will be a refined but not a perfectly uniform grain. If uniformity of grain is sought by re-heating the entire axle to a uniform degree and then allowing it to cool, after the work of forging has been completed, the result is that although a uniform grain is thus obtained, such grain is, at least, the coarsest and generally a coarser grain than any that previously existed in the axle. Generally speaking therefore, the reduction of the grain in a forged axle to uniformity is effected by an annealing process by virtue of which there is necessarily a lowering of the strength and hardness of the steel.

Under the methods of manufacturing steel axles by rolling as heretofore practiced, it was, of course, sought to reduce the steel to a uniform texture or structure, but the old rolling processes could not effect a deep working or penetration of the refining operation into the mass of steel, as could be effected by the forging process, and in consequence, an axle, which is a comparatively thick section, is not worked as deeply or refined as thoroughly as to grain or structure by the rolling process as by the forging operation. Furthermore, in the ordinary rolling processes, the steel can not be worked at as low a temperature as in the forging operation, for the reason that the lowering of the placidity of the steel, with the lowering of the temperature thereof, endangers the rolling machinery and renders the same liable to breakage. By the ordinarily practiced rolling processes, the working or refining that is done upon an axle would correspond to what, in a rolling process, is called "breaking down" or reducing the steel to shape for final finishing and refining for quality. In general then, rolling processes for producing axles are not largely practiced, because they do not produce popular shapes of axles, and for a still more important reason that they do not refine the steel and produce a fine homogeneous, uniform grain which is necessary to a structurally reliable article. In fact, the rolling processes as heretofore employed, produce a mere surface working or refining of the grain of the steel.

From the foregoing it will be apparent that neither the forging nor the rolling processes as heretofore practiced produces a satisfactory car axle possessing the desirable qualities of hardness, toughness, ductility, strength, characterized by a substantially uniform, homogeneous, fine grain and temper throughout the body of the metal.

The present invention is intended to obviate the difficulties inherent in the alternative methods as heretofore practiced, and to produce a rolled tempered axle having the desirable qualities enumerated; and it will be shown hereinafter that by a combination of the longitudinal and cross rolling processes, and the application, at the same time, of a tempering, strengthening or hardening process, a better quality of axle can be produced than has been heretofore produced by any forging or rolling process, or the application of an annealing or tempering process to the finished axle.

The accompanying drawings represent a suitable form of apparatus for carrying out the process.

In said drawing, Figure 1 is a conventional representation of a set of two-high rolls for effecting the preliminary longitudinal rolling of the billet. Fig. 2 is a rear elevation of a stand of rolls for effecting the cross rolling and tempering. Fig. 3 is an end view of the same and Fig. 4 is a vertical section on the line 4—4 of Fig. 2.

In carrying out the improved process, a bloom of the usual approximately square cross section is cut to a suitable length to produce a finished axle, as in the other processes of making axles. This bloom is heated to the desired temperature and put through a set of two-high or three-high rolls, as in the case of rolling ordinary round sections, with this important exception, to wit, at the end of this rolling, instead of being finished round, the bloom section is intentionally finished with a flattened or elliptical cross section. During this preliminary rolling no special care need be taken to finish the section or billet straight, as the essential object of such preliminary rolling is to effect as much working, or refining of the steel in the billet as possible, and to prepare the billet for the next stage in the process. Ordinarily, in rolling rounds, the finishing passes of this first stage should be devoted to making the section as truly round as possible and to keep it as straight as possible, after which the round would be allowed to cool. Under the improved process, however, the first stage being preliminary, may be entirely devoted to working the steel as deeply as possible and thereby refining the grain as far below the surface and into the body of the steel, as is practicable. After the billet has been given this elliptical or flattened cross section, the same is placed in a system of rolls, consisting of an upper and lower set, the lower set comprising two parallel rolls connected by gearing to produce the correct relative movement of the rolls, said parallel rolls constituting the bottom or bed rolls for the elliptical billet and the upper set consisting of either one or two rolls which are idlers and mounted in standards so as to be capable of adjustment toward or from the lower set of rolls. Between these upper rolls and the means by which they are raised or lowered, there are placed stout helical springs which allow some resisted motion of the upper roll or rolls until the springs have been entirely closed, after which the further lowering of the upper rolls by the adjusting mechanism, will effect a positive, uniformly increasing pressure on the billet which is being worked simultaneously over its entire length between the rolls, by what is termed a cross rolling operation. If two rolls are used in the upper set, the billet is held and rolled between the four rolls, and if a single upper roll only is used, the latter is arranged above the opening between the parallel lower rolls, so that, as indicated, the billet is positively engaged by all of the rolls and operated upon under a gradually increasing pressure.

The elliptical billet section comes from the first two-high or three-high rolls quite hot; it has not however the temperature at which ordinary rolling is commenced, but on the contrary, the temperature at which ordinary rolling is finished. The section having been placed on the two lower rolls of the cross rolling mill, the latter is started and the elliptical section begins to roll over and over in place on said rolls. The upper roll or rolls is or are now brought to bear upon the billet through the resistance of the springs which connect them with the adjusting mechanism. The result is that the elliptical section tends to become round, the greater the pressure applied to the springs, the greater this tendency, and when finally the springs are closed and positive pressure of the upper rolls results, a truly round section will be produced. One of the results of the rolling in this second system of rolls is a perfectly straight and truly round section, but this is an incidental and not the primary or essential object of such second rolling, but such essential object is to keep the steel in the billet in an agitated condition as it continues to cool below the temperature where ordinary rolling ceases, and thus to continue the refining or reducing of the grain of the steel, in much the same manner as would be effected by a forging process, with this material difference, however, that the refining and reducing of the grain is effected in a uniform manner throughout the entire extent of the axle. This is rendered possible because of the fact that the rolling of the axle is accomplished transversely or over its entire length at one operation.

The production of the billet of elliptical or flattened cross section preparatory to the second rolling operation constitutes an essential feature of the present invention, and it will be observed that there is no reduction in cross section of the billet such as would result in longitudinal rolling, but there is effected a change from the elliptical to a circular cross section, and this latter change of cross section produces the necessary agitation which causes the steel to take the finer and finer grain in much the same manner as would be effected by forging or working the steel under a hammer, under decreasing temperature. In fact, this second operation may be compared, in its results, to the light taps which a blacksmith gives to a finished tool as it is cooling, which is a recognized expedient for refining the grain of the steel. When this second or cross rolling operation is begun, the steel has lost so much of its plasticity, owing to the reduction in temperature, that ordinary rolling would be difficult, as well as liable to produce breakage of machinery. The transverse rolling, however, is accomplished quite readily, nevertheless, for the reason that the whole axle is operated upon at once and there is produced only the change of shape of the section and not a reduction in cross section as would necessarily follow by a drawing action incident to the ordinary longitudinal rolling operation. The reduction of plasticity during this second operation is an advantage, in the improved process, as the increased resistance of the steel to a change of shape, causes a greater penetration of the working or refining operation of the rolls.

From the foregoing considerations, it will be apparent that in the second or cross rolling operation, the refinement of the steel is carried considerably beyond the point which it is possible to reach by the ordinary rolling methods, and may even be readily carried beyond the point attainable in forging, for the reason that the entire axle is operated upon at one time, and this uniformity of treatment cannot be effected in any other manner, so far as I am advised.

While a steel axle superior to any heretofore produced will result from the foregoing treatment, it is preferable to carry the refining operation still further. Soon after the second or cross rolling is commenced, and as the axle is approaching a circular cross section, a blast of some cooling medium is applied to it over the entire length. This blast may be air, steam, water, oil, or whatever vapor or liquid medium that may be found most convenient or desirable to produce certain and positive results. In the case of steam, for instance, a vapor of known temperature and regulable temperature may be readily applied. One result of this blast is to hasten the cooling of the axle, while the latter is still undergoing severe agitation in the cross rolls, and thus secure the superior refinement of the grain resulting from agitation under decreasing temperature, more effectively than could be produced by the normal cooling of the axle. Another result of this blast is to produce a superior refinement of the grain of the steel due to accelerated cooling, the same as is effected in a tempering or hardening process. The refining due to these operations of agitation and accelerated cooling is very uniform throughout the entire mass of the axle, due to the fact that the entire axle is operated on at once, as distinguished from the successive working of different parts of the axle under the old practices.

The object sought and effected by the foregoing process is the coördination, in a steel axle, of the qualities of hardness, toughness, ductility, strength and reliability that can be produced by no other method, so far as I am advised. The combination of the agitation and the accelerated cooling processes raises the ordinary or normal strength of the steel to a point which, under the ordinary methods heretofore in vogue, would require a greater carbon content. This raising of the strength is not accompanied by the usual increase in brittleness that more carbon would give, however, hence there results the increased toughness and reliability. The grain produced by the agitation, at temperatures lower than the usual or normal rolling temperatures, is much finer than that produced by the ordinary processes heretofore in vogue, hence the steel is harder and possesses better wearing qualities under treatment than axles made by the old processes and moreover, the fineness of the grain extends throughout the body of the metal.

Referring to the drawings, Fig. 1 illustrates a typical two-high rolling mill for reducing a longitudinal blank or billet of ordinary square cross section to one of elliptical cross section, for which purpose the coöperating rolls 1 and 2 are provided with the usual reducing passes. The remaining figures of the drawings illustrate a convenient form of mill for effecting the cross rolling. Referring to said drawings, 3, 3 indicate the side frames or housings of the mill in which is journaled an upper idler roll 5, in two sliding boxes 12, operating in the guides 4. Below the roll 5 are two bed rolls 6, journaled in the housings 3 and provided with pinions 7 which mesh with a driving gear 9 mounted upon a power shaft 10. The roll 5 is located above and intermediate the two rolls 6, 6 and is adapted to be adjusted toward and from said roll 6, 6, by means of screws 15 operated by hand wheel 19 and shaft 17 through two sets of miter gears 16 and 18. The screws 15 are connected to the sliding bearings 12 by means of a yoke 13, and interposed between the lower headed ends 15 and the bearings 12 are stout helical springs 14, by means of which the preliminary pressure on the roll 5 is effected. During the first downward adjustment of the roll 5 the pressure is transmitted through the springs 14, and after the latter are set up or completely closed, the pressure from screws 15 is transmitted directly through the bearings 12 and roll 5 to the axle which is being operated upon. Located below and intermediate the two lower rolls 6, 6 is a jet pipe 20 adapted to supply the desired cooling medium directly upon the axle as the same is being operated upon, as hereinbefore described.

What I claim is:—

1. The method of producing car axles of great hardness, toughness, ductility and strength, which consists in forming from a bloom a billet of steel of elliptical or flattened cross section, and second, working and shaping the said billet by cross or transverse rolling throughout its length under gradually increasing pressure, whereby the billet is reduced to a circular cross section and the steel is reduced to a substantially homogeneous, uniform fineness of structure or grain.

2. The method of producing car axles of great hardness, toughness, ductility and strength, which consists in first heating a billet or bloom of steel of the necessary size, second, forming said bloom into a billet of elliptical or flattened cross section by rolling the same longitudinally, and third, working and shaping said billet by cross or transverse rolling throughout its length under gradually increasing pressure.

3. The method of producing car axles of great hardness, toughness, ductility, and strength, which consists in first heating a billet or bloom of steel of the necessary size, second, forming said bloom into a billet of elliptical or flattened cross section by rolling the same longitudinally, third, working and shaping said billet by cross or transverse rolling throughout its length under gradually increasing pressure, and, fourth, subjecting the billet during such cross rolling to a blast of fluid medium to temper or harden the same.

4. A steel axle having a dense, fine, tough, crystalline grain or structure beyond that normally due to its carbon content, hardened uniformly on longitudinal elements, and of uniformly varying hardness on radial elements.

In testimony whereof I affix my signature, in presence of two witnesses.

ANDREW C. CUNNINGHAM.

Witnesses:
SAMUEL GORDON,
CLINTON D. THURBER.