

Sept. 4, 1934.

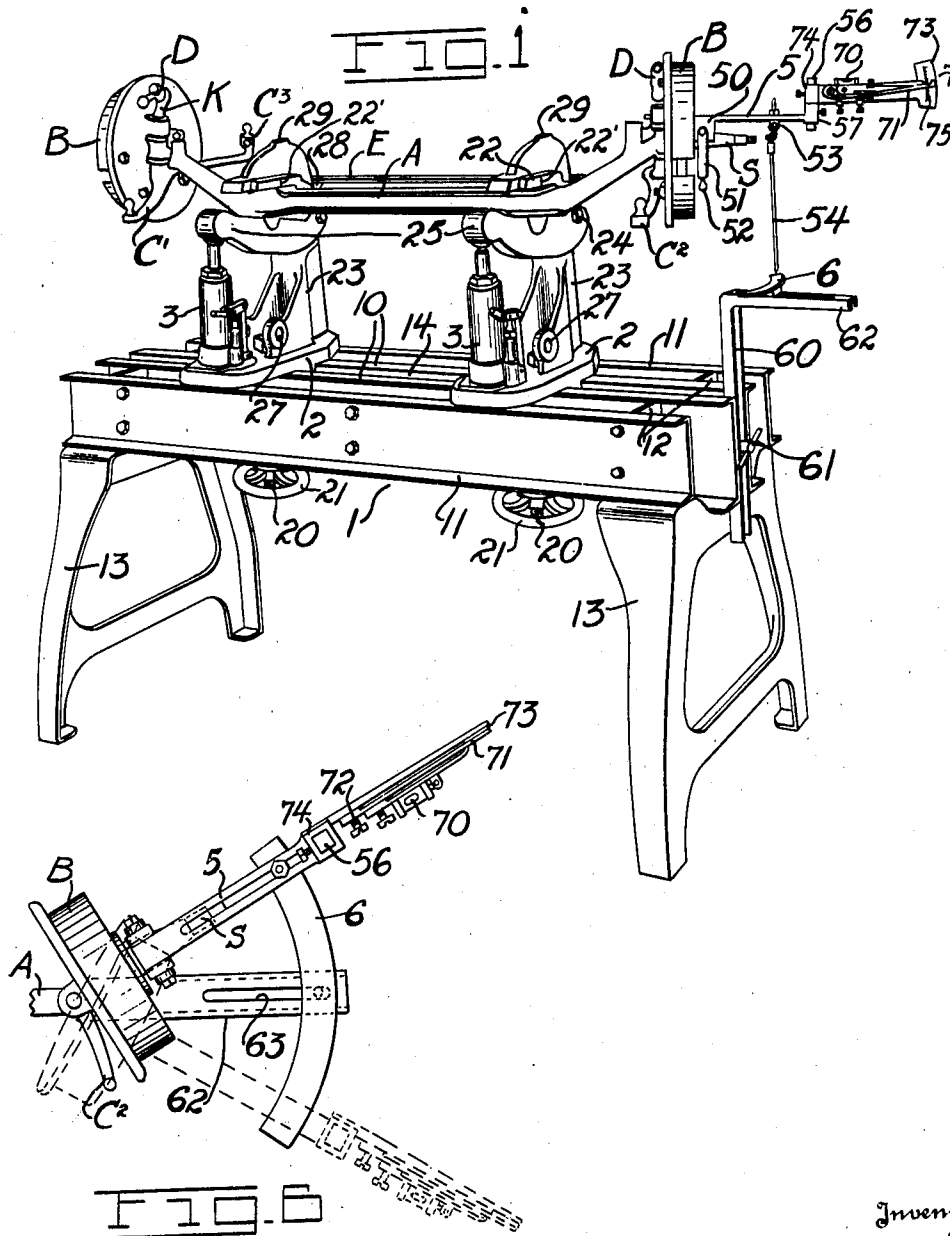
C. C. BENNETT

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Filed June 22, 1931

7 Sheets-Sheet 1



Inventor
Claude C. Bennett
By *Charles L. Reynolds*
Attorney

Sept. 4, 1934.

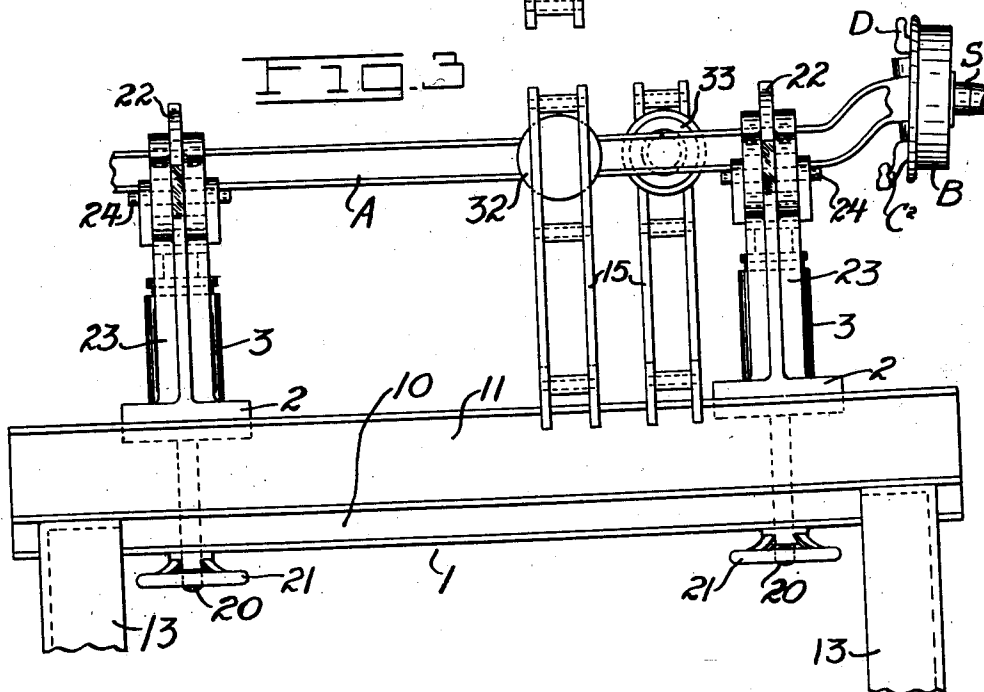
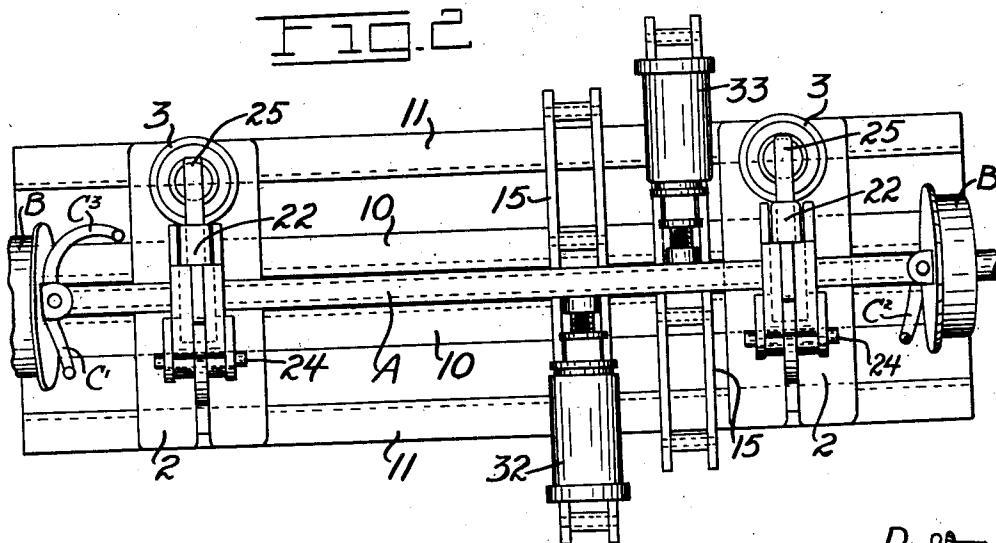
C. C. BENNETT

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Filed June 22, 1931

7 Sheets-Sheet 2



Inventor

Claude C. Bennett

34 Charles L. Reynolds
Attorney

Attorney

Sept. 4, 1934.

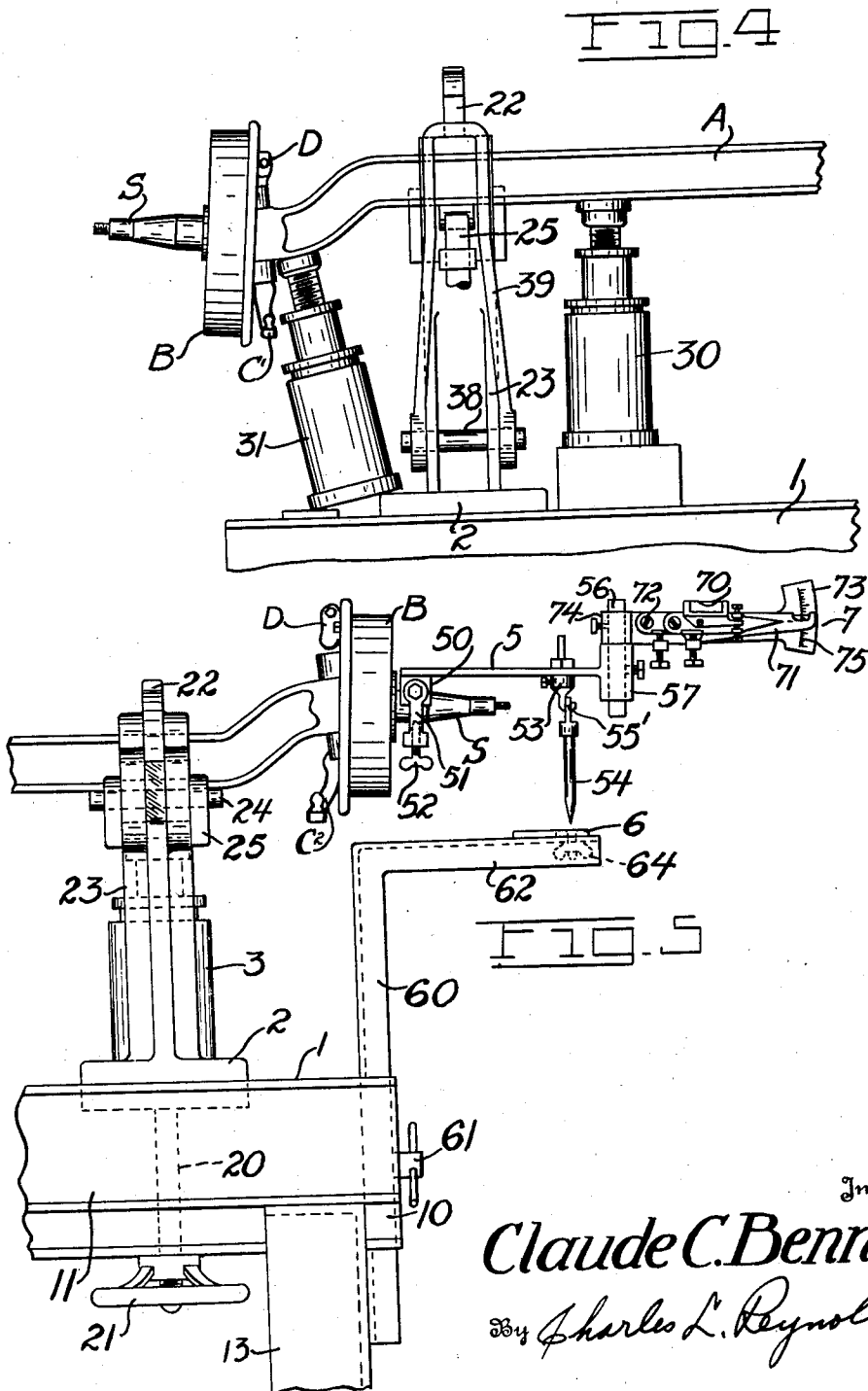
C. C. BENNETT

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Filed June 22, 1931

7 Sheets-Sheet 3



Inventor

Claude C. Bennett

By Charles L. Reynolds

Attorney

Sept. 4, 1934.

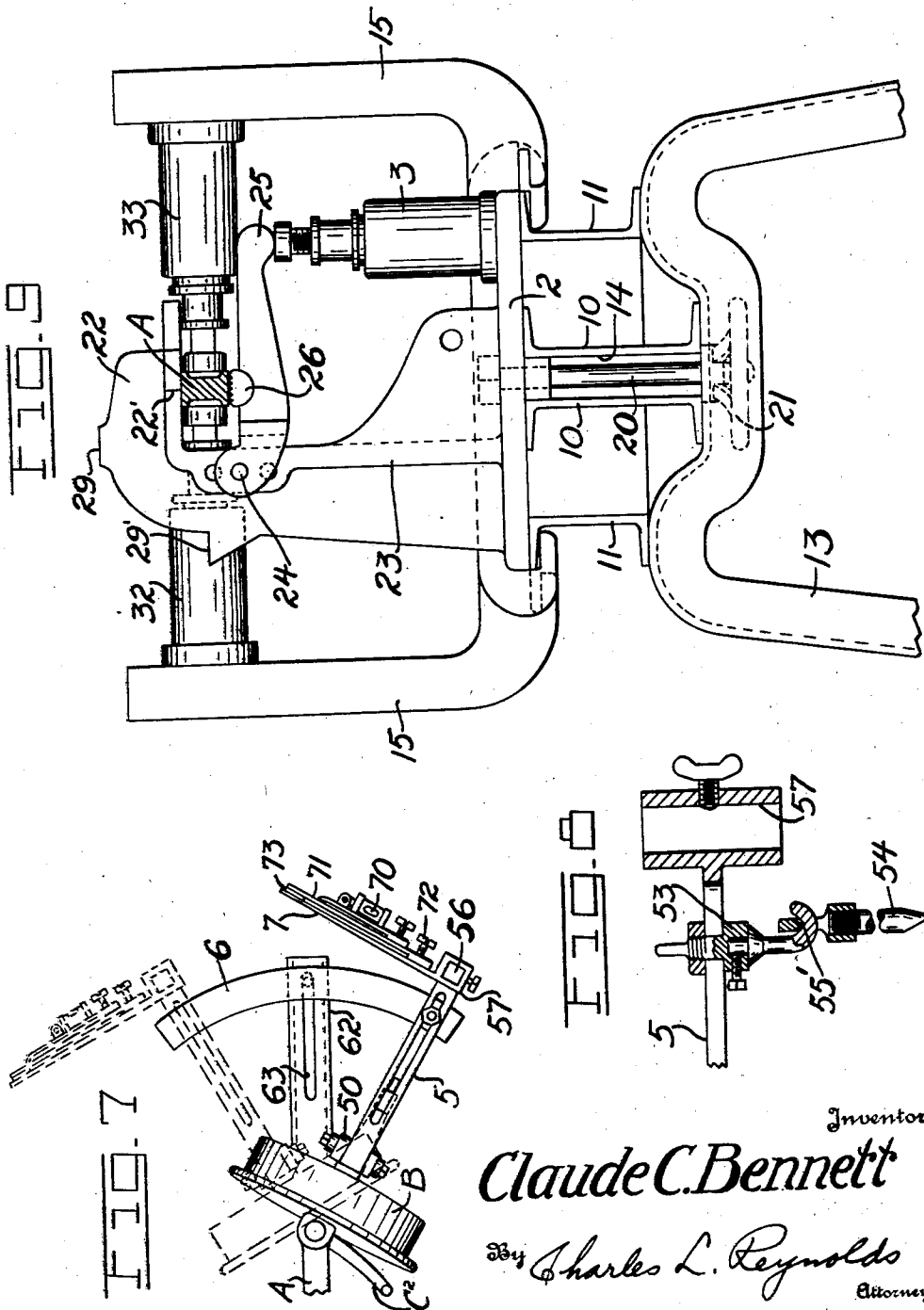
C. C. BENNETT

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Filed June 22, 1931

7 Sheets-Sheet 4



Inventor
Claude C. Bennett
By *Charles L. Reynolds*
Attorney

Sept. 4, 1934.

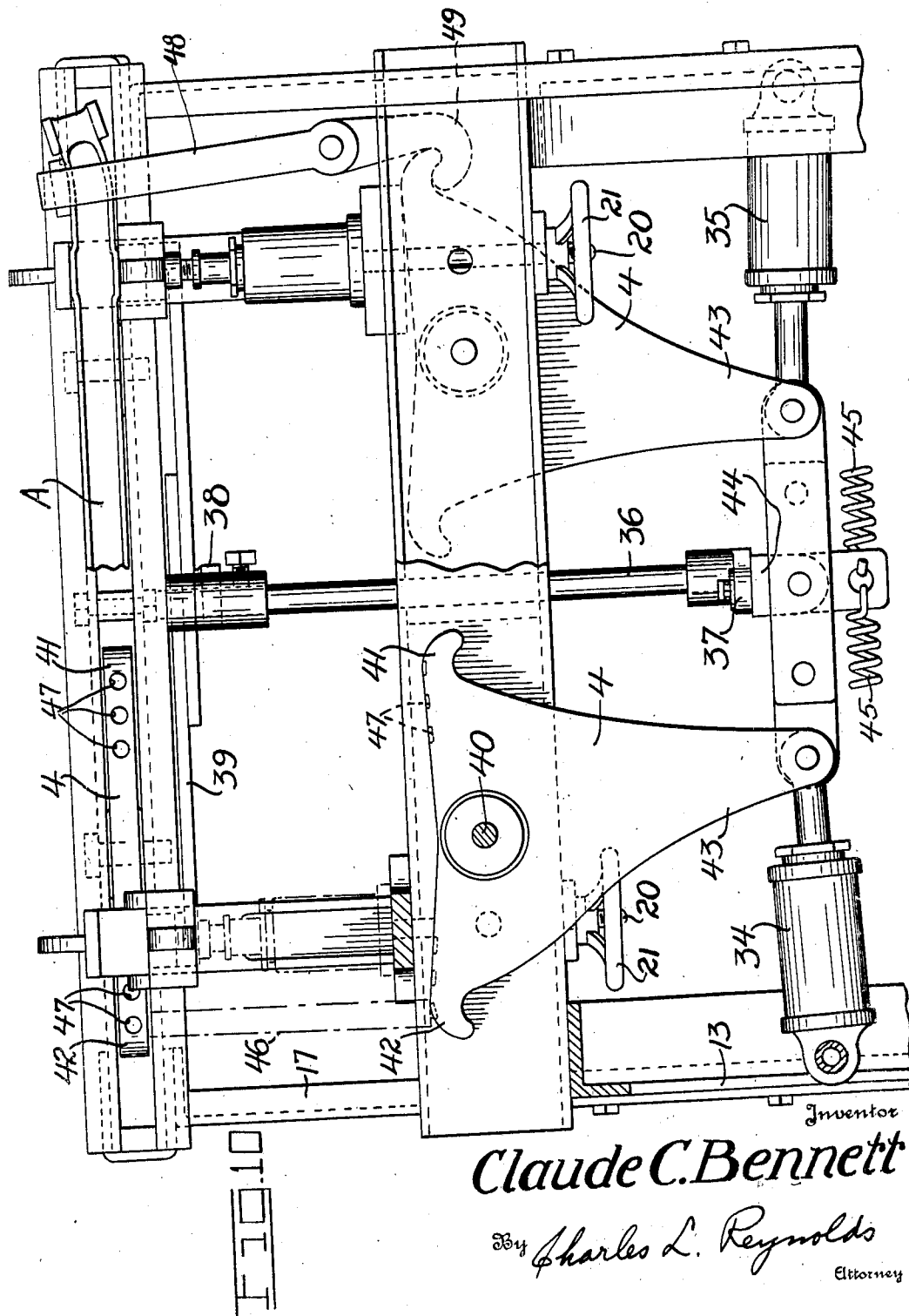
C. C. BENNETT

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Filed June 22, 1931

7 Sheets-Sheet 5



Inventor
Claude C. Bennett
By *Charles L. Reynolds*
Attorney

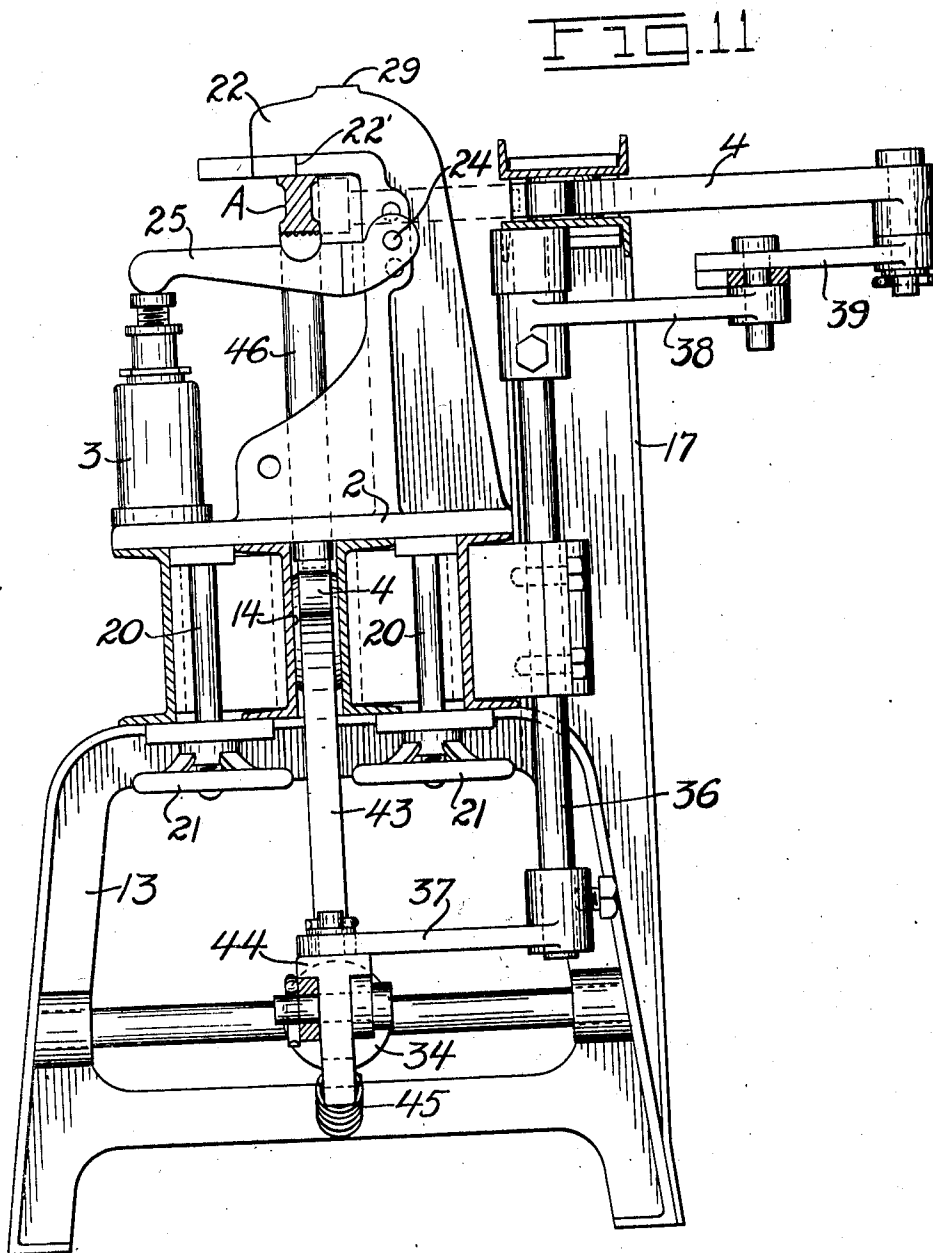
Sept. 4, 1934.

C. C. BENNETT

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Filed June 22, 1931. 7 Sheets-Sheet 6



Inventor

Claude C. Bennett

By *Charles L. Reynolds* Attorney

Attorney

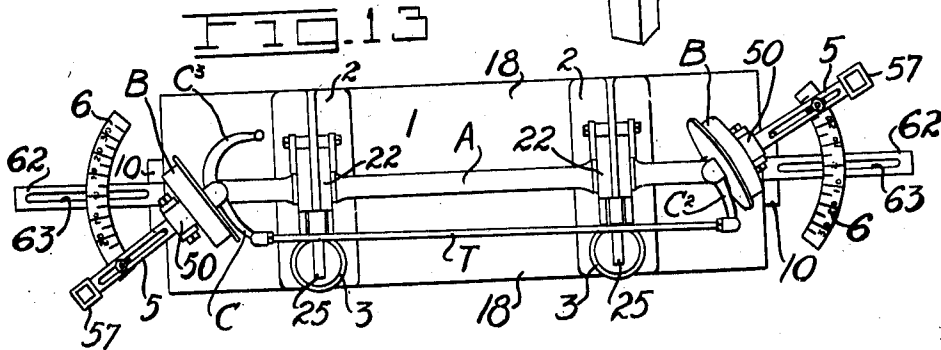
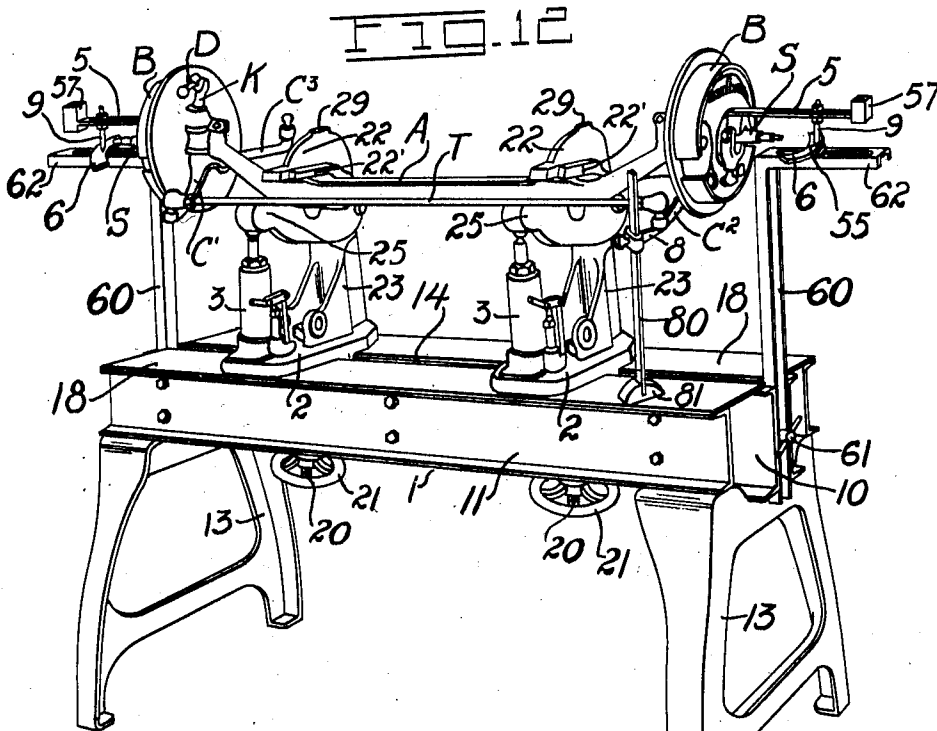
Sept. 4, 1934.

C. C. BENNETT

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Filed June 22, 1931 . 7 Sheets-Sheet 7



Inventor

Claude C. Bennett

By Charles L. Reynolds

Attorney

UNITED STATES PATENT OFFICE

1,972,285

PROCESS AND APPARATUS FOR BENDING AXLES

Claude C. Bennett, Seattle, Wash., assignor to
A. E. Feragen, Inc., Seattle, Wash., a corporation
of Washington

Application June 22, 1931, Serial No. 546,086

19 Claims. (Cl. 153—32)

My invention relates to the art of automobile wheel alignment, and more especially to the bending and gauging of front axles to bring the steering wheels to be mounted thereon into proper alignment. My invention is concerned both with the method of bringing about proper alignment, and with apparatus whereby the necessary operations can be performed.

By means of various known indicators and gauges, it may be determined when the parts of a steering system, particularly the axle, spindle, and king pin, are out of alignment, and by how much, without removing the axle from the car. By careful measurements misalignment of steering arms can be discovered. By the use of such devices, the owner of the car may be convinced that parts are not in proper alignment, but in order to correct all but the most simple cases of misalignment, it becomes necessary to remove the axle from the car, and it has always been considered necessary to remove from the axle the various steering arms, spindles and the like. Not only is their removal and replacement a job which requires some little time and effort, but with the spindle removed it is only possible to check its alignment relative to the axle, and the consequent alignment of the wheel, indirectly, by checking upon the king-pin hole, by means of which the spindle is supported and pivoted.

In the final analysis, the wheels rotate upon the spindles, hence, it is the spindles themselves which must be in accurate alignment. By methods and with apparatus heretofore in use, it has come to be the custom to assume that the spindle is properly aligned if the king pin hole, wherein is received the king pin which supports the spindle body, is properly aligned. This, however, is not a valid assumption, and may lead to a false conclusion. The king pin may be bent somewhat; the spindle may be bent relative to its supporting body; the post inserted in the king pin hole, for use as the base from which measurements are made, may be bent, or may not be precisely centered in the hole. Any or all of these factors may introduce an error, which, though small, is serious because the angular magnitudes involved are very small. By the present process and with the present apparatus, such errors can be eliminated.

It has not been found convenient with apparatus heretofore in use (nor was any useful purpose served), to accomplish bending operations upon an axle with any accessory devices, such as the spindle body, the brake drums, the steering arms and the like, attached to the axle, but I have worked out a process whereby this can not only

be accomplished, but greater accuracy results. By this process, and with the apparatus which forms a part of the present invention, these can all be left in place, thus eliminating the work necessary first to remove them and then to replace them, and in addition, contributing markedly to the accuracy of the process, as has been indicated above.

The object of my invention, then, is to provide a method, and an apparatus for carrying out the same, whereby axles may be bent to return parts to proper alignment more accurately because the spindle bodies are left in place, and more expeditiously and cheaply because of the increased accuracy, and because it is not necessary to remove such parts from the axle.

Referring more particularly to the apparatus, it is a further object to provide apparatus of this character and for the purpose indicated which shall be simple and sturdy in construction, and easily operated, and in which the axle can be handled and automatically set up and exactly positioned for a variety of bending and gauging operations to be performed thereon, and by means of which the axle can be handled and straightened without the removal of accessory parts therefrom.

It is also an object to provide devices by means of which determination of proper alignment can be made while the bending operations are being performed upon the axle, so that the work can be checked as it progresses, all the while retaining the axle in the position in which it is set, during all the bending and gauging operations.

It is also an object to provide a device of this character which will enable the operator to work with the least lifting and handling of heavy parts, especially heavy hydraulic jacks for holding, clamping and bending the axle.

Apparatus embodying my invention is shown in a number of forms in the accompanying drawings, as at present preferred by me, and is further described in this specification and more particularly pointed out by the claims, which define the principles of my invention, and certain mechanical forms wherein these principles are embodied.

Figure 1 is a perspective view of a simple form of my device, showing an axle in place thereon and a gauging operation being carried out.

Figure 2 is a plan view, and Figure 3 is a side elevation of my device, operating to bend an axle.

Figure 4 is a side elevation of an end of my device, showing a different type of bending operation being carried out upon an axle.

Figure 5 is a side elevation of an end of my

device, showing a gauging operation being carried out, and Figure 6 is a plan view of the end of the axle and the gauge associated therewith for the same operation as is illustrated in Figure 5, and as illustrated also in Figure 1.

Figure 7 is a view similar to Figure 6, showing a different gauging operation being carried out.

Figure 8 is a detail sectional view through a gauge part.

Figure 9 is an end view of my device, the axle being shown in section, illustrating such an operation as is shown in Figures 2 and 3.

Figure 10 is a front elevation, with parts broken away, showing a modified form of my device with an axle in place, and Figure 11 is a cross section therethrough.

Figure 12 is a perspective view, and Figure 13 a plan view of a further gauging operation being performed with this device.

Essentially, the apparatus consists of a bed frame, from which the bending operations may be carried out, vises or holding means upon the bed frame, by means of which the axle can be held elevated above the bed plate and held rigidly with respect thereto, in an accurately predetermined position relative to certain gauging devices, means in the nature either of portable jacks, or jack-controlled levers with spacer bars extending between these levers and the axle, certain thereof being intended for bending the axle and others for resisting the bending at points where it is not desired to bend the axle, but where the reaction of the bending effect might cause a bend, and devices for accurately gauging an axle which is held in the predetermined position, or the parts which are mounted thereon.

The mechanical form of the apparatus may, of course, vary considerably, and the bed frame, generally designated 1, is shown in the accompanying drawings as composed of two central channels 10 and other channels 11, of somewhat less depth than the channels 10, all being secured together by spacer members 12 at the ends of the channels and by end frames 13 which connect and support the elements forming the bed frame. Bed plates 18 may be used or not, as preferred (Figure 12). The parts thus assembled leave channels such as the central channel 14, through which bolts 20 may be passed, to secure bases 2, in which they are secured, to the bed frame 1, clamping nuts 21 of any convenient form being employed for this purpose.

Supported upon the bases 2 are the vises or axle-clamping means. Preferably, a fixed upper jaw 22 is formed integrally with the base 2, being supported at a distance thereabove by a standard 23 disposed at the rear side of the base. Pivoted at 24 upon the standard 23, below the fixed jaw 22, is a movable jaw 25, which cooperates with the fixed jaw 22 to hold an axle A between them. The jaw 25 is moved toward the fixed jaw 22 by such means as a hydraulic jack 3 resting upon the base 2 and engaging the outer end of the movable jaw 25. The spacing between the two jaws is so designed that it will hold an axle at a given level, and in a given line, so that it may properly cooperate with gauging devices hereafter to be described. Index marks 22' cooperate with like marks upon the axle, to insure that it is straight in the vise, or the positioning of the axle may be accomplished by employing a V recess in the jaw 25, or preferably, by receiving a bearing block 26 (Figure 9) in this recess. It is also possible to vary the height of the pivot pins 24, for axles of different heights, by disposing the pivot

pin 24 in any one of several holes in the standard, as may be observed in Figures 9 and 11. In instances where there is a severe upward stress upon the fixed jaw 22, this can be reinforced by a clevis 39 passed over the outer end of the fixed jaw 22 and extending downwardly to a point where apertures in its lower end are in registry with apertures in the standard 23, whereby a retaining pin 38 (see Figure 4) may hold the clevis down. Such a situation is illustrated in Figure 4, wherein two bending jacks, designated 30 and 31 to distinguish them, press upward against the under side of the axle close to one of the clamping devices.

Figure 4 illustrates how an axle may be bent by pressure exerted directly upwardly from the bed frame 1 against the axle. In this instance, the jack 31 is bending the outer end of an axle in an upward direction, and the jack 30 is resisting any tendency to bend the axle in the center. While the bending in the illustration is in an upward direction, the axle in this figure is inverted, so that the outer end thereof is actually being bent downwardly, that is, in such a way as to increase the camber of the wheel upon the end of the spindle S.

Various lateral bending operations may be accomplished, either by turning the axle upon its side and proceeding in the manner illustrated in Figure 4, or by employing knees which hook over the edges of the outer channel members 11, as may be seen in Figure 9, and which extend thence across the bed frame and upwardly to form a resisting element for bending or holding jacks, illustrated at 32 and 33 (Figures 2, 3 and 9).

According to my process, the axle is removed from the car; it has been found convenient first to remove the wheels and the steering arm drag link, and preferably the tie rod between the two steering arms is removed. The removal of these parts, it should be noted, is purely a matter of convenience; it is less work to remove and replace them than to try to work around them, but if the operator prefers they can be left in place, and the gauging done from the wheel or spindle. In cars with demountable wheels, for instance, the wheel only might be removed. It will never be found inconvenient, however, to leave the spindle, the brake shoes, the brake arms, the steering arms, the king pin, and all such devices in place. An axle so prepared is illustrated in Figure 1, and B designates the brake shoes, C¹ and C² the steering arms, and C³ the arm to which the drag link is connected. A brake cam lever is illustrated at D, the spindle at S and the king pin at K. Now this axle is placed in the jaws of the vises, these fitting at about the location of the spring perch or pad. This spring perch is generally flat and its machined surface offers a reference surface which can fit against the flat surface of the fixed jaw 22.

The first consideration is to make certain that the two spring perches are in the same plane and properly aligned in such plane, and that the axle between them is straight. If the axle, between the perches, is bent, the perches will be out of alignment, and usually this can be detected through failure of both perches to bear fully and fairly against the inner side of the fixed jaws 22. Deviation of the axle from a straight line, between the perches, can be determined by comparison of the axle, held by the jaws 25 against the jaws 22, with a straight-

edge E, supported upon finished surfaces 28 or 29 upon the standards. The comparison may be purely visual, or may include measurement or gauging with a contact gauge. Assuming the perches to be out of alignment, one or the other is held between the jaws 22 and 25, and the axle is bent or twisted between the perches to return the opposite perch to proper alignment, as may be determined by the straight-edge and gauges mentioned, and by the ability of the two perches to lie flat against the inner faces of the jaw 22. Local inaccuracies, not affecting the final result, may also be located and corrected, chiefly for the sake of appearance.

Now the spring perches are used as reference surfaces, being held against the jaws 22 by the movable jaws 25 and their bearing blocks 26. Thus held, the axle is substantially centered along the median plane of the press, and is accurately positioned in this plane by the index marks 22'. It can now be determined if the axle is straight at each end, beyond the spring perches. To do this, the straight-edge E may be used again, and by visual comparison or by measurement with a rule or contact gauge it can be determined if the ends of the axle are bent forward or backward from a straight line through the center of the perches, and if either end is higher than the other, with respect to the plane of the spring perches.

These are preliminary steps, to make the axle as nearly straight as possible, thereby tending to position the king pins K and the spindles S in their proper positions, but because such measurements cannot be made so accurately as is necessary, and because in the manufacture of the axle or the spindles errors in alignment may have crept in, the process cannot stop here. It is now necessary to determine whether or not the inclination of the king pin (in the vertical plane of the axle) is correct, if the camber angle of the spindle is correct, and in axles wherein caster is provided for by the inclination of the king pin in a forward and rearward plane relative to the perches (rather than by tilting the axle as a whole), to determine if the king pin has the proper caster angle. If the axle is not intended to have caster, it should be definitely established that it has not, in fact.

Such determinations are made with the axle in place in the press, accurately positioned in the manner heretofore indicated, and since the spindle S is that part of the steering system the position and movement of which directly controls the rotation of the wheel in true alignment, it is preferable that all gauging be done from the spindle itself.

In measurements of caster and king pin inclination, such a device as is shown in the patent to Duby, No. 1,679,934 may be employed, though certain inaccuracies would result. However, I prefer to use apparatus which I will proceed to describe, for by its use all necessary gauging operations can be performed quickly and accurately, from time to time as the work progresses.

As a means of applying a gauge to the spindle, I may support upon the spindle a member which carries a point lying precisely in the axis of the spindle, or in outward extension thereof, from which point measurements are, in effect, made. Various ways may be employed to support such a member, and it may take various forms. Conveniently, it may consist of an arm 5 having a V-block 50 at one end adapted to straddle a cylindrical portion of the spindle, which V-block

and arm may be held in place by a clevis 51 and clamping screw 52. The arm is slotted (Figures 6 and 7), and a slide 53 is slidable in this slot longitudinally of the arm 5, and at its lower end a point 55 is provided, which may be used to indicate angular movements directly (see Figure 12), or the slide 53 may be slightly hooked and recessed to provide a support at 55', at which point may be supported a plumb bob in the form of the steel pencil 54. In either case the point 55 or 55' lies precisely in an extension of the spindle's axis, and may be vertically adjustable to this end. The point of the plumb bob or pencil is thus maintained directly beneath the support 55', and a given distance therebelow, which, of course, is the length of the plumb bob.

By these or like means, angular movement of the spindle from a position corresponding to straight-ahead position of the car can be determined. To assist in this, I provide a segment plate 6, which is suitably supported from the bed frame 1, for instance, by means of an angled bracket, the vertical arm 60 of which is guided between the channels 10 for vertical movement, being held in adjusted position by a clamping nut 61, and the horizontal member 62 of which is slotted, as indicated at 63, and extends in the vertical plane of the axle outwardly beneath the spindle and the arm 5 when the latter are in the straight-ahead position—that is, the position wherein the spindle's axis is in the vertical plane of the axle, and the wheels would roll directly ahead, disregarding toe-in. The segment plate 6 is adjustable by means of the slot 63 and the clamping nut 64 to bring it directly beneath the point 55, or directly beneath the point of the plumb bob 54, in which position the center about which the plumb bob swings coincides with the center of the segment plate. When the spindle is turned upon the king pin K, the angular departure from the straight-ahead position, either forward or rearward, can be measured by means of an angular scale upon the segment plate 6, the plumb bob acting as a pointer.

I have discovered that the lateral angle of inclination of the king pin can be ascertained in a simple manner and by application of a gauge directly to the spindle. When the wheels turn on their spindles this angle of lateral inclination is measured by determining the angle of roll of a diameter, the lower end of which is the point of contact of the wheel with the roadway, as that diameter rolls from a position wherein the wheel is turned thirty degrees forward of the straight-ahead position to a position thirty degrees rearward. Because the wheel has camber and the king pin is oppositely inclined to meet the plane of the wheel at the point of contact with the roadway, the lower part of the wheel (where it contacts with the roadway) does not shift as the wheel pivots about the inclined king pin, but the end of the spindle does shift from somewhat behind the axis of the king pin to somewhat in front thereof, or the reverse. It also drops from its elevation in the straight-ahead position (disregarding toe-in) when turned either forward or rearward. These drops evidence the change in inclination of the diameter from the point of contact through the end of the spindle, and the sum of this angular change in position of the diameter mentioned when the wheel or spindle is turned thirty de-

grees forward and thirty degrees rearward, is the angle of lateral inclination of the king pin.

This method of determining king pin inclination is described more fully and claimed in a co-pending application Serial No. 546,084, filed June 22, 1931, and the same may be carried out with the present apparatus and as a step in the present process; or any other suitable gauging system may be employed. For such a purpose I may employ apparatus which is commonly employed in conjunction with wheels in making angular determinations, and thus, in Figure 7, an upright square bar 56 is shown received and clamped in an upright socket 57 at the outer end of the arm 5. Upon the bar 56, extending laterally at right angles to the arm 5, is a gauge arm, generally designated by the numeral 7, the construction of which is described in said co-pending application. In its essence, this comprises a bubble tube 70, mounted upon an arm 71, pivoted at 72 upon an arm 73, which has a socket 74 fitting upon the non-circular bar 56, so that the arm 71 can be adjusted about its pivot 72 angularly with respect to a scale 75 upon the fixed arm 73. By such a device the angle of lateral inclination of the king pin, and for that matter, the caster and camber angles, can be determined. Care must be taken in measuring this angle of lateral inclination that the gauge be applied so that it extends and measures angles in a plane which is at right angles to the axis of the spindle.

Determination of camber angle can be made directly with such a device, the plumb bob 54 being set so that the spindle S projects in the vertical plane of the axle, that is, in the straight-ahead position of the wheel, and since the arm 5 is parallel to the axis of the spindle, and the arm 73 is held parallel to the arm 5, the bubble tube 70 on the arm 71 will enable a direct reading of the camber angle, as may be seen in Figure 5.

The caster angle can also be determined in a similar way. Due to caster inclination of the king pin, the end of the spindle will rise when it is turned forward, say thirty degrees, and when it is turned rearward thirty degrees (in each instance, from the straight-ahead position) it will fall, since its rotation is in a plane perpendicular to the axis of the inclined king pin. Due to this rise and fall of the spindle end the plane of its movement can be determined by the two measurements of angle, thirty degrees forward and thirty degrees rearward, and its angle relative to the horizontal is the caster angle.

To determine the caster angle, the gauge arm 7 may be secured upon the bar 56, extending in line with the arm 5 and the spindle's axis, rather than at right angles thereto, as in the measurement of lateral inclination. The spindle with the gauge thus supported thereon is moved forwardly and rearwardly, thirty degrees each way, and if there is any caster in the king pin a difference in inclination is observed. This constitutes the caster angle of the king pin.

Reverting now to the process, after the outer ends of the axle have been straightened as nearly accurately as may be determined by contact gauges, measurements, and the like, the spindle is gauged in the manner indicated above, or in any other suitable manner, to indicate the king pin inclination angle, the camber angle of the spindle, and the caster angle of the king pin, if any. Knowing the manufacturer's specification for the car in question, it is possible to determine if the observed angles are improper, and

it is also possible to compare the caster, camber and king pin inclination angles of the opposite ends of the axle, for obviously, they should be alike at the two ends. If it is observed that the camber angle is incorrect, it is possible to apply jacks somewhat after the manner indicated in Figure 4 to increase the camber angle, or in the same manner but with the axle re-inverted, to decrease the camber angle of the spindle. Similarly, if it is observed that the king pin inclination angle is incorrect, it can be corrected in the same manner. If, after the king pin inclination angle has been corrected, the camber angle is still incorrect, it may be necessary to discard the spindle and to install a new and correct spindle, for the spindles are often bent with respect to the spindle bodies, and it has not been found economical to attempt to restore them to proper condition. If the caster angle is incorrect, it may be necessary to apply a wrench to the outer end of the axle to twist it, and to restore the caster angle to the one which experience or the specifications for the particular car show to be correct.

While all of these operations are proceeding, it is possible from time to time to apply the gauge and to gauge the work as it progresses, since the axle is always held in accurate position for gauging, and the gauge may be easily applied. Thus, with the least effort, both as to gauging and as to lifting and moving about the axle or the jack, it is possible to determine how the work is progressing, and to make it accurate to a fine degree, and because it is an easy and quickly accomplished operation, it will be frequently performed.

The angle, length, manner of connection and elevation of the steering arms materially affect the operation of the steering system. The inter-connection between the two steering arms, effected by means of the tie rod, determines the angles which the wheels will assume in making a turn. Frequently, this is assumed to be a matter merely of getting the correct length of tie rod, but when it is appreciated that the effective length of the tie rod varies with a variation in the angle of the steering arm, whether in a lateral direction or in a vertical direction, and that very small differences in the effective length of the tie rod cause magnified inaccuracies in the position of the wheels, it is appreciated that these factors should be exact in order to obtain the best results, the easiest steering and the least wear on tires. Accordingly, it will usually be found desirable to check the relative positions of the ends of the steering arms.

The steering arms of an automobile are so disposed angularly with respect to the plane of the wheels they control, at such a distance therefrom, and so connected to the opposite steering arm by the tie rod T, that the end of the steering arm of the inside wheel moves longitudinally of the car to a greater extent than does the end of the steering arm of the outside wheel, but the latter moves more transversely of the car than does the inside steering arm. The result is that the angular movement of the inside wheel is more than that of the outside wheel. In turning, the wheels of a car should roll about a single point; this point lies in an extension of the rear axle, and the plane of each of the front wheels is tangent to a radius through the same point. It will be evident, then, that the inside wheel must turn through a slightly greater angle than the outside wheel, but because of the shortness of the steering arm in any

event, relative to the distance from the point about which the turning of the car progresses, very small errors in the location of the end of the steering arm will produce serious errors in alignment when the car is turned. It is essential, then, that these inaccuracies be determined and corrected.

As a means for doing this, the apparatus illustrated in Figures 12 and 13 may be employed. The ends of the steering arms C' and C² are gauged for elevation above the bed frame 1; and for this purpose I have shown a contact gauge consisting of an upright 80, a base 81 and a contact finger 8, the latter being movable vertically of the standard 80 to contact with the end of the steering arm, and thus with the axle fixed in position to indicate whether the end of one arm or the other is lower than the standard fixed by the manufacturers, or if there is a difference in elevation between the two. Naturally, the spindle must be in the straight-ahead position, as the steering arms rise and fall due to inclination and caster in the king pin.

For further determination of the correctness of the position of the steering arms, it is desirable that they be connected in the normal manner with the tie rod T. If this has heretofore been disconnected, it should now be connected up again, and the spindles should be tested to make certain that the tie rod is of such length that both spindles extend in the vertical plane of the axle. Now with the arm 5 applied to each spindle there may be employed a pointer 9, supported in the slide 53 heretofore referred to, and slidable in the arm 5, the point 55 of this pointer being movable over the segment plate 6 to indicate angular movement of the spindle. One of the spindles is moved so that, were it an outside wheel, it would move through thirty degrees, for instance. The other spindle, as shown by the opposite pointer 9, will have moved through a greater angle, if the steering arms are properly adjusted, and the magnitude of this angle will depend upon the wheelbase of the car and the camber and caster angles. The observed reading can be compared with the manufacturer's specifications, or with those known to be correct for the car in question. If the steering arm is too far out or too far in, too high or too low, proper correction may be made by disconnecting the tie rod and bending the arm. To a limited extent errors in length can be corrected, or new arms can be installed.

Such operations are continued until the ends of the steering arms are correctly positioned, whereupon it should result that the entire steering system is properly adjusted. Naturally, the steering arms would not be adjusted until the axle and spindle are first adjusted to proper position, and then, when the steering arms are adjusted so that they are at equal angles to the plane of their respective wheels, at the same elevation above the bed frame 1, and at the proper distance from the axis of the king pin K, all parts should be in proper position, and the wheels, when placed upon the spindles, should roll in proper alignment, not only on the straightaway, but on turns as well.

The apparatus which has been described for use in the various bending operations is convenient, but still necessitates occasional lifting and handling of comparatively heavy hydraulic jack units, and since the axle is at all times rather exactly positioned along a given line, it is possible to provide bending members acting along such a line, both in a vertical plane and in a horizontal

plane, whereby the bending operations can be effected without handling of the jack units. Such apparatus is shown in Figures 10 and 11. The bed frame, base, standards and jaws need not be altered in construction, except as I prefer to employ two clamping bolts 20 to hold down the base 2. This leaves the central slot 14 free for the reception of double-ended bending levers 4, which are pivoted at 40 in the bed frame, and which have the lateral arms 41 and 42 and the depending arms 43. Extending between the arm 43 and the end frames 13 are jack members 34 and 35, to distinguish them, the depending arms 43 of the two levers being connected preferably, as by means of the links 44; springs 45 tend to return parts to a neutral position such as is shown in Figure 10.

The bending effort is exerted upward by means of spacer members 46 supported upon one or the other of the arms 41 or 42, for instance, having an end seating in a socket 47 in these arms, and its upper end bearing against the axle at or beyond the point to be bent upward. The reaction would be resisted by yokes, bridges, or spacer members (not shown) bearing beneath the axle at the point of resistance and seating upon the bed frame. Downward bending effort may be exerted by such means as the loop or clevis 48 straddling the axle at the point to be bent, and connecting at its lower end to a hook 49 engaging beneath a hooked end, as 42 (see Figure 10), of one of the bending levers.

For exerting lateral bending effort precisely similar arms 4 may be supported in a frame 17 upstanding behind the bed frame, and these may be operated by jacks independent of the jacks 34 and 35, or may be connected for operation by these same jacks; the latter form is shown herein. Thus, for example, the vertical shaft 36 may be supported in the frame 17 or from the bed frame, and an arm 37, connected to the link 44, causes this shaft 36 to oscillate as the jacks 34 and 35 are manipulated. This motion is communicated to the horizontally disposed levers 4 by means of the arms 38 and links 39.

Such an arrangement is susceptible of a number of refinements, for instance, connecting the control valves and pumps of the several jacks to one given point so that they may be relieved or may have the power applied without bending down to manipulate the controls upon each jack. It is also possible to supply fluid to the jacks as selected by valves thus located, the fluid coming from a reservoir outside of the jacks themselves, thus in effect, producing a hydraulic press with a number of jacks pressed from a common pressure supply source.

What I claim as my invention is:

1. The method of aligning the steering system of an automobile which consists in removing the wheels from their spindles and the axle, with spindles in place, from the car, subjecting the axle to bending or twisting moments or both, to correct previously determined departures from proper alignment, gauging the spindles as the bending progresses to determine the proper setting thereof, gauging the steering arms, and finally altering the position of their ends, as required, to bring both steering arms into proper and like relationship to the planes of their respective wheels.

2. The method of aligning the steering system of an automobile which consists in applying twisting or bending moments, as required, to the axle between the spring perches, to bring the lat-

- ter into alignment, and into a common plane, gauging the angularity of the king pin, applying twisting or bending moments, as required, to the axle outside of the perches, to bring the king pins into correct position, gauging the spindles in their normal assembled places, and again altering the angularity of the king pin to correct slight deviations of the spindles.
3. An axle press comprising a bed frame, spaced vises adapted to hold an axle at the spring perches, angular gauge means, means to support the latter in predetermined positions from the spindle, means supported from the bed frame to measure the angular swing of the spindle from straight-ahead position in each direction, and means to apply bending stresses to the axle, while held by the vises in operative relationship to the several gauging means.
4. An axle press comprising a bed frame, spaced vises adapted to hold the axle in a predetermined position, angular gauge means, means including a supporting arm adapted to be secured upon a spindle and to extend parallel thereto, for supporting said gauge means, a segment bar supported from the bed plate, means disposed in the extension of the spindle's axis, supported from said arm and cooperating with the segment bar to measure the angular swing of the spindle from straight ahead position in each direction, and means to bend the axle, while it is held by the vises in operative relationship to the several gauging means, thereby to alter such relationship.
5. An axle press comprising a bed frame, spaced vises adapted to hold the axle in a predetermined position, angular gauge means, means including a supporting arm adapted to be secured upon a spindle and to extend parallel thereto, for supporting said gauge means, a segment bar supported from the bed plate, means disposed in the extension of the spindle's axis, supported from said arm and cooperating with the segment bar to measure the angular swing of the spindle from straight ahead position in each direction, means to adjust said segment bar vertically and lengthwise of the axis, and to adjust the point of support of the cooperating element lengthwise of the spindle, and means cooperating with the vises to bend the axle, while it is held in operative relationship to the several gauging means.
6. An axle press comprising a bed frame, spaced vises adapted to hold the axle in a predetermined position, angular gauge means, means including a supporting arm adapted to be secured upon a spindle and to extend parallel thereto, for supporting said gauge means, a segment bar supported from the bed plate and a plumb bob supported from said arm, and depending from a point in extension of the spindle's axis, said plumb bob cooperating with the segment bar to measure the angular swing of the spindle from straight-ahead position in each direction, and means to apply bending stresses to the axle, while it is held by the vises in operative relationship to the several gauge means, thereby to alter the relationship of the plumb bob to the segment bar.
7. An axle press comprising a bed frame, spaced bases supported thereon, a downwardly facing jaw fixed upon and spaced above each base, a movable jaw beneath the fixed jaw, and pivoted upon each base, a jack adapted to rest upon the base, and to bear upward beneath the pivoted jaw to clamp an axle between the jaws, and thereby to fix it in a predetermined position, angular gauge means, means to support the latter in predetermined positions from the spindles in place upon the axle, means supported from the bed plate to measure the angular swing of the spindle from straight-ahead position in each direction, and means to bend the axle, while thus held, to alter the relationship of the spindle-supported and the bed plate-supported gauge means to each other, and to enable gauging as the bending progresses.
8. An axle press comprising a bed frame, spaced vises adapted to hold an axle in a predetermined position, bending levers independent of said vises and pivotally supported from the bed frame in the plane of an axle thus held, means for transmitting bending moments from said bending levers to selected points upon the axle, and means to swing said bending levers.
9. An axle press comprising a bed frame, spaced means to hold an axle in a predetermined position thereabove, bending levers pivotally supported from the bed frame in the vertical and horizontal planes of an axle thus held, means for transmitting bending moments from said bending levers to selected points upon the axle, and means to swing said bending levers.
10. In an axle press, in combination, axle clamping means comprising a base, a fixed jaw supported from and above said base, a jaw pivotally supported from the base, below the fixed jaw, means reacting from the base to move the pivoted jaw to clamp an axle, and means associated with the jaws to fix the axle thus clamped in a predetermined position relative to the base.
11. A method for aligning the steering system of an automobile, such system including two wheels, a spindle whereon each wheel is rotatably mounted, and an axis normally supporting the car, and to the ends of which the respective spindles are pivotally mounted to swing forwardly and rearwardly of the axle, which method consists in removing the axle from the car, leaving the spindles in place upon the axle, subjecting the axle to bending or twisting moments, or both, to correct previously determined departures from proper alignment, and independently gauging by separate reference to each spindle axis to determine its relation to fixed reference points on the axle, as the bending progresses, to determine the alignment of the steering system.
12. A method whereby may be aligned the steering system of an automobile, such system including an axle provided at its ends with king pin holes, a spindle whereon is rotatably mounted a wheel, and swingably supported by a king pin received in the axle's king pin holes, such method comprising the steps of removing the wheels from their spindles, removing the axle, with spindles in place, from the car, disposing the axle in position wherein the king pins are generally upright, subjecting the axle to bending moments to correct previously determined departures from proper alignment, and independently gauging each individual spindle as the bending progresses to determine the alignment of the steering system as a whole.
13. A method whereby may be aligned the steering system of an automobile, such system including two road wheels, spindles whereon each of said wheels is rotatably mounted, and an axle normally supporting the car, and to the ends of which the respective spindles are pivotally mounted by king pins to swing on a generally upright axis, which method comprises gauging the steer-

ing system to determine the nature and extent of misalignment, removing the wheels from their spindles, leaving the spindles secured by their king pins upon the axle, removing the axle, with
 5 spindles in place, from the car, distorting the axle to correct observed departures of the steering system from proper alignment, and gauging the spindles as the bending progresses to determine the alignment of the steering system.

10 14. A method whereby may be aligned the steering system of an automobile, such system including two wheels, a spindle whereon each wheel is rotatably mounted, and an axle normally supporting the car, and to the ends of which the
 15 respective spindles are pivotally mounted to swing on an inclined, generally upright axis, which method consists in removing the wheels from their spindles, leaving the spindles in place upon the axle, supporting the axle in a position fixed
 20 in relation to a predetermined reference line, subjecting the axle while thus supported to bending or twisting moments, or both, to correct previously determined departures from proper alignment, and separately gauging the individual relation of each spindle to such predetermined reference line as the bending progresses, and with
 25 the axle so fixed in position, thus to determine the alignment of the steering system.

30 15. A method whereby may be aligned the steering system of an automobile, such system including two road wheels, spindles whereon each of said wheels is rotatably mounted, and an axle normally supporting the car, and to the ends of which the respective spindles are pivotally mounted
 35 to swing on a generally upright axis, which method consists in removing the wheels from their spindles and the axle, with spindles in place, from the car, gauging the axle itself and the spindles to determine the nature and extent of misalignment, subjecting the axle to bending or
 40 twisting moments, or both, as indicated, to correct observed departures from proper alignment, and as the bending or twisting progresses, gauging the axle to determine its straightness, and the spindles to determine the alignment of the steering system.

45 16. A method whereby may be aligned the steering system of an automobile, such system including two wheels, a spindle whereon each wheel is rotatably mounted, and an axle normally supporting the car, and to the ends of which the
 50 respective spindles are pivotally mounted to swing on an inclined, generally upright axis, which method consists in removing the wheels from their spindles and the axle, with the spindles in place, from the car, supporting the axle substantially in its normal position of use and in a definite relation to a vertical reference line, gauging the steering system with respect to such reference
 55 line, with the axle thus supported, to determine the nature and extent of misalignment, subjecting the axle to bending or twisting moments, or

both, as indicated, to correct observed departures from proper alignment, and as the bending or twisting progresses, gauging the steering system with respect to such reference line to determine its alignment.

80 17. A method whereby may be aligned the steering system of an automobile, such system including two wheels, a spindle whereon each wheel is rotatably mounted, and an axle normally supporting the car, and to the ends of which the
 85 respective spindles are pivotally mounted to swing on an inclined, generally upright axis, which method consists in removing the wheels from their spindles and the axle, with the spindles in place, from the car, subjecting the axle to bending or
 90 twisting moments, or both, as indicated by previous determinations of departure from proper alignment, supporting the axle in its normal horizontal position of use, and gauging each spindle separately with respect to a vertical line, with
 95 the axle thus supported, to determine the alignment of the steering system.

100 18. A method for aligning the steering system of an automobile, such system including an axle normally supporting the car, a spindle pivotally mounted at each end thereof to swing forwardly and rearwardly of the axle, wheels rotatably
 105 mounted on the spindles, and means interconnecting the two spindles to effect simultaneous swinging thereof in opposite directions relative to the axle, which method comprises removing the axle from the car, leaving the spindles in place upon the axle, and the interconnecting means between the two spindles connected, independently gauging the relation of each spindle
 110 to the axle for each of a plurality of positions assumed by the interconnecting means, correcting parts indicated to be improperly adjusted, and independently gauging the spindles as the correcting progresses to determine the alignment of the steering system as a whole.

115 19. A method for aligning the steering system of an automobile, such system including an axle normally supporting the car, a spindle pivotally mounted at each end thereof to swing forwardly and rearwardly of the axle, and wheels rotatably
 120 mounted on the spindles, which method comprises removing the axle from the car, leaving the spindles in place, supporting the axle in a predetermined position, applying gauging means to a spindle, gauging the spindle in a plurality of positions swung about its pivot relative to the axle, to determine the nature and extent of misalignment, subjecting the axle while thus supported to bending or twisting moments, or both, as indicated, to correct observed departures of the
 125 spindle from proper alignment, and gauging the spindle, as the distortion of the axle progresses, in a plurality of positions swung about its pivot relative to the axle, to ascertain the effect of the bending or twisting moments on the axle.

CLAUDE C. BENNETT.