June 13, 1939. G. D. SHAEFFER 2,162,360

ROAD GRADER

Filed May 15, 1937 2 Sheets-Sheet 1

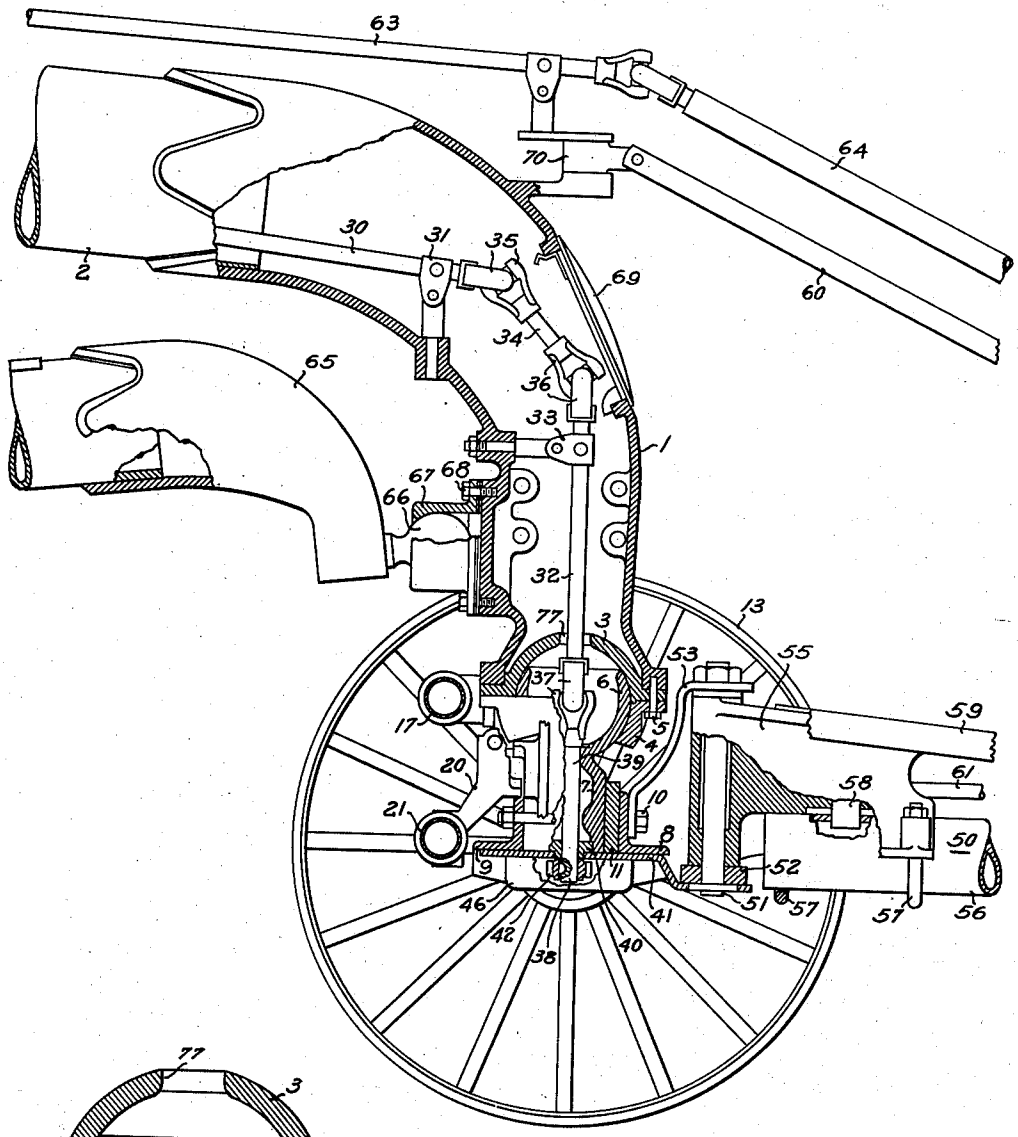


Fig. 1

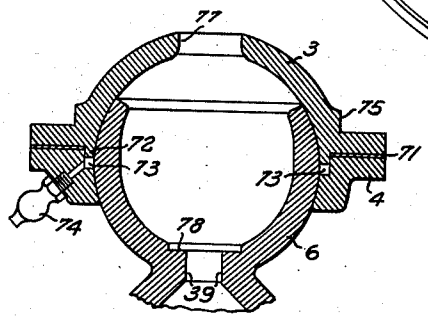


Fig. 5.

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ROAD GRADER

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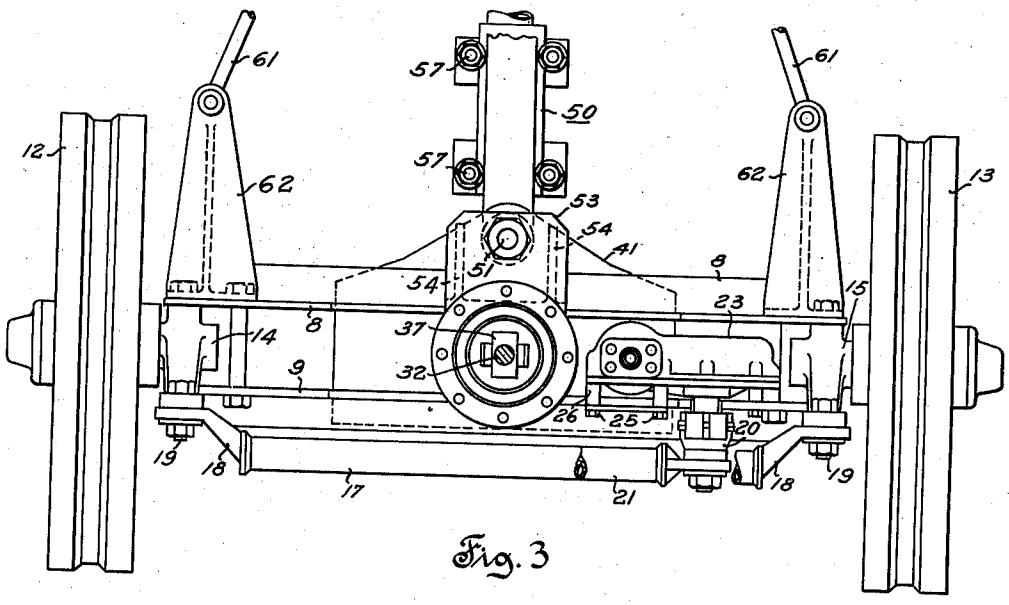


Fig. 3

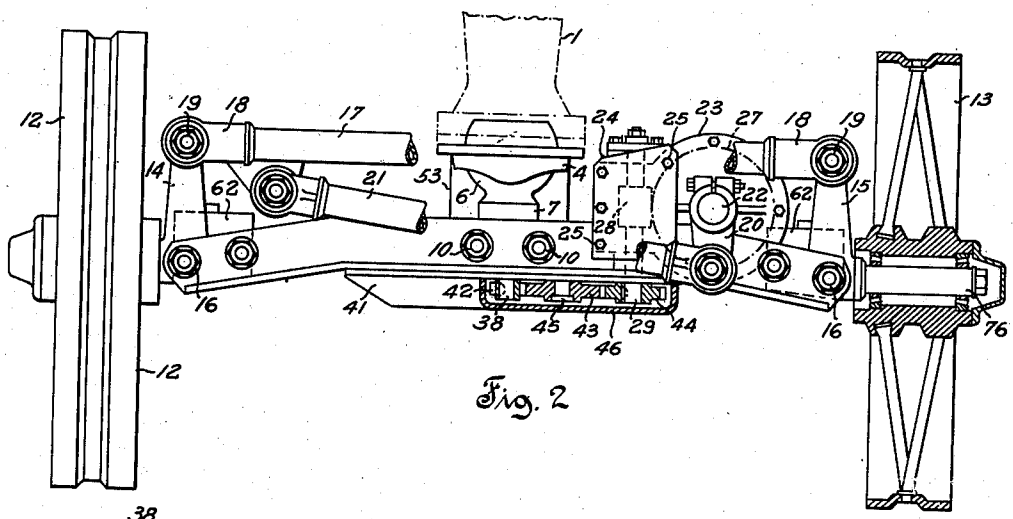


Fig. 2

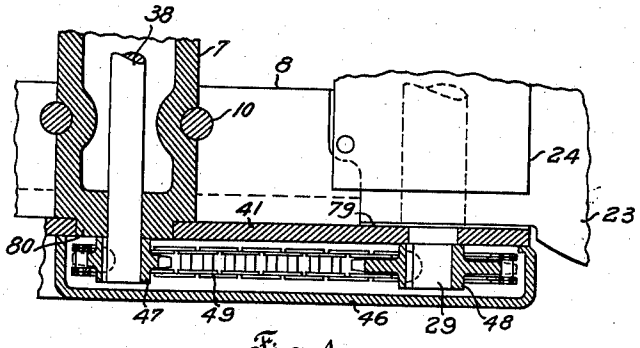


Fig. 4

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UNITED STATES PATENT OFFICE

2,162,360

ROAD GRADER

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Application May 15, 1937, Serial No. 142,774

17 Claims. (Cl. 280—95)

The invention relates to road graders and it is concerned more specifically with an improved grader front assembly.

In road graders which have the blade mounted on a main frame, for instance by means of a drawbar connected at its forward and rearward ends with the main frame, it is desirable that draft forces applied at the forward end of the main frame act in a plane as close to the ground as possible. The counter-forces which act upon the grader blade are concentrated substantially at the ground level, and if the draft forces are applied to the main frame in a plane above the ground level these draft forces and counter-forces set up a force couple which imposes a downward thrust upon the front end of the main frame. This downward thrust may become undesirably high if the draft forces are applied to the main frame in a relatively high plane above the ground level, and for that reason the plane in which the draft forces are applied to the main frame should be kept as close to the ground as possible. From a practical standpoint, however, it is difficult to meet this requirement, especially where a wheel supported front axle is universally connected with the main frame and the wheels are leanable, these latter features being desirable for well known reasons. The requirement that the wheels be leanable makes it necessary to provide a mechanism for leaning the wheels, and as such mechanism is preferably mounted on the front axle and must be operable from the main frame, a problem is presented as to how the front wheels can be made leanable and at the same time the point of draft application to the main frame can be kept at a desirably low level. Generally speaking, it is an object of the invention to provide a solution for this problem.

More specifically, it is an object of the invention to provide an improved grader front assembly including an axle universally connected with the main frame at a relatively low level above the ground, a wheel lean mechanism mounted on the axle, and driving means for the wheel lean mechanism operable from the main frame.

Another object of the invention is to provide an improved drive for the front wheel lean mechanism or other adjustable elements.

Another object of the invention is to protect the universal connection between the main frame and the front axle and the drive for the wheel lean mechanism from dust and dirt, the operating conditions of a grader being particularly apt to cause injury of these parts by dust and dirt.

Another object of the invention is to keep the universal connection between the main frame and the front axle and the drive for the wheel lean mechanism properly lubricated without frequent attention by the operator of the grader.

Still another object of the invention is to provide for lubrication of the drive for the wheel lean mechanism with lubricant which will flow easily at low temperatures, as in cold weather, and to prevent loss of such lubricant at high temperatures, as in hot weather.

Still another object of the invention is to provide an improved grader front assembly which is simple and compact in construction, efficient in operation, and which may be manufactured at low costs.

These and other objects and advantages of the invention will be apparent from the following description. In the drawings accompanying and forming part of this specification an embodiment of the invention and a possible modification are shown, from which the invention and the operation of a device constructed in accordance therewith will be readily understood.

Fig. 1 is a vertical longitudinal section through the front assembly of a leaning wheel grader, parts of a drawbar and of a draft tongue being shown in elevation and other parts being fractionally shown for purposes of disclosure.

Fig. 2 is a rear view, partly in section, of the axle unit of the assembly shown in Fig. 1.

Fig. 3 is a top view of the axle unit shown in Fig. 2.

Fig. 4 shows a modification of the gearing shown in Fig. 2 for driving the wheel lean mechanism.

Fig. 5 is an enlarged detail view of the hollow ball and socket joint shown in Fig. 1.

A hollow casting indicated by the reference character 1 comprises a vertical tubular portion forming the front post of a main frame, and an upper arcuate tubular portion connected with a pipe 2, the pipe 2 extending rearwardly in a slightly upwardly inclined direction and forming a central reach member of the main frame. The rear end of the main frame, which is not shown, is supported on a wheel supported axle as will be understood without further description. A hemispherical bearing element 3 has a short cylindrical shoulder 75 fitted into the flared lower end of the front post, and a radial flange of the hemispherical bearing engages a fillet at the flared lower end of the front post. A collar 4 forms a continuation of the hemispherical bearing element 3 and has a spherical bearing surface which is extended at the front and rear by

downwardly projecting portions of the collar, the rearward downward projection being shown in Fig. 2. A radial flange of the collar 4 extends below the radial flange of the hemispherical bearing element 3, shims 71 being inserted between the flanges as more clearly shown in Fig. 5. An annular shoulder 72 of the bearing element 3 fits into an annular recess of the collar 4 to insure an accurate position of the collar 4 on the bearing element 3. The annular recess of the collar 4 is somewhat deeper than the height of the annular shoulder 72 of the bearing element 3, as more clearly shown in Fig. 5, and the space between the lower surface of the shoulder 72 and the horizontal and vertical surfaces of the recess of the collar 4 forms a groove 73 which communicates with a grease fitting 74. The bearing element 3 and the collar 4 constitute the socket part of a ball and socket joint and they are secured to the front post by bolts 5 which are screwed into the fillet at the lower end of the front post. The ball part of the ball and socket joint consists of a spherical hollow element 6 which is open at the top and which is integrally formed at the bottom with a mounting shank 7.

The front post of the main frame is connected by means of the ball and socket joint with a front axle structure comprising two parallel angle irons 8 and 9 which are slightly arched (Fig. 2), and between which the shank 7 of the ball element 6 is secured by means of bolts and nuts 10 and spacers 11. Leanable ground wheels 12 and 13 are mounted on knuckles 14 and 15 which have wheel spindles 76 and are pivoted between the ends of the angle irons 8 and 9 on horizontal axes by means of bolts 16, the bolts having heads and nuts and extending through the vertical legs of the angle irons. The knuckles have upwardly extending arms the upper ends of which are offset towards the rear of the axle structure, and a tierod 17 still further offset towards the rear of the axle structure so as to clear the ball and socket joint, is connected to the upper ends of the knuckle arms by means of offset rod ends 18 and bolts and nuts 19.

Transverse tilting or leaning of the wheels 12 and 13 about the axes of the bolts 16 is effected by rotation of a crank 20, a link 21 being connected at one end with the crank and at the other end with the tierod 17 near the knuckle 14. The link 21 is disposed in the same vertical plane as the tierod 17, as may be seen from Fig. 1, and the crank 20 is offset so as to permit rotation without interference with the link 21. The hub of the crank is clamped upon a shaft 22 projecting above the angle iron 9 from a gear casing 23 which is mounted between the angle irons 8 and 9, and in which the shaft 22 is rotatably mounted. An upwardly extending plate 24 is secured to the vertical leg of the angle iron 9, and the gear casing is secured to the angle iron 9 and to the plate 24 by bolts 25 and spacers 26. Secured to the shaft 22 within the gear casing 23 is a worm wheel 27, and a worm 28 in mesh with the worm wheel is secured to a vertical shaft 29 rotatably mounted in a lateral extension of the gear casing. It will be noted that the crank and gear casing are disposed laterally of the ball element 6 and shank 7, leaving space for mounting the ball element in close proximity to the axle, and that the gear casing is sufficiently spaced from the ball and socket joint so as to afford adequate freedom of vertical swinging movement of the axle about the center of the ball and socket joint.

Rotation of the worm shaft 29 for the purpose of swinging the crank 20 and thereby leaning the wheels 12 and 13 is effected by means of the following mechanism. A shaft 30 which may be rotated by any suitable means, for instance by a motor or hand operated device on the main frame, extends longitudinally within the pipe reach 2 and is journaled at its forward end in a bearing 31 mounted within the upper portion of the front casting 1. A vertical shaft 32 extends within the vertical tubular portion of the front casting and is journaled at its upper end in a bearing 33 mounted within the casting 1. The forward end of the shaft 30 and the upper end of shaft 32 are operatively connected by a short intermediate shaft 34 and universal joints 35 and 36. The lower end of the vertical shaft 32 extends through a central aperture 77 in the hemispherical bearing element 3, and a universal joint 37 concentric with the ball and socket joint connects the shaft 32 with a vertical shaft 38. The shaft 38 is journaled at its upper end in the lower part of the ball element 6 which merges with the shank 7, a bore 39 through the merging portion of ball 6 and shank 7 forming a bearing for the shaft 38. The lower part of the universal joint 37 is seated on a spot face 78 at the upper end of the bearing 39, preventing downward movement of the shaft 38 and sustaining the shaft 32 against axial displacement downwardly. Fitted into the lower end of shank 7 is a collar 40 which forms a bearing for a lower part of shaft 38, the collar having a shoulder fitted into a hole in a plate member 41 which extends between the angle irons 8 and 9 and is secured to the horizontal legs thereof from below. The collar 40 has sealing engagement with the shank portion 7 and with the plate member 41. Keyed on the end of shaft 38 below the plate member 41 is a pinion 42 which meshes with an idler gear 43, and the idler gear meshes with a gear 44 keyed to the end of worm shaft 29 below the plate member 41. The idler gear 43 is rotatably mounted on a collared stub shaft 45 which is supported by the plate member 41, and it will be noted that the gears 42, 43 and 44 extend in a horizontal plane below the plate member 41, and do not materially obstruct the ground clearance of the axle structure. A cover 46 for the gear train is secured to the plate member 41 from below, and the plate and cover provide an enclosure for the gear train. The worm gear 27 and worm 28 are enclosed within the gear casing 23, and the lower part of the portion of the gear casing which houses the worm 28 is sealingly connected with the plate member 41 so that no dirt or dust can enter the compartment for the gears 42, 43 and 44 from above through the opening in plate 41 for the worm shaft 29. A cork seal 79 (Fig. 4) is preferably interposed between the gear casing 23 and the plate member 41.

Instead of a train of intermeshing gears for transmitting power from shaft 38 to worm shaft 29 a chain drive as shown in Fig. 4 may be used. The chain drive comprises sprocket wheels 47 and 48 secured to the lower ends of shafts 38 and 29, respectively, and a chain 49 trained over the sprocket wheels. As also shown in Fig. 4, the lower bearing for the shaft 38 may be formed integrally with the shank 7, and the shank may have a shoulder 80 sealingly fitted into a hole in plate member 41.

The plate member 41 extends forwardly beyond the forward angle iron 8 for connection with a draft tongue 50. A portion of the plate

member 41 in front of the angle iron 8 is offset into a horizontal plane below the plane of the horizontal legs of the angle irons 8 and 9, and has a hole in it for the reception of a coupling pin 51. The hole being reinforced by a washer 52 which is secured to the plate. The upper end of the coupling pin is supported in a bracket 53 which is strengthened by lateral webs 54 and which is secured to the vertical leg of the angle iron 8 by means of the bolts 10 which also extend through the spacers 11, the shank 7 and through the vertical leg of angle iron 9. A casting 55 is pivoted on the coupling pin 51 and has a semicylindrical recess at its under side in which a pipe 56 is retained by U-bolts 57, a stud 58 being secured to the casting and projecting through the wall of the pipe 56 to transmit the draft forces which act upon the pipe 56. A brace 59 secured to the casting is connected at its forward end with the pipe in any suitable manner, not shown. For purposes of supporting the draft tongue in a substantially horizontal position any well known means may be employed, a link 60 pivotally secured to a swiveled support 70 at the upper part of the casting 1 forming part of such supporting means, and a further description in this connection is believed unnecessary. Likewise it will suffice to say that any suitable means may be employed between a forward portion of the tongue and the ends of the axle structure for swinging the tongue about the axis of the coupling pin 51 and for holding it in any adjusted angular position relative to the axle. Such means may include a horizontally disposed sprocket wheel rotatably mounted on a forward portion of the tongue, a chain trained over the sprocket wheel and connected at its ends to rearwardly extending rods, such as the rods 61 indicated in Fig. 3, which are pivotally connected with forwardly extending brackets 62 mounted at the ends of the axle structure. A suitable mechanism for rotating the sprocket wheel may be operated by rotation of the shafts 63, 64 indicated in Fig. 1.

The forward part of a drawbar is indicated in Fig. 1 at 65, and a ball 66 on the forward end of the drawbar is retained in a socket 67 secured by bolts 68 to the rear of the tubular front post above the ball and socket joint formed by the ball element 6 and the socket parts 3 and 4. The drawbar, as will be understood, carries a grader blade and is adjustably connected at its rear end with an intermediate portion of the main frame, for instance by means of cranks and links as shown in applicant's earlier Patent 1,915,105, June 20, 1933, Grader. Assuming that a horizontal cut is to be made, as in grading a road surface, the rear end of the drawbar is adjusted to the desired depth of cut, and draft forces applied to the forward end of the main frame in a plane above the ground level, on the one hand, and the resistance encountered by the grader blade which centers substantially at the ground level, on the other hand, will set up a force couple which results in a downward thrust upon the front casting 1 and the front axle structure. In the front assembly disclosed hereinbefore the draft forces which are applied to the draft tongue 59 are transmitted to the main frame through the ball and socket joint 3, 4, 6, and in a grader equipped with this front assembly the arm of the mentioned force couple is substantially equal to the distance of the center of the ball and socket joint from the ground level. It should be noted that the axes of the wheel spindles 76 in the position shown in Fig. 2, which they occupy when the wheels are not leaned, extend horizontally below but in proximity to a horizontal plane through the center of the ball and socket joint 3, 4, 6. The center of the ball and socket joint is therefore located at a relatively low level above the ground with the result that the downward thrust upon the front end of the main frame due to the mentioned force couple, will be comparatively little. The wheel lean mechanism and its drive are arranged to accommodate universal movement of the axle about the center of the ball and socket joint 3, 4, 6. The worm and gear mechanism for rotating the crank 20 is mounted on the front axle laterally of the ball and socket joint where it does not interfere with rotary horizontal movements of the axle nor with vertical swinging movements of the axle within wide limits. The drive for the worm shaft 29 may be operated from the main frame in any position which the front axle may assume in practical operation, the universal joint 37 being arranged concentrically with the ball and socket joint between the front post and the axle.

It should also be noted that the drive for the worm shaft 29 and the worm and gear mechanism are fully enclosed and thereby protected from dust and dirt. The arrangement of the ball and socket joint as shown, with the ball part mounted on the axle and the socket part mounted on the front post, tends to protect the ball and socket joint against the ingress of dirt because the exposed surface of the ball faces downwardly and not upwardly as would be the case if the socket part were mounted on the axle and the ball part on the front post.

Finally, the working parts of the ball and socket joint and of the entire drive mechanism for the crank 20 may be kept properly lubricated without frequent attention by the operator of the greater. A relatively light lubricant which flows easily at low temperatures, as in cold weather, is ordinarily desired for the universal joint 37, for the bearings for shaft 38, for the gears 42, 43 and 44 or for the chain drive, and for the worm and gear mechanism 27 and 28, while a relatively heavy lubricant is ordinarily desired for the ball and socket joint 3, 4, 6. Light lubricant may be poured into the front post through an aperture which is normally closed by a cover 69, and the interior of the hollow ball and socket joint may thus be filled with such light lubricant. The pivots of the universal joint 37 will be kept immersed in this lubricant and the upper and lower bearings for shaft 38 will be lubricated by lubricant passing down along shaft 38. If desired, enough lubricant may be poured into the front post to raise it to a level above the hemispherical bearing 3, the space within the hollow front post above the hemispherical bearing 3 forming a suitable reservoir. A bath of light lubricant may also be maintained in the enclosure for the gear train 42, 43, 44, or for the chain drive 47, 48, 49. Likewise, the housing 23 for the worm and gear mechanism 27, 28 will be filled with lubricant. A proper seal between the cover 46 and the plate 41, and the cork seal 79 (Fig. 5) between the housing 23 and the plate 41 prevent loss of light lubricant from the enclosure and from the housing even if the lubricant should become quite thin as in hot weather when the grader is exposed to the sun. Relatively heavy lubricant for the ball and socket joint 3, 4, 6 may be forced through the fitting 74 into the groove

73 between the hemispherical bearing 3 and the collar 4, said groove causing such heavy lubricant to completely surround the ball at the junction of the two parts of the socket. The light lubricant within the hollow ball and socket joint may assist in keeping the relatively engaging surfaces of the ball 6 and its socket at the upper edge of the ball properly lubricated.

It should be understood that it is not intended to limit the invention to the exact details of construction herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In a front assembly for road graders, a substantially vertical hollow front post, an axle structure, a hollow ball and socket joint connecting said axle structure with said front post, the socket part of said ball and socket joint being secured to said front post and having a relatively large aperture below its center and a relatively small aperture above its center, and the ball part of said ball and socket joint having an aperture above its center larger than the upper aperture of said socket element and a downwardly extending portion mounted on said axle structure, a lower shaft mounted on said axle structure for rotation on an axis extending through the center of said ball and socket joint, an upper shaft extending downwardly through said upper aperture in said socket element and having sufficient clearance within said upper aperture to permit a substantial flow of lubricant from the interior of said hollow front post into the interior of said hollow ball and socket joint, and means within said hollow ball and socket joint universally connecting the lower end of said upper shaft with the upper end of said lower shaft.

2. A front assembly for road graders, comprising a front post, a front axle structure including a beam element universally connected with said front post, vertically tiltable wheel knuckles mounted at the ends of said axle structure, a gear casing mounted on said axle structure providing an enclosure below said beam element, a rotatable driving shaft having a lower end within said enclosure and extending upwardly from said beam element on an axis passing through the center of said universal connection, a rotatable driven shaft having a lower end within said enclosure and extending upwardly from said beam element laterally of said driving shaft, gearing within said enclosure drivingly connecting said driving and driven shafts, and mechanism drivingly connected with an upper portion of said driven shaft and with said wheel knuckles for tilting said wheel knuckles by rotation of said shafts.

3. A front assembly for road graders, comprising a front post, a front axle structure, including a beam element, vertically tiltable wheel knuckles mounted at the ends of said axle structure, a ball element and a socket element forming a ball and socket joint, one of said elements, forming an upper part of said ball and socket joint, being secured to said front post and the other of said elements, forming a lower part of said ball and socket joint, being secured to said axle structure, a gear casing mounted at the under side of said beam element sealingly connected with the lower part of said ball and socket joint, a shaft rotatable on an axis extending through the center of said ball and socket joint and having a lower end within said gear casing, and means for tilting said wheel knuckles including gear mechanism within said gear casing operable by rotation of said shaft and operatively connected with said wheel knuckles.

4. A front assembly for road graders, comprising a front post, a front axle structure including a beam element, vertically tiltable wheel knuckles mounted at the ends of said axle structure, a spherical socket element secured to the lower end of said front post, a ball element cooperating with said socket element and having a downwardly extending shank portion secured to said axle structure, a gear casing arranged at the under side of said beam element and sealingly connected with the lower end of said shank portion, a rotatable shaft extending through said shank portion and having a lower end within said gear casing, and means for tilting said wheel knuckles including gear mechanism within said gear casing operable by rotation of said shaft and operatively connected with said wheel knuckles.

5. A front assembly for road graders, comprising a front post, an axle structure, vertically tiltable wheel knuckles mounted at the ends of said axle structure, a ball element and a socket element forming a ball and socket joint, one of said elements, forming an upper part of said ball and socket joint, being secured to said front post and the other of said elements, forming a lower part of said ball and socket joint being secured to said axle structure, a lower gear casing mounted at the under side of said axle structure and sealingly connected with said lower part of said ball and socket joint, a shaft rotatable on an axis passing through the center of said ball and socket joint and having a lower end within said lower gear casing, an upper gear casing mounted on said axle structure laterally of said ball and socket joint and sealingly connected with said lower gear casing, and means for tilting said wheel knuckles including gear mechanism within said lower and upper gear casings operable by rotation of said shaft and operatively connected to said wheel knuckles.

6. A front assembly for road graders, comprising a front post, a front axle structure, vertically tiltable wheel knuckles mounted at the ends of said axle structure, a socket element secured to the lower end of said front post, a ball element cooperating with said socket element and mounted on said axle structure, a lower gear casing mounted on said axle structure below said ball element, and sealingly connected with said ball element, a shaft rotatable on an axis extending through the center of said ball element and having a lower end within said lower gear casing, an upper gear casing mounted on said axle structure laterally of said connecting element and sealingly connected with said lower gear casing, and means for tilting said wheel knuckles including gear mechanism within said lower and upper gear casings operable by rotation of said shaft and operatively connected with said wheel knuckles.

7. In a road grader, a main frame having a substantially vertical hollow post, a socket element forming part of a ball and socket joint, secured to the lower end of said hollow post, an axle structure, a hollow ball element cooperating with said socket element and having associated therewith below its center a shank portion secured to said axle structure, a rotatable shaft extending through said shank portion and into said hollow ball element, an upper journal bearing for said shaft associated with said ball element below its center, and a lower journal bear-

ing for said shaft associated with said shank portion, the interior of said hollow ball element communicating with the interior of said hollow post through an aperture in the upper part of said ball element and through an aperture in said socket element, whereby the interior of said hollow ball element may readily be filled with lubricant poured into said hollow front post.

8. In a road grader, a main frame having a substantially vertical hollow front post, an axle structure, a hollow ball and socket joint connecting said axle structure with said main frame, the socket part of said ball and socket joint being secured to said main frame and having a relatively small aperture above its center, and the ball part of said ball and socket joint being hollow and having an aperture above its center larger than said aperture in said socket part, a downwardly extending shank portion associated with said ball part and mounted on said axle structure, a bearing in said shank portion, a lower shaft journaled in said bearing and having an upper end within said hollow ball part, an upper shaft extending downwardly through said aperture in said socket part and having sufficient clearance therein to permit a substantial flow of lubricant from the interior of said hollow front post into the interior of said hollow ball and socket joint, and a universal joint within said ball and socket joint connecting said upper and lower shafts, said ball and socket parts providing a lubricant chamber around said universal joint in communication with said bearing.

9. In a road grader, a main frame, a socket element forming part of a ball and socket joint, secured to said main frame, an axle structure, a hollow ball element cooperating with said socket element and mounted on said axle structure, a gear casing below said ball element sealingly connected with the latter, a lower shaft extending from said gear casing into said ball element, a bearing for said shaft associated with said ball element, an upper shaft extending downwardly through said socket element, and a universal joint between said upper and lower shafts within said ball and socket joint, said hollow ball element forming a lubricant reservoir above said bearing and in communication therewith.

10. In a vehicle, a main frame, an axle connected with a downwardly projecting portion of said frame for vertical swinging movements about a center in close proximity to said axle, a pair of ground wheels, a knuckle connecting each ground wheel with said axle for pivotal movements about a first axis and for rotation about a second axis angularly disposed relative to said first axis, an upper rotary shaft on said frame, a downwardly extending lower shaft flexibly connected with said upper shaft, bearing means for said lower shaft on said axle below said center of movement of said axle, gearing including driving and driven elements mounted on a portion of said axle intermediate its ends and laterally of said downwardly projecting portion of said frame, a power transmitting member on said driving element transversely spaced from the axis of said lower shaft, means operatively connecting said power transmitting member with said lower shaft, and means operatively connecting said driven element with said knuckles for adjusting said ground wheels about said first axes.

11. In a vehicle, a main frame, an axle connected with a downwardly projecting portion of said frame for vertical swinging movements about a center in close proximity to said axle, a pair of ground wheels, a knuckle connecting each ground wheel with said axle for pivotal movements about a first axis and for rotation about a second axis angularly disposed relative to said first axis, an upper rotary shaft on said frame, a lower rotary shaft flexibly connected with said upper shaft and extending downwardly through a portion of said axle below said center of movement of said axle, gearing including driving and driven elements mounted on a portion of said axle intermediate its ends and laterally of said downwardly projecting portion of said frame, a power transmitting element secured to said lower shaft at the under side of said axle, means operatively connecting said power transmitting element with said driving element, and means operatively connecting said driven element with said knuckles for adjusting said ground wheels about said first axes.

12. In a vehicle, a main frame, an axle connected with a downwardly projecting portion of said frame for vertical swinging movements about a center in close proximity to said axle, a pair of ground wheels, a knuckle connecting each ground wheel with said axle for pivotal movements about a first axis and for rotation about a second axis angularly disposed relative to said first axis, an upper rotary shaft on said frame, a lower shaft flexibly connected with said upper shaft, means on said axle supporting said lower shaft for rotation about a vertical axis extending through said center of movement of said axle, a driving element extending upwardly from said axle laterally of said downwardly projecting portion of said frame, bearing means on said axle supporting said driving element for rotation about a vertical axis transversely spaced from the axis of said lower shaft, a driven element cooperating with said driving element, means for transmitting rotary movement from said lower shaft to said driving element, and means operatively connecting said driven element with said knuckles for adjusting said ground wheels about said first axes.

13. In a vehicle, a main frame, an axle connected with a downwardly projecting portion of said frame for vertical swinging movements about a center in close proximity to said axle, a pair of ground wheels, a knuckle connecting each ground wheel with said axle for pivotal movements about a first axis and for rotation about a second axis angularly disposed relative to said first axis, an upper rotary shaft on said frame, a lower shaft flexibly connected with said upper shaft and extending downwardly through said axle, means on said axle supporting said lower shaft for rotation about a vertical axis extending through said center of movement of said axle, a driving element extending upwardly and downwardly from said axle, bearing means on said axle supporting said driving element for rotation about a vertical axis transversely spaced from the axis of said upper shaft, means at the under side of said axle for transmitting rotary movement from said lower shaft to said driving element, and means operatively connecting an upper portion of said driving element with said knuckles for adjusting said ground wheels about said first axes.

14. In a vehicle, a main frame, an axle connected with a downwardly projecting portion of said frame for vertical swinging movements about a center in close proximity to said axle, a pair of ground wheels, a knuckle connecting each ground wheel with said axle for pivotal movements about

a first axis and for rotation about a second axis angularly disposed relative to said first axis, upwardly and downwardly extending rotary shafts on said frame and axle, respectively, having a flexible connection with each other concentrically with said center of movement of said axle, an upwardly extending support mounted on said axle in juxtaposition to said downwardly extending portion of said frame, an upright shaft mounted in said support for rotation about an upwardly extending axis in transversely spaced relation to the axis of said downwardly extending shaft, a first gear wheel secured to said downwardly extending rotary shaft, a second gear wheel secured to said upright shaft, a power transmitting element cooperating with said first and second gear wheels to transmit rotation of said downwardly extending shaft to said upright shaft, and means operatively connecting said upright shaft with said knuckles for adjusting said wheels about said first axes.

15. A road grader having ground wheels tiltably mounted on a universally swingable axle, a control shaft rotatable on an axis extending through the center of universal movement of said axle, gearing at the under side of the portion of said axle underlying said center of universal movement and drivingly connected with said control shaft, and power transmitting means above said under side of said axle portion laterally of said center of universal movement and operatively connected with said gearing and with said ground wheels for tilting the latter by rotation of said control shaft.

16. In a road vehicle having a frame, an axle structure, adjustable means mounted on said axle structure, a movable connection between said frame and said axle structure having a passage therethrough, a rotatable shaft extending through said passage, a power transmitting element at the under side of said axle structure secured to said shaft, a power transmitting means at said under side of said axle structure including a second power transmitting element drivingly connected with said first power transmitting element, and mechanism operatively connecting said second power transmitting element with said adjustable means, said mechanism including a driving element secured to and extending upwardly from said second power transmitting element, and a driven element having driving connection with said driving element above said under side of said axle structure.

17. A road vehicle having an axle structure, a post structure above said axle structure, and a ball and socket joint connecting said axle structure with said post structure, said ball and socket joint being hollow to form a lubricant receptacle and the portion thereof secured to said post structure having an open passage affording an inlet for lubricant into said receptacle, said passage communicating with an interior hollow space of said post structure thereabove, and a wall portion of said post structure enclosing said space having an aperture affording direct access to said space for the admission of lubricant thereto.

GEORGE D. SHAEFFER.

Patent No. 2,162,360. CERTIFICATE OF CORRECTION.

GEORGE D. SHAEFFER. June 13, 1939.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 42, for the word "greater" read grader; page 4, second column, line 42, claim 5, for "to" read with; page 6, second column, line 8, claim 16, strike out the article "a"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 8th day of August, A.D. 1939.

(Seal)

Leslie Frazer,
Acting Commissioner of Patents.