Jan. 25, 1944. F. E. ARNDT 2,340,100

ROAD GRADER

Filed Aug. 1, 1941 5 Sheets-Sheet 1

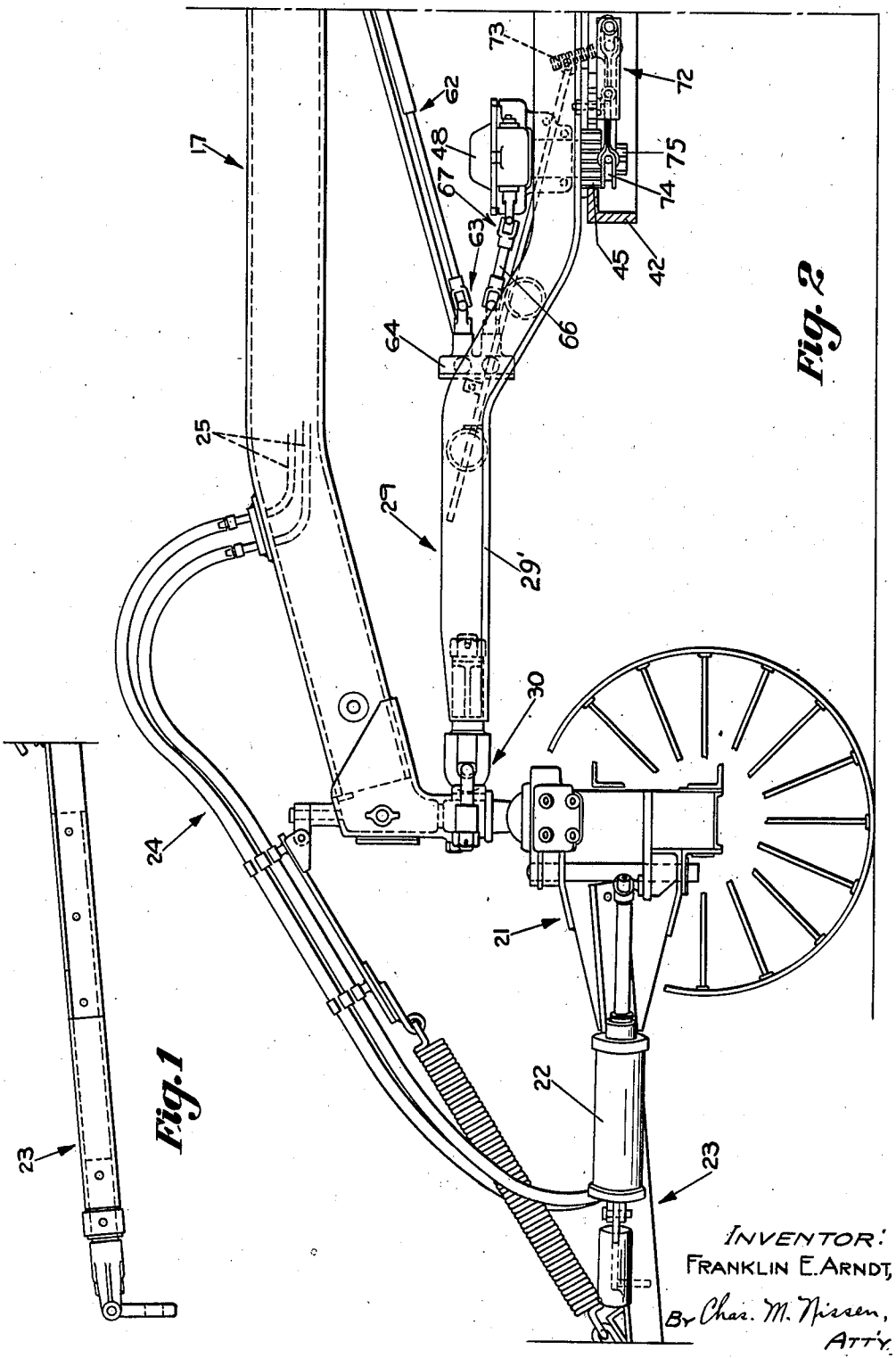


Fig. 2

Fig. 1

INVENTOR:
FRANKLIN E. ARNDT,
By Chas. M. Nissen,
ATT'Y.

Jan. 25, 1944. F. E. ARNDT 2,340,100

ROAD GRADER

Filed Aug. 1, 1941 5 Sheets-Sheet 2

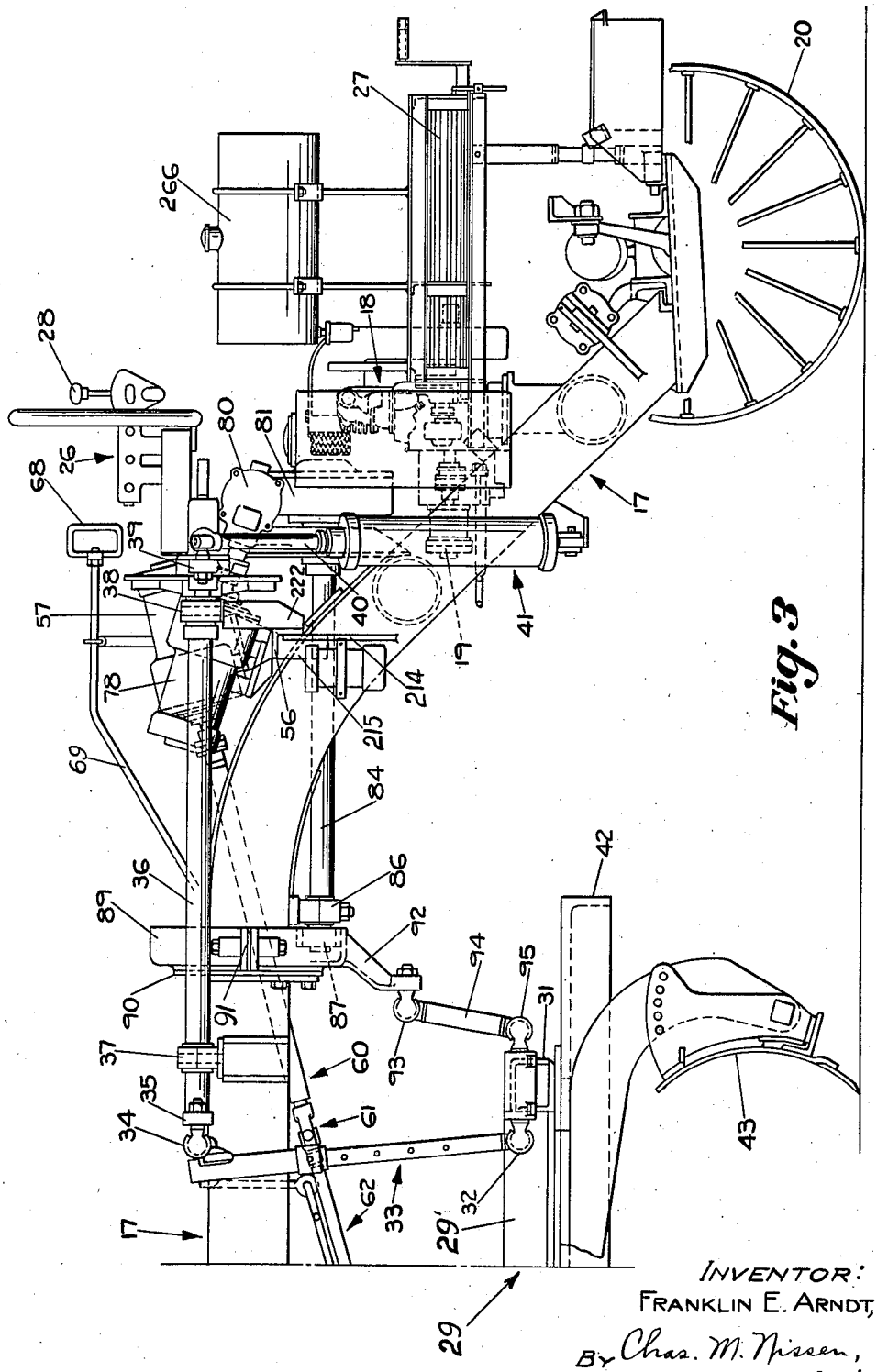


Fig. 3

INVENTOR:
FRANKLIN E. ARNDT,
BY Chas. M. Nissen,
ATT'Y.

Jan. 25, 1944. F. E. ARNDT 2,340,100

ROAD GRADER

Filed Aug. 1, 1941 5 Sheets-Sheet 3

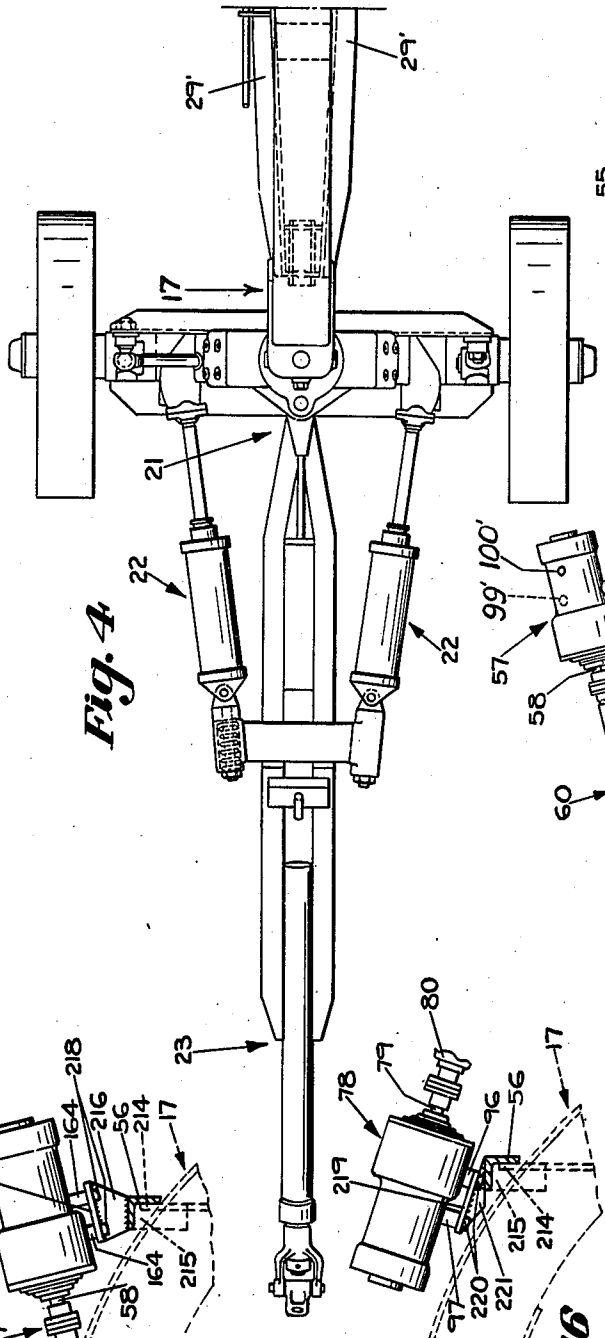


Fig. 4

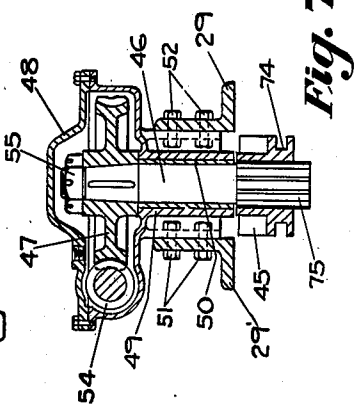
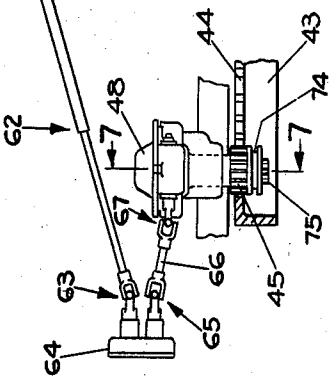


Fig. 7

Fig. 6

Fig. 15

Fig. 16



INVENTOR:
FRANKLIN E. ARNDT,
By Chas. M. Nissen,
ATT'Y.

Jan. 25, 1944. F. E. ARNDT 2,340,100

ROAD GRADER

Filed Aug. 1, 1941 5 Sheets-Sheet 4

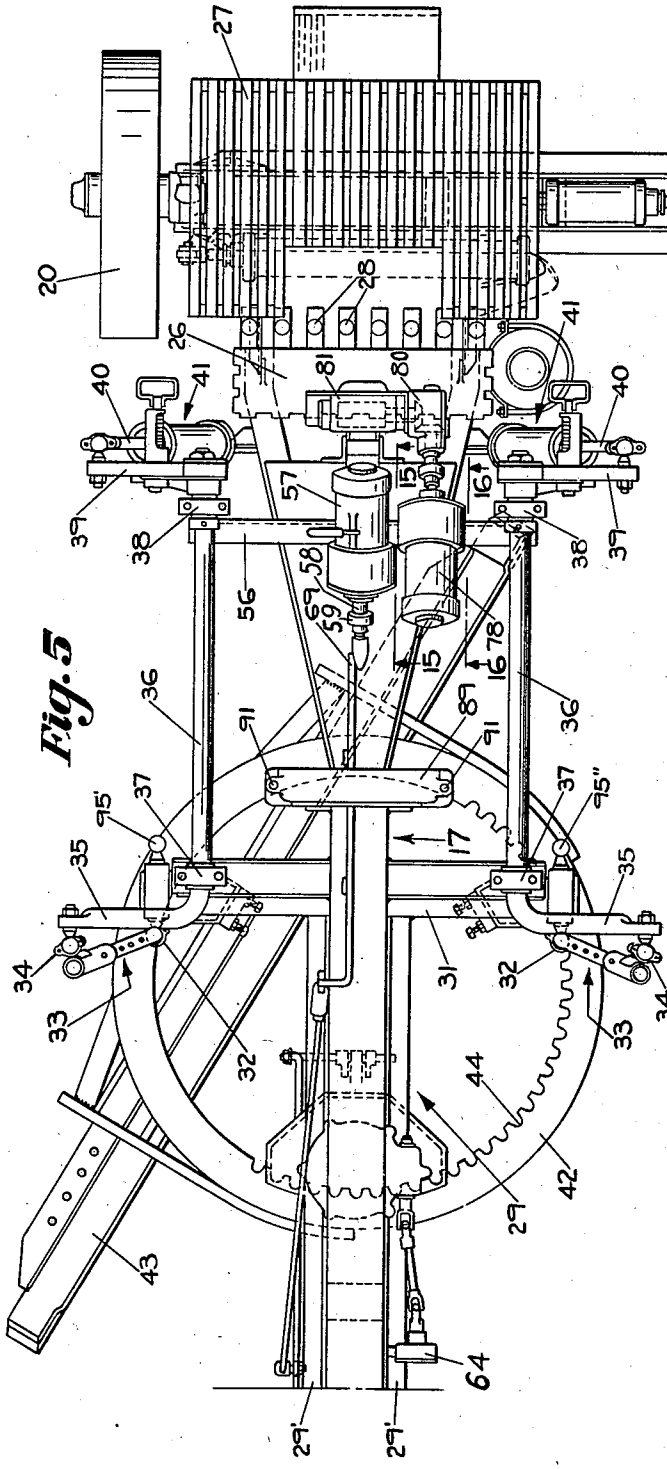


Fig. 5

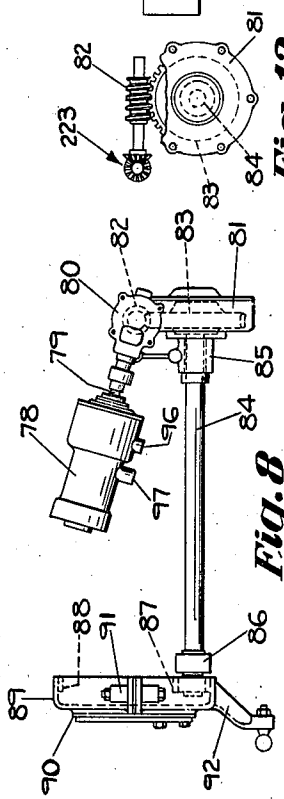


Fig. 8

Fig. 13

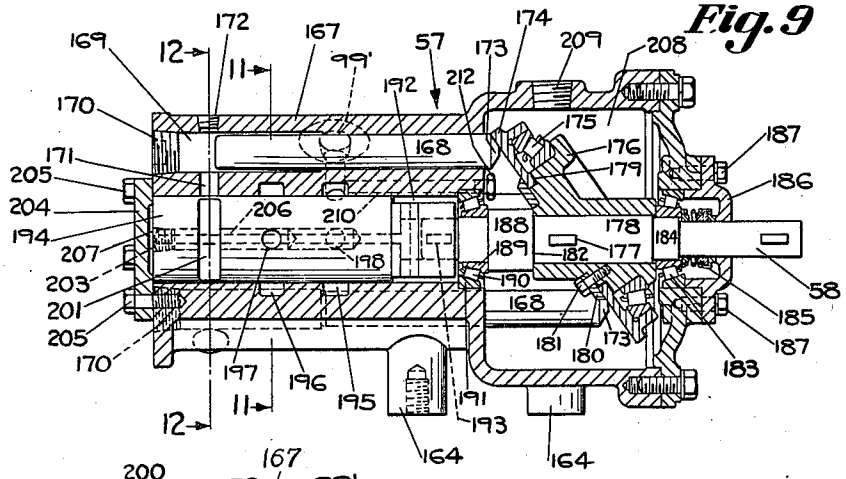
INVENTOR:
FRANKLIN E. ARNDT,
By Chas. M. Nissen,
ATTY.

Jan. 25, 1944. F. E. ARNDT 2,340,100

ROAD GRADER

Filed Aug. 1, 1941 5 Sheets-Sheet 5

Fig. 9



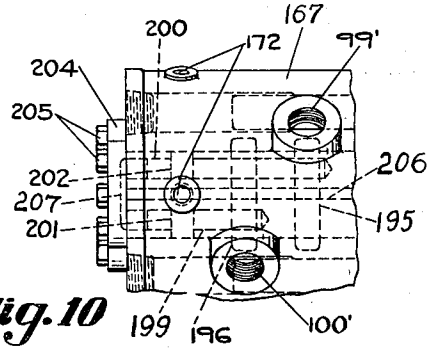


Fig. 10

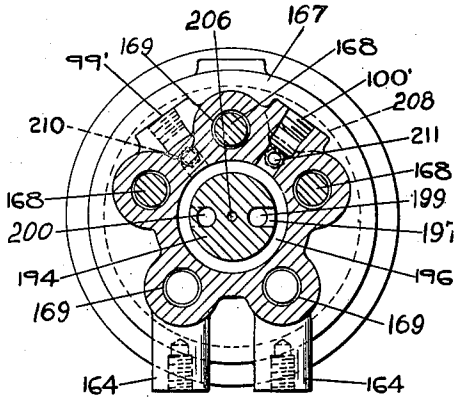


Fig. 11

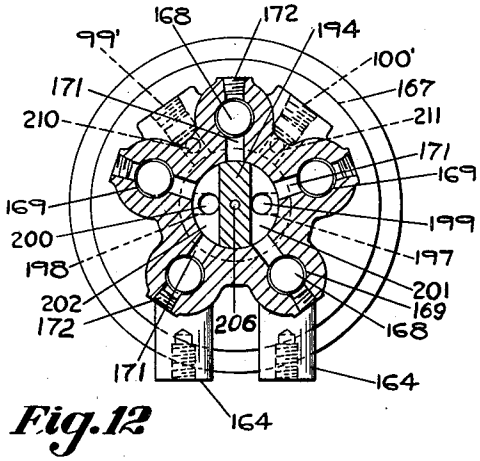


Fig. 12

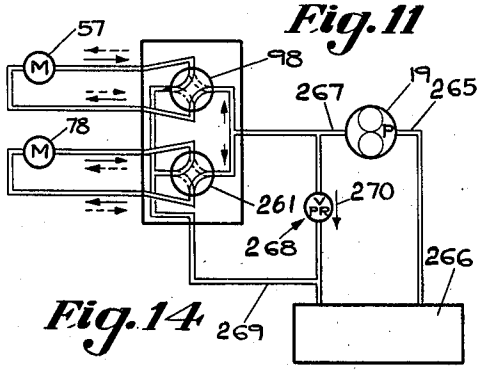


Fig. 14

INVENTOR:
FRANKLIN E. ARNDT,
BY Chas. M. Nissen,
ATT'Y.

Patented Jan. 25, 1944 2,340,100

UNITED STATES PATENT OFFICE

2,340,100

ROAD GRADER

Franklin E. Arndt, Galion, Ohio, assignor to The Galion Iron Works & Manufacturing Company, a corporation of Ohio

Application August 1, 1941, Serial No. 405,047

14 Claims. (Cl. 37—156)

My invention relates to road graders, and one of its objects is the provision of improved and efficient fluid-pressure motor means mounted on the vehicle frame and connected to the circle carrying the grader blade to angularly adjust the latter on an upright axis.

Another object of the invention is the provision of improved and efficient fluid-pressure motor means mounted on the vehicle frame and connected to the drawbar of a road grader for both laterally shifting the grader blade and angularly adjusting the same on an upright axis.

A further object of the invention is to associate in fixed relation to each other on the vehicle frame of a road grader, an engine connected to a pump for supplying rotary hydraulic motors with the necessary fluid-pressure medium and mechanically connect said hydraulic motors to the drawbar of the road grader for laterally shifting the grader blade and angularly adjusting the same on an upright axis and thereby reduce to a minimum, leakage from the connections between the pump and the motors, such adjustments of the grader blade being effected without bending the connections between the pump and the motors since such connections are in fixed relation to the vehicle frame.

Another object of the invention is the provision of a rotary hydraulic motor on the vehicle frame of a road grader with its axis inclined downwardly and extending forwardly to facilitate connection to and operation of self-locking worm gearing for actuating circle turning mechanism to adjust the grader blade on an upright axis.

A further object of the invention is the provision of a rotary hydraulic motor on the vehicle frame with its axis extending downwardly and rearwardly to facilitate connection to and operation of self-locking worm gearing connected by spur gearing to laterally shift the rear end of the drawbar and thereby laterally adjust the grader blade.

Another object of the invention is the provision of a rotary hydraulic motor on the vehicle frame of a road grader connected through reduction worm gearing and reduction spur gearing in series, to effect adjustment of the grader blade with considerable power while the relatively high speed of the rotary hydraulic motor enables such adjustments to be made rapidly.

A further object of the invention is the provision of a rotary hydraulic motor on the vehicle frame connected to worm gearing on the drawbar for turning on an upright axis a grader blade carrying circle relatively to the drawbar.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings,

Figs. 1, 2 and 3 placed end to end show in elevation a road grader embodying my improvements;

Figs. 4 and 5, placed end to end, are plan views of the road grader embodying my improvements;

Fig. 6 illustrates the power-operated mechanism for turning the grader blade carrying circle on an upright axis;

Fig. 7 is a sectional elevational view taken on the line 7—7 of Fig. 6, looking in the direction of the arrows;

Fig. 8 illustrates the power-operated mechanism for shifting laterally the drawbar of the road grader;

Fig. 9 is an enlarged sectional elevational view of either the hydraulic motor shown in Fig. 6 or the hydraulic motor shown in Fig. 8;

Fig. 10 is a plan view of a broken away portion of the rotary hydraulic motor shown in Fig. 9;

Fig. 11 is a sectional elevational view taken on the line 11—11 of Fig. 9, looking in the direction of the arrows;

Fig. 12 is a sectional elevational view taken on the line 12—12 of Fig. 9, looking in the direction of the arrows;

Fig. 13 is an elevation of the right-hand end of Fig. 8 with the gearing casing broken away to show the internal gearing;

Fig. 14 is a piping diagram for the rotary hydraulic motors;

Fig. 15 is a sectional elevational view taken on the line 15—15 of Fig. 5, looking in the direction of the arrows; and

Fig. 16 is a sectional elevational view taken on the line 16—16 of Fig. 5.

Referring to Figs. 2 and 3, placed end to end, it will be seen that the grader frame 17 is mounted at its rear end on ground engaging wheels 20, 20. Mounted on the forward end of the vehicle frame 17 is a steering wheel unit 21 connected by means of the reciprocating hydraulic motors 22, 22 (Fig. 4) to the tongue or machine draft bar 23. The hydraulic motors 22, 22 are connected by means of the flexible hose 24 to pipes 25 which lead rearwardly along the vehicle frame to the valve manifold 26 (Fig. 5) at the operator's station 27. That is to say, the operator while at his station 27 may control the steering wheel unit 21 by manipulating two of the

valves 28 at the rear end of the machine, as shown in Fig. 5. The operator at his station, as shown in Fig. 5, has before him all the various levers for not only steering the machine but also controlling the operation of the engine and the various adjustments in the road grader hereinafter more fully explained.

The drawbar 29, as shown in Fig. 2, is flexibly connected at 30 to the front end of the grader frame 17. The rear end of the drawbar 29 has a cross-piece 31 to the ends of which are connected by means of ball and socket joints 32, 32, the lower ends of the extensible hangers 33, 33, the upper ends of which are connected by ball and socket joints 34, 34 to the laterally extending arms 35, 35 which are connected to the rock shafts 36, 36 journaled in the bearings 37, 37, as shown in Fig. 5.

The rear ends of the rock shafts 36, 36 are journaled in similar bearings 38, 38 and are connected to laterally extending arms 39, 39 flexibly connected to the upper ends of piston rods 40, 40 of a pair of double acting hydraulic motors 41, 41. From the operator's station 27 either or both of the piston reciprocating hydraulic motors 41, 41 may be operated to lift or lower the hangers 33, 33 individually and thus adjust the elevation of the drawbar 29 and its inclination transversely of the road surface.

Carried by the drawbar frame 29 for rotation relatively thereto on an upright axis is a circle 42 carrying the moldboard 43. The circle 42 carries an annular gear 44 which meshes with the pinion 45 secured to the lower end of the shaft 46 the upper end of which is keyed to the worm gear 47, the latter being enclosed in a casing 48, as shown in Fig. 7.

The casing 48 is provided with a lower cylindrical extension 49, as shown in Fig. 7. A bearing bushing 50 lines the cylindrical extension 49. The cylindrical extension 49 is bolted at 51, 51 and 52, 52 to the angle irons 29', 29' of the drawbar 29.

Also mounted within the casing 48 is a worm 54 meshing with the worm gear 47. The pinion 45 may be connected to the splined extension 75 of the lower end of the vertical shaft 46. The pinion 45 is movable along the extension 75 into and out of mesh with the circle rack or gear 44. The upper end of the shaft 46 is screw-threaded to receive the locking nut 55.

Rigidly mounted on the vehicle frame 17 is a cross-piece 56 to serve as the support for the rotary hydraulic motors 57 and 78. The ends of the cross-piece 56 may be welded to the bracket plates 214, 215 which in turn may be welded to the outer sides of the channels of the vehicle frame 17. As shown in Fig. 15 a vertical plate 216 may have its upper edge welded to an inclined plate 217. The latter may have two holes on each side of the plate 216 to receive screws 218, 218 for threading into the four feet 164, 164 at the bottom of the motor 57. In a similar manner the motor 78 may be mounted on the inclined plate 219 by means of the screws 220, the plate 219 being welded to the vertical plate 221 and the latter welded to the cross-piece 56. Each of the rotary motors 57, 78 is therefore detachably connected to the vehicle frame.

Vertical plates 222 secured to the ends of the cross-piece 56, support the journal bearings 38, 38.

As shown in Figs. 3 and 6, the rotary hydraulic motor 57 has its axis inclined downwardly and forwardly. The motor shaft 58 is coupled at 59 to a shaft 60 which is connected by a universal joint 61 to another extensible shaft 62. The lower forward end of the extensible shaft 62 which is connected by means of the universal joint 63 to intermeshing spur gearing located in the casing 64 which is mounted on the drawbar 29, as shown in Fig. 2. The shafts of the spur gearing in the casing 64 both extend rearwardly, the lower shaft being connected by the universal joint 65 to the link 66, the rear end of which is connected by means of the universal joint 67 to the worm 54 in the casing 48. It will thus be seen that the operator at his station 27 may by means of one of the levers 28 start and stop the rotation of the motor 57 in reverse directions to impart rotation to the worm 54 and thus effect rotation of the circle through the spur gearing 44, 45 in either direction and thereby adjust the grader blade on an upright axis for either right-hand or left-hand grader work.

This may be done when the operator at his station releases the handle 68 (Fig. 3), so that the spring 73 may be relied on to hold the pinion 45 in mesh with the arcuate rack 44 on the circle 42.

An important feature of the invention is the provision of relatively low pitch worm gearing 54, 47 so as to be operable with considerable power in rotating the circle against such resistances as may be encountered by the grader blade 43 in contact with the road surface. The worm gearing being of low pitch is self-locking and therefore may be relied upon to eliminate the use of the usual pin and hole locking mechanism to hold the circle in adjusted position relative to the drawbar. In this connection it should be noted that the clutch mechanism 72 comprises a grooved collar 74 secured to the lower side of the pinion 45 and splined onto the lower end of the shaft 46 at 75. In other words, when the operator at his station pulls on the handle 68, the grooved collar 74 is moved down along the splined lower end of the shaft 46 so as to disconnect the pinion 45 from the gear 44 of the circle, thereby freeing the latter when it is desired to move the grader blade manually to any desired position. This may be desirable particularly when the grader blade is to be moved through an angle of 180° in order to reverse the same for operations during rearward travel of the machine.

I have in commercial machines used worms 54 each having a pitch of .75". That is to say, the worms have been single cut with the leads of .75". The worm gears 47 meshing with such worms in such commercial structures have each been single cut circular pitch .75" with forty-two teeth. Furthermore, in such commercial structures the spur pinions 45 each has six teeth of the circular pitch of 2.618" and this arrangement rotates the circle which has a pitch diameter of 52" and sixty-five teeth; that is to say, 1.25 diametral pitch or 2.5138 circular pitch. The ratio of the gearing between the motor shaft 58 and the circle 42 in such commercial structures is approximately 455 to 1. These dimensions and the ratio may, of course, be varied as desired and the figures are set forth merely by way of example to show that the hydraulic motor 57 must rotate its shaft 58 a great many times to rotate the circle once. In the illustration given, the shaft 58 rotates 455 times to secure one rotation of the circle.

A complete rotation of the circle, however, is seldom necessary and is desired only when the

grader blade 43 is to be reversed from the position shown in Fig. 5 and the grader operated by backing the same or traveling rearwardly. During ordinary operations in practice the circle may be shifted about 90° to adjust the machine from a right-hand working machine to a left-hand working machine, and vice versa. But even a quarter of the rotation of the circle 42 would require about 114 rotations of the shaft 58 of the hydraulic motor 57.

The speed of the hydraulic motor 57 may be controlled by the operator at his station 27 by actuating one of the valve levers of the manifold valve 26 shown in Fig. 5. The hydraulic pump 19 is driven directly by the internal combustion engine 18, and rigid metal pipes may be used for connecting a pumping mechanism to the ports 99' and 100' (Fig. 6) since the rotary motor 57 is mounted rigidly on the vehicle frame 17. In other words, since the rotary hydraulic motor 57 is in fixed relation to the vehicle frame and in fixed relation to the internal combustion engine, metal piping connections may be used between the motor and the pumping mechanism, thus preventing leakage which is likely to take place if the hydraulic motor is mounted on the drawbar frame and connected by flexible hose to the pumping mechanism on the vehicle frame. Furthermore, fixed piping connections being available between the pumping mechanism and the rotary motor 57 because the latter is mounted on the vehicle frame, the extent of adjustment of the moldboard to steep bank-cutting positions on either side of the machine is not limited by any flexible hose connections.

The direction of flow of the operating medium, such as oil, through the motor 57 will determine the direction of rotation of the latter, and the rotation of the motor shaft 58 determines the direction of rotation of the circle which carries the moldboard. It will thus be seen that the speed of the hydraulic motor 57 is controlled by the amount of oil which the pump is permitted to deliver to the motor 57. The speed of the motor 57 can be slowed down by throttling action of the valve in the manifold 26 (Fig. 5).

The hydraulic motor 57 used in the commercial structures referred to, can rotate at approximately 145 rotations per minute, and it will thus be seen that the circle can be rotated through approximately 90° in less than a minute. It is reiterated, however, that this reference is made, for example, to show the high speed of rotation of the motor 57 and not the exact speed thereof as in any event the operator at his station may so operate the manifold valve lever as to secure a slower rotation of the motor so as to adjust the moldboard or grader blade to certain definite angles relative to the line of draft of the road grading machine.

The mechanism for laterally shifting the rear end of the drawbar to effect lateral shifting of the grader blade, is shown in Figs. 3, 5 and 8. A rotary hydraulic motor 78 is mounted on the cross-piece 56 and has its axis inclined downwardly and rearwardly so that its shaft 79 may be connected by means of bevel gearing 223 in the casing 80 to worm gearing in the casing 81. This worm gearing comprises a worm 82 in mesh with the worm gear 83, the latter being mounted on a shaft 84 journaled in the bearings 85, 86. The shaft 84 extends forwardly, as shown in Figs. 3 and 8, and is connected at its forward end to a pinion 87 which meshes with the internal annular gear 88 of the ring 89 mounted on an annular bearing 90 which surrounds the vehicle frame 17 at the rear end of its upper horizontal portion, as shown in Fig. 3. The ring gear 89 may be made in upper and lower sections which may be secured together at 91, 91 to lock the ring gear in the annular guide bearing 90.

Extending from the lower side of the ring gear 89 is an arm 92 which may be connected by means of the ball and socket joint 93 to the upper end of the transversely extending link 94 the lower end of which is connected by means of the ball and socket joint 95 to one side of the rear end of the drawbar crosspiece 31. The link 94 may be connected to the ball 95' at one end of the cross-piece 31 or to the ball 95'' at the other end thereof, depending upon whether the moldboard is moved to steep bank-cutting position at one side of the machine or the other, it being preferred in bank-sloping adjustments to have the link 94 in suspension.

The worm gearing 82, 83 is of relatively low pitch so that many rotations of the motor shaft 79 will be necessary to move the arm 92 through a small angle. Such low pitch gearing enables the laterally shifting mechanism to be operated with considerable power so that the moldboard or grader blade may be shifted laterally of the road surface even though the scraping blade may be in contact therewith. Inasmuch as the motor 78 is of relatively high speed under the control of the operator at his station 27, the lateral shifting of the moldboard may be effected in a short space of time. By means of one of the levers of the manifold valve 26, the motor 78 may have directed to its ports the supply and return flow of the oil or other fluid-pressure medium through metal pipes which are in fixed relation to the vehicle frame.

The motor 78 may be reversed or controlled to operate in either direction and therefore the arm 92 may be swung laterally of the vehicle frame either toward one side or toward the other side, and the grader blade with the assistance of adjustment of extensible links or hangers 33, 33 may be adjusted to bank-sloping position at either side of the machine without limitation as to any hydraulic motor piping connections because all of such connections are in fixed relation to the vehicle frame.

The motor shown in Fig. 9 is composed of a cylinder block 167 which remains in stationary position during operation of the motor. As shown in Fig. 12 which is a sectional elevation taken on the line 12—12 of Fig. 9, looking in the direction of the arrows, the pistons 168 fit in cylinders 169 each of which may be formed by boring and counterboring and then closing the left-hand ends as viewed in Fig. 9 with screw plugs 170, 170. The radial ports 171, 171 may be formed by radial boring, with the outer ends closed by the screw plugs 172, 172. The right-hand ends 173 of the pistons 168 each has the shape of a frustum of a cone in position to engage the thrust plate 174 mounted by means of the thrust ring roller bearing 175 on the tilted thrust block 176 which is keyed at 177 to the shaft 178. The thrust plate 174 is held to an annular seat 179 on the thrust block 176 by means of the ring plate 180 held in place by the cap screw 181 extending through the plate 180 into the screw-threaded opening in the block 176, as shown in Fig. 9.

The left-hand end of the block 176, as shown in Fig. 9, fits against an annular shoulder 182 on the shaft 178 while the right-hand end of the

thrust block 176 rests against the inner race of a roller thrust bearing 183 surrounding a reduced portion 184 of the shaft 178. A further reduced portion 58 extends through a liquid seal 185, comprising a spring-pressed stuffing box held in place by the cap 186 and the screws 187, 187.

An enlarged portion 188 of the shaft 178 has an annular shoulder fitting against the inner race 189 of the ring thrust bearing 190, the outer race 191 of which fits against an annular shoulder surrounding the chamber 192 within the cylinder block. It will thus be seen that endwise movement of the shaft 178 relative to the motor frame or casing is resisted by the oppositely arranged thrust bearings 183 and 190.

The inner end of the shaft 178 is keyed at 193 to a reduced extension of the cylindrical port block 194 which by reason of its connections to the shaft 178 rotates with the latter during operation of the motor.

Supply and exhaust pipes extending from the pumping mechanism are adapted to be connected to the screw-threaded ports 99' and 100' shown in Fig. 10. The port 99' communicates with the cylindrical port 195 which is located in the cylinder block and completely surrounds the rotating cylindrical port block 194. In a similar manner, the port 100' communicates with the circular port 196 which is located in the cylinder block and completely surrounds the cylindrical port block 194.

In the cylindrical port block are two radial openings 197 and 198 on opposite sides, as shown in Fig. 9. The ports 197 and 198 communicate with separate passageways 199 and 200 in the cylindrical port block 194. The passageways 199 and 200 are parallel to each other and parallel to the axis of rotation of the shaft 178. These passageways lead toward the left as viewed in Fig. 9 and respectively communicate with the ports 201 and 202. Each of the passageways 199 and 200 may be formed by boring and their left-hand ends closed by screw plugs as illustrated at 203 in Fig. 9.

As shown in Figs. 10 and 12, the port 100' is in communication with the ports 196, 197, 199, 201 and two of the cylinders 169 at the lower right-hand portion of Fig. 12. The other port 99' communicates with the ports 195, 198, 200 and 202, thereby communicating with the cylinders 169 at the lower left-hand portion of Fig. 12. The uppermost cylinder is cut off when the port block 194 is in the position shown in Fig. 12.

As shown in Fig. 9, a cap plate 204 is secured in place by means of the screws 205, 205 to close the cylindrical opening in which the cylindrical port block 194 rotates. A passageway 206 extends axially through the port block 194 so that oil escaping into the chamber 207 may flow into the main chamber 208 of the motor. The right-hand end of the motor may be provided with an inspection opening normally closed by means of the screw plug 209.

It should be particularly noted that two separate parallel passageways 210 and 211 lead respectively from the ports 99' and 100' into the chamber 208. The passageways 210 and 211 are parallel to each other and parallel to the axis of rotation of the shaft 178. The passageway 211 leads from the chamber 208 to the port 100' and is therefore seen in full lines in Fig. 11 which is a section taken on the line 11—11 of Fig. 9, looking in the direction of the arrows. The other passageway 210 is shorter, as may be seen in the elevational view of Fig. 9.

The right-hand ends of the passageways 210 and 211 are each provided with check valves 212, 212 which are so arranged as to open from the chamber 208 into the passageways 210 and 211. In other words, when either port 99' or 100' is a supply port, the check valve connected thereto remains closed by supply pressure, while the other check valve connected to the exhaust automatically opens to relieve the chamber 208 of built-up pressure therein due to leakage past the pistons or otherwise.

Although the rotary hydraulic motor shown in detail in Figs. 9 to 12, inclusive, has been designated 57, it should be understood that the other hydraulic rotary motor designated 78 in Figs. 5 and 8, is of the same construction. The check valves in these motors assure maintaining the chamber 208 filled with oil for lubricating purposes, and the interior pressure is limited by the check valves. In other words, the check valves obtain these advantages which are particularly desirable in road graders.

Each of the rotary hydraulic motors 57 and 78 is detachably mounted on the cross-piece 56 by means of screws inserted through bracket plates 217, 219 on the cross-piece 56 into screw-threaded openings in the feet 164, 164, of the motor 57 and into the screw-threaded openings in the feet 96 and 97 of the rotary motor 78 shown in Fig. 8; see also Figs. 15 and 16.

Inasmuch as each of the rotary motors 57 and 78 is reversible, the valves connected to the levers 28 at the manifold 26 are so arranged as to control the direction of flow of the fluid-pressure medium, such as oil, through each motor individually. When the motor 57 is rotated in one direction, the circle 42 will be rotated clockwise as viewed in Fig. 5, and when the motor 57 is reversed, the circle 42 will be rotated anti-clockwise. When the rotary motor 78 is rotated in one direction, the rear end of the drawbar together with the grader blade will be laterally shifted to one side of the machine, and when the motor 78 is reversed, the grader blade will be shifted to the other side of the machine. These operations can be carried out under the control of the operator at his station at the rear end of the machine while the internal combustion engine 18 drives the pump 19 continuously because the valves at the manifold 26 are under the control of the operator to start, stop and reverse each of the motors 57 and 78 individually.

The piping connections for the rotary hydraulic motors 57, 78 are shown diagrammatically in Fig. 14. The pump 19 is driven continuously to draw oil from the supply tank 266 through the suction pipe 265 and force the same into the supply pipe 267. By means of the reversing valves 261, 98 in the manifold 26, the liquid may be supplied to either motor 57 or 78 as indicated by the full line arrows, to drive them in certain directions; or, the liquid may be supplied to the motors 57, 78 as indicated by the dotted line arrows, to drive them in reverse directions. The motors may be individually started, stopped and reversed, by means of the valves 261, 98. When the motors are operating the return flow of the oil to the supply tank 266 is through the pipe 269. When the valves 261, 98 are closed and all the other valves of the manifold 26 are likewise closed, the pump may nevertheless continue to operate because then the by-pass valve 268 will automatically open to by-pass the liquid in the direction of the arrow 270.

The motor illustrated in Figs. 9 to 12, inclusive, is disclosed and claimed in my co-pending application, Ser. No. 379,971, filed Feb. 21, 1941, for an improvement in Road graders as a division of Ser. No. 348,981, filed July 31, 1940, for an improvement in Road graders.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and I therefore wish not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

I claim:

1. In a road grader, the combination with a vehicle frame, of a drawbar connected thereto, a grader blade carried by said drawbar, means for adjusting said drawbar, an annular spur gear journaled on said frame, an actuating arm extending from said annular gear, a link connecting said arm to said drawbar, a pinion meshing with said gear, a shaft carrying said pinion, a rotary fluid-pressure motor, mechanism comprising bevel gearing and self-locking worm gearing for connecting said motor to said shaft, and means for controlling said motor.

2. In a road grader, the combination with a vehicle frame, of a drawbar connected thereto, a grader blade carried by said drawbar, means for adjusting said drawbar relative to said frame, a longitudinal shaft, an actuating arm, a link connecting said arm to one side of the rear end of the drawbar, actuating means between said shaft and said arm, a worm gear connected to said shaft, a worm meshing with said worm gear, a rotary hydraulic motor mounted on said frame and having a rotary shaft extending downwardly and rearwardly longitudinally of said frame, driving connections comprising bevel gearing between said last-named shaft and said worm, and means for controlling said hydraulic motor to effect lateral swinging of said arm to laterally shift the drawbar together with the grader blade carried thereby.

3. A road grader comprising the combination with a vehicle frame comprising spaced-apart beams having upwardly and forwardly inclined portions, of a drawbar flexibly connected at its forward end to said frame, hanger mechanism between said frame and said drawbar for effecting adjustment in elevation of the rear end of said drawbar, a grader blade carried by said dawbar, a horizontal shaft extending horizontally and longitudinally along said frame between the upwardly and forwardly inclined portions of said beams, worm gearing connected to the rear end of said shaft, an arcuate rack, mechanism on said frame for guiding said rack along a path lying in a circle surrounding said frame, a pinion at the forward end of said shaft in position to mesh with said arcuate rack, an arm extending from said arcuate rack, a link connecting said arm to said drawbar, a rotary hydraulic motor mounted on said vehicle frame and connected to said worm gearing to drive the same and thereby effect lateral shifting of said arm and lateral shifting of said grader blade, and means for controlling said motor.

4. In a road grader, the combination with a vehicle frame, of a drawbar connected thereto, a grader blade carried by said drawbar, a tertiary frame surrounding said vehicle frame, a link connecting said tertiary frame to one side of the free end of said drawbar, and motor-operated mechanism comprising bevel gearing and worm gearing in series for effecting rotation of said tertiary frame to secure lateral shifting of said grader blade relative to said vehicle frame.

5. In a road grader, the combination with a vehicle frame, of a drawbar connected thereto, a road working implement carried by said dawbar, laterally shifting mechanism between said vehicle frame and said drawbar and comprising a ring guided around said vehicle frame on a longitudinal axis and having a radial arm connected by a link to one side of the free end portion of said drawbar, a rotary motor mounted on said vehicle frame, and power-transmission mechanism comprising bevel gearing and worm gearing between said motor and said laterally shifting mechanism.

6. In a road grader, the combination with a vehicle frame, of a drawbar flexibly connected at its forward end to said vehicle frame, a road-working implement carried by said drawbar, mechanism for supporting the rear end of said drawbar and said road-working implement at adjusted elevations relative to the road surface, an arcuate rack, means for guiding said rack along the arc of a circle surrounding said vehicle frame, an arm extending radially from said arcuate rack and movable with the latter to positions on opposite sides of the vehicle frame, a link connecting said arm on said arcuate rack to one side of the free end of said drawbar, a rotary motor on said vehicle frame, a shaft, a pinion on one end of said shaft in mesh with said arcuate rack, and reduction gearing between said motor and the other end of said shaft.

7. In a bank cutting machine, the combination with a vehicle frame, of a drawbar mounted thereon for adjustment relative thereto, a grader blade carried by said drawbar, an arcuate rack, an arcuate bearing on said vehicle frame for guiding said rack along an arc of a circle surrounding said vehicle frame, the center of such circle being in a relatively high position extending longitudinally through said vehicle frame, a link connecting said arcuate rack to one side of the rear end portion of said drawbar, a rotary motor having its axis of rotation extending longitudinally of said vehicle frame, and power-transmission mechanism between said motor and said arcuate rack comprising a train of bevel gearing and self-locking worm gearing.

8. In a road grading machine, the combination with a vehicle frame, of a drawbar flexibly connected thereto, mechanism for adjustably supporting the rear end of said drawbar from said vehicle frame, a grader blade carried by said drawbar, an annular gear, mechanism for guiding said annular gear to rotate around said vehicle frame on an axis extending longitudinally through the upper portion of said frame, a radial arm on said annular gear and movable with the latter to positions extending upwardly and diagonally outwardly above a horizontal plane extending through the axis of said annular gear, a link connecting said arm to one side of the rear end of said drawbar, an operator's station, a rotary motor on said vehicle frame, power-transmission mechanism between said motor and said annular gear, and means for controlling said motor from said operator's station.

9. In a road grader, the combination with a vehicle frame comprising an upper narrow elon-

gated portion, of a ring surrounding said upper narrow elongated portion, a radial arm on said ring, a drawbar flexibly connected at one end to said vehicle frame, a grader blade carried by said drawbar, mechanism for adjustably hanging the rear end of said drawbar from said vehicle frame, a link connecting said radial arm to the free end of said drawbar, means on said vehicle frame for guiding said ring for rotation on an axis the center of which extends longitudinally through said narrow elongated portion of said vehicle frame, a rotary motor mounted on said vehicle frame, power-transmission mechanism between said motor and said ring, and means for controlling said motor to effect rotation thereof in reverse directions and at a relatively high speed to secure a relatively low speed of rotation of said ring to effect lateral shift of said grader blade to either side of said vehicle frame.

10. In a bank cutting machine, the combination with a vehicle frame, of a drawbar flexibly connected at its forward end to said vehicle frame, a grader blade carried by said drawbar, an arcuate rack, means for guiding said rack along an arc of a circle surrounding said vehicle frame in an upright plane fixed relative to said frame, said rack being confined by said guiding means to adjustment in such upright plane, a link connecting said arcuate rack to one side of the free end of said drawbar, mechanism for adjustably suspending the rear end of said drawbar from said vehicle frame, a rotary motor on said vehicle frame, power-transmission mechanism between said motor and said arcuate rack and comprising a train of bevel gearing and worm gearing, and means for controlling the direction and speed of rotation of said motor to effect by means of said arcuate rack and said link the lateral shifting of the grader blade toward either side of the machine.

11. In a road grader, the combination with a vehicle frame having a laterally expanded rear end portion and a narrow elongated forward portion, of a drawbar pivotally connected at its forward portion to the forward end of said vehicle frame, mechanism adjustably suspending the rear end portion of said drawbar from said vehicle frame, a road-working implement carried by said drawbar, an arcuate rack, mechanism mounting said rack on said frame and guiding the same relatively thereto along the arc of a circle surrounding said vehicle frame, mechanism comprising a link connecting said arcuate rack to one side of the free end of said drawbar, a pinion meshing with said arcuate rack, a rotary motor mounted on the laterally expanded rear end portion of said vehicle frame, power-transmission mechanism between said motor and said pinion, and means for controlling the speed and direction of rotation of said motor to effect lateral shifting of said road-working implement to either side of said vehicle frame.

12. In a road grader, the combination with a vehicle frame, comprising an elongated box-like portion, of a ring surrounding said box-like portion, a radial arm on said ring, a drawbar flexibly connected at one end to said vehicle frame, a grader blade carried by said drawbar, mechanism for adustably suspending from said frame the free end portion of said drawbar, a rotary motor mounted on said frame, power-transmission mechanism between said motor and said ring, and means for controlling said motor to effect lateral shifting of said grader blade to either side of the machine.

13. In a power road grader, the combination with a vehicle comprising rear traction wheels and a front steering wheel unit, of a drawbar flexibly connected at its front end to the frame of said vehicle, means for adjusting the elevation of the rear end of said drawbar, laterally shifting mechanism between the vehicle frame and the rear end of the drawbar, a circle carried by said drawbar, a grader blade carried by said circle, a rotary hydraulic motor carried by said frame, power transmission mechanism between said motor and said circle for turning the latter to adjust the grader blade on an upright axis, said power transmission mechanism comprising a train of bevel gearing and worm gearing and spur gearing, an engine on the vehicle frame, a pump connected to the said engine, and means at the operator's station on said vehicle frame for controlling the operation of said hydraulic motor to effect adjustment of the grader blade on said upright axis, the construction and arrangement being such that the rotary hydraulic motor always remains in fixed relation to the pump and the engine on the vehicle frame.

14. In a power road grader, the combination with a vehicle comprising gear ground engaging wheels and a front steering wheel unit, of a drawbar flexibly connected at its front end to the frame of said vehicle, a circle carried by the drawbar, a grader blade carried by the circle, means for adjusting the elevation of the rear end of the drawbar, laterally shifting mechanism between the vehicle frame and the rear end of the drawbar and comprising self-locking worm gearing mounted on the vehicle frame, a rotary hydraulic motor mounted on the vehicle frame and operatively connected to said self-locking worm gearing, circle turning mechanism comprising self-locking worm gearing mounted on said drawbar, another rotary hydraulic motor mounted on said vehicle frame and operatively connected to said last-named self-locking worm gearing, an engine on said vehicle frame, a pump connected to said engine for operation thereby, and means at the operator's station on said vehicle frame for controlling the operation of one of the rotary hydraulic motors to effect lateral shifting of the grader blade toward either side of the machine and for controlling the operation of the other rotary hydraulic motor to effect turning of the circle and the grader blade on an upright axis, the construction and arrangement being such that both of the rotary hydraulic motors are always in fixed relation to the pump and in fixed relation to the operator's station on the vehicle frame.

FRANKLIN E. ARNDT.