

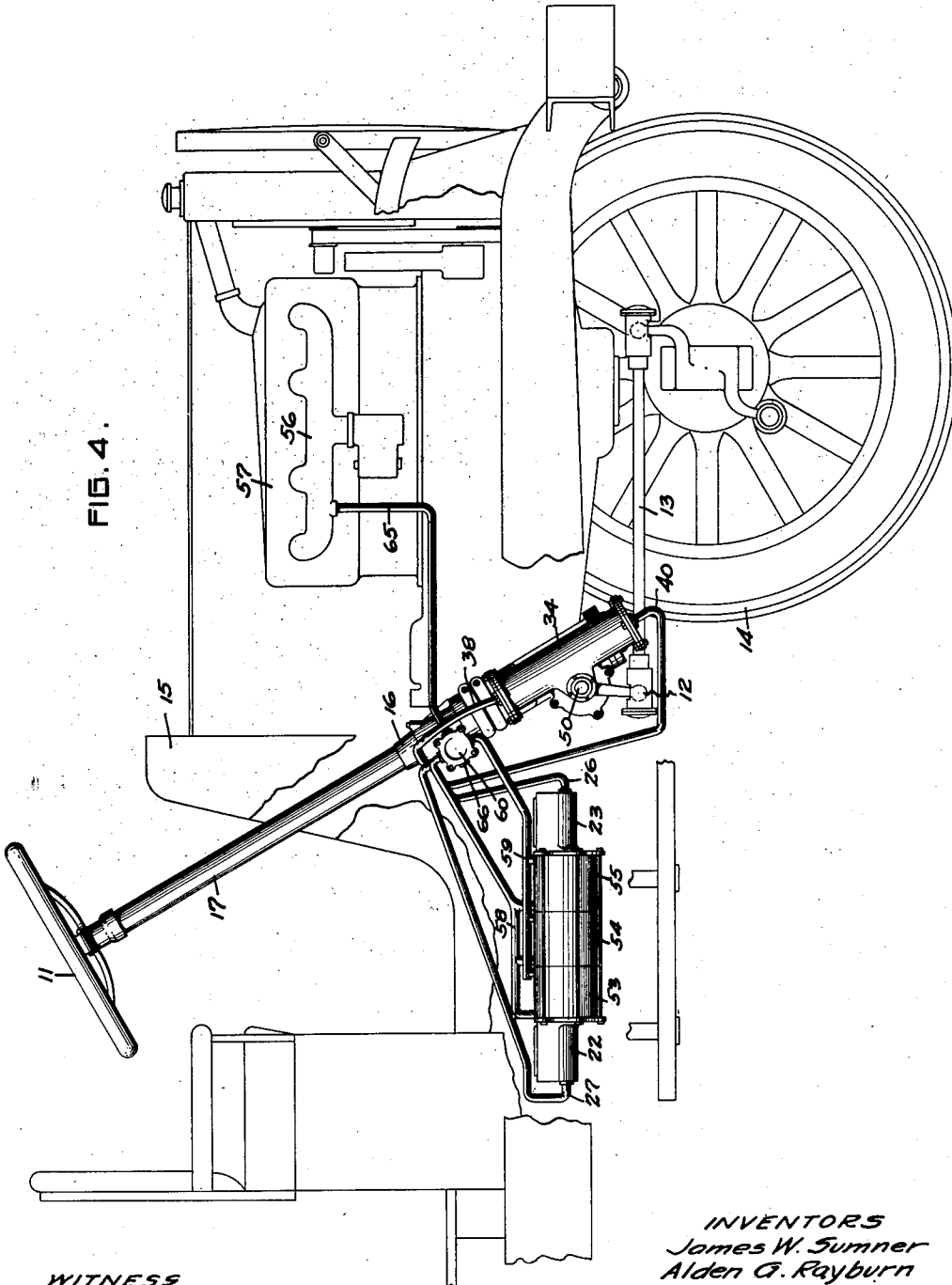
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J. W. SUMNER ET AL
FLUID PRESSURE CONTROL SYSTEM

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WITNESS

H. S. Kierbaum

INVENTORS
James W. Sumner
Alden G. Rayburn
BY White Post & Coan
their ATTORNEYS

UNITED STATES PATENT OFFICE.

JAMES W. SUMNER AND ALDEN G. RAYBURN, OF LOS ANGELES, CALIFORNIA, ASSIGNORS TO EMBORY WINSHIP, OF SAN FRANCISCO, CALIFORNIA.

FLUID-PRESSURE-CONTROL SYSTEM.

Application filed June 7, 1923. Serial No. 643,877.

To all whom it may concern:

Be it known that we, JAMES W. SUMNER and ALDEN G. RAYBURN, citizens of the United States, and both residents of the city of Los Angeles, in the county of Los Angeles and State of California, have invented a new and useful Fluid-Pressure-Control System, of which the following is a specification.

This invention relates to a system for operating a mechanism by the aid of fluid pressure, and more particularly to such a system in which the extent of movement of an element moved by fluid pressure may be manually controlled by moving a controlling device, and in which this extent of movement is dependent upon the extent of movement of the controlling member.

Such a system is described and claimed in an application, Serial Number 599,777, filed Nov. 9, 1922 in the name of James W. Sumner, and entitled Power steering mechanism. In that mechanism, a source of fluid pressure for operating the device is described, comprising an engine driven pump. It is one of the objects of our invention to provide a simpler and less expensive source of fluid pressure. It is another object of our invention, in this connection, to provide a pneumatically operated device to replace the pump of the prior application.

Since the source of power for creating the fluid pressure is itself operated by fluid pressure, it is possible to control the entire mechanism by controlling either one or both of the fluid pressure devices, and thereby ensure against possible failure. It is thus another object of our invention to provide a form of double control for such a mechanism.

In the form of the invention which we illustrate, the control mechanism is used as a power steering device for road vehicles, such as automobile trucks. In that form, the device of our invention has many advantages; for example the suction created in the intake of the internal combustion engine for driving the vehicle may be used for operating a pneumatic cylinder, the piston of which in turn is connected to a fluid pressure piston for generating the working fluid pressure.

Our invention possesses other advantageous features, some of which with the fore-

going, will be set forth at length in the following description, where we shall outline in full that form of the invention which we have selected for illustration in the drawings accompanying and forming part of the present specification. Although we have shown in the drawings but one embodiment of our invention, we do not desire to be limited thereto, since the invention as expressed in the claims may be embodied in other forms also.

Referring to the drawings:

Figure 1 is a diagrammatic plan of the invention as applied to a steering device and some of the elements separated farther than actually necessary in order the better to allow clearness in the drawing;

Figs. 2 and 3 are diagrams illustrating one phase of the mode of operation of the device shown in Fig. 1;

Fig. 4 is an outline view of the device as applied to an automobile truck, the front end only of the truck being indicated, and parts thereof broken away; and

Fig. 5 is a sectional view, along plane 5-5 of Fig. 1, showing a detail of a valve construction used in this form of device.

In the present instance, the control of the mechanism is effected by manually rotating a handwheel 11, and the element the movement of which is thus controlled, is shown as a drop arm 12 that is arranged to operate a drag link 13 for steering the front wheels 14 of a motor vehicle 15. The steering elements, including link 13 and arm 12, may operate in a well-known manner to move the front wheels 14 in either direction, and it is considered unnecessary here to enter into further details in this regard.

The steering wheel 11 may be of conventional design, as is common in motor vehicles, and may be provided with a shaft 17 to which it is rigidly attached and which is supported in a column 16 appropriately fastened to vehicle 15. Angular movement of the steering wheel 11 sets into operation a fluid pressure mechanism for moving the arm 12, but before attempting to set forth the details of this control, it is advisable to describe how the fluid pressure may be generated. There are for this purpose, two fluid pressure cylinders 22 and 23, each having a piston 24, the pistons being connected mechanically, as by a rod 25. These pistons

are so arranged that when the rod 25 is moved in one direction, say toward the right, then the right hand cylinder 23 is active to create a pressure in the space 30 between the piston and the right hand head 28 of cylinder 23, while at the left hand cylinder 22, the pressure is released in the space between the piston and the left hand head 29 of cylinder 22. The reverse effects are obtained when the rod 25 moves toward the left. It would of course be possible to replace the two single acting cylinders with a double acting one, in which the chambers on both sides of the pistons are active and correspond to the two active spaces just described.

The active pressure spaces or chambers 30, as well as all spaces leading thereto, are maintained filled with a fluid such as oil so that the exertion of a pressure in these chambers may be immediately effective at the place where it is utilized to produce mechanical motion. In order to insure that all these spaces will be filled in spite of leaks or the like, we provide oil reservoirs 31 above the cylinders 22 and 23, which are in communication with the active spaces only when the pistons 24 are in their extreme pressure-releasing positions, as by the aid of a small aperture 32. After the piston 24 moves far enough to place this aperture into communication with the other side of the cylinder, as shown in the drawings, oil will be allowed to drip into this space, but will be returned to the reservoir 31 on movement of the piston in the reverse direction, and in this way there is no loss of the liquid. In order to ensure complete return, a large aperture 33 at the end of the cylinder connects to the reservoir 31.

Pipes 26 and 27 connect to the pressure chambers 30 and serve to conduct the oil under pressure to the place where it is useful to produce movement of the drop arm 12. For this purpose, a double cylinder 34 is used, in which there are two pistons 35 and 36, connected to a common rod 37. Movement of the pistons in either direction is effected by fluid under pressure being forced against one piston, while the fluid from the other piston is withdrawn. Pipe 38 supplies this fluid to the top pressure chamber 39 and piston 35, while pipe 40 accomplishes the same result for the lower chamber 41 and piston 36. Pipe 38 leads to cylinder 22 through a valve 42 and pipe 43, while pipe 40 leads to cylinder 23 through the pipe 44, valve 42 and pipe 45. It is thus evident that a force acting to move rod 25, connecting the pistons 24, say to the left, will force fluid under pressure through pipes 43 and 38 and thereby urge piston 35 in cylinder 34 downwardly, while at the same time, fluid is urged to return from chamber 41 through pipes 40, 44 and 45 to the cyl-

inder 23. A reverse movement of rod 25 will cause these effects to be reversed, as is evident.

In case the fluid pressures thus created are free to act on the pistons 35 and 36, they will be moved axially of cylinder 34, and their movement may be caused to rotate arm 12. Although a large variety of mechanical connections may be used to effect this result, we show a form in which the rod 37 carries an enlarged seat 47 for rotatably seating a flat slotted disk 46. The slot 48 of the disk accommodates an arm 49 which is mechanically connected to the arm 12 so that these arms form a bell crank lever mounted on shaft 50 which may be appropriately journaled. The cylinder 34 and its associated parts are preferably mounted near or on the steering column 16. The slotted disk arrangement as the rod 37 moves, serves to rotate the arm 49 and thereby the arm 12.

The force that is necessary to operate the piston rod 25, is conveniently supplied by a vacuum cylinder 51 which is located between the two cylinders 22 and 23, and which operates on one or more pistons 52. In the present instance the vacuum cylinder 51 has three compartments 53, 54 and 55, and three pistons 52. Due to the multiplication of cylinder compartments, even a relatively small difference in pressure is sufficient to exert a comparatively large force on piston rod 25, since all the pistons present in combination a very large surface to the fluid pressure. We find it advantageous to utilize the vacuum produced in the intake manifold 56 of the driving engine 57. For this purpose a pipe manifold 58 connects to each of the cylinder compartments at one side of the pistons 52, and a similar manifold 59 connects to each compartment on the other side of pistons 52. In order to exert a force say to the right on rod 25, manifold 59 is connected to the intake manifold 56, and manifold 58 is connected to atmosphere. There is thus a preponderance of pressure on the left hand sides of pistons 52 and a corresponding force is exerted toward the right. In order to create a force tending to move the rod 25 to the left, the manifold 58 is connected to intake manifold 56, while manifold 59 is connected to atmosphere.

The valve that controls these connections is illustrated at 60, and comprises a cylindrical valve body 61 at opposite sides of which enter pipes 62 and 63 connecting respectively to the manifolds 58 and 59. A rotatable valve member 64 is disposed in the body 61 and in the position shown, shuts off the passageways 65 and 66, leading respectively to the intake manifold 56 and to the atmosphere. In case the member 64 be rotated in a clockwise direction, passage-way 66 will be placed in communication

with pipe 62, and passageway 65, with pipe 63. For this condition the rod 25 will move to the right. A reverse movement of member 64 will have the opposite effect.

In neutral position as shown, the air in the cylinder chambers 53, 54, and 55 is trapped, and the piston rod 25 remains in position.

In order to make certain that the piston rod 25 may be maintained in any intermediate position, as well as end positions, the valve 42 hereinbefore mentioned, is provided. This valve has a stem 67 mechanically connected with valve member 64. This stem carries a pair of members 68 that close the passageways between pipes 38 and 43, and also between pipes 44 and 45, when the member 64 is in the neutral position shown. In this way the oil in the cylinder chambers 39 and 41 is trapped, and rod 37 cannot move, and the same is also true of the oil in the pressure producing cylinders 22 and 23. It is thus evident that no oscillation of any of the pistons or rods can result, and even if the vacuum fails, there is an assurance that the steering gear including arm 12 will be maintained in position, so long as valves 42 and 60 are in their neutral positions.

The movement of steering wheel 11 to the right or left is caused to operate both valves 42 and 60 so as to set into action the agencies described hereinbefore. The arrangement is furthermore such that the closing of these valves, or rather the bringing them to neutral position, is effected by the movement of the steering gear to a position corresponding to that of wheel 11. In other words, for every setting of wheel 11, there corresponds but one stable position of arm 12, and the movement of the arm 12 to this position is coincident with the closure of these valves.

In order to effect these results, an arrangement somewhat similar to that disclosed in the prior Sumner application hereinbefore identified may be used. A collar 69 is splined to the steering wheel shaft 17 so that there may be relative axial movement between them but no relative rotational movement. A circular rack 70 is cut on the exterior of this collar, which is adapted to engage a pinion 71 rigidly fastened to the shaft 72 that serves to operate the valves 42 and 60, as diagrammatically indicated by the dot-dash line 73. It is evident that mere rotation of rack 70 is insufficient to cause rotation of pinion 71, and that axial movement thereof is necessary.

For producing this axial movement the collar 69 is provided with a depending portion 74 in which are cut one or more slanting grooves or slots 75 (see Figs. 2 and 3). These grooves form an inclined plane by the aid of which the collar 69 may be axially moved. Rollers 76 which we may for

the present consider as having fixed axes radial with respect to the axis of the shaft 17, engage in these grooves 75 and serve to provide a surface on which the grooves may slide.

Now referring to Fig. 2, it is evident that if the rack 70 is rotated in a direction represented by the developed arrow 77, and assuming that roller 76 is stationary, then the rack is forced to move in a downward direction, as represented by arrow 78. This downward movement in turn causes rotation of shaft 72 in a counterclockwise direction; and valve 60 moves from its neutral position to connect manifold 58 to the intake manifold 60, and manifold 59 to the atmosphere. A force is thus exerted toward the left in cylinder 51, and the oil cylinder 22 creates a fluid pressure. This fluid pressure exerts a force downwardly against piston 35 in cylinder 34, and there is a tendency to rotate the drop arm 12 in a counterclockwise rotation. Movement of the wheel 11 in the opposite direction will reverse these effects.

While thus far in our discussion we have assumed that rollers 76 were located on stationary axes, they are in fact supported with their axes radial, on a rotatably mounted shaft 18, which is coaxial with the steering wheel shaft 17. This shaft 18, which is appropriately journaled in the steering column 16, as by the roller bearings 19 and 20, and the roller step bearings 21, is mechanically connected with the drop arm 12 in such a way that motion may be transmitted from one to the other. This connection may be provided by any type of gearing for example, and is provided for the purpose of restoring the valve 60 as well as valve 42 to the neutral position as soon as the drop arm 12 reaches a definite position that is dependent upon the extent of movement of the steering wheel 11. In order to comprehend how this is accomplished, attention is invited to Fig. 3, in which it is assumed that the slot 75 is now stationary and corresponds in angular position with that of the steering wheel 11. The mechanical arrangement is such that the shaft 18, rotated indirectly through the steering devices, has a movement in the same direction as that in which wheel 11 was moved. Therefore arrow 79, parallel to arrow 77, represents the direction of movement of the rollers 76. It is evident from Fig. 3 that the sleeve 69 will be thereby forced upwardly, as indicated by arrow 80. This upward movement of sleeve 69 continues until the valve 60 has been returned to its original position, which corresponds to the condition that shaft 18 rotate as much as shaft 17. It is thus seen that the effect on the steering mechanism is the same as if wheel 17 were directly connected to the shaft 18.

Furthermore, as in the prior application, the slots 75 are somewhat limited in extent, so that in case the pressure fails, the rollers 76 soon reach the end of their travel in the slots upon continued rotation of wheel 11, and shaft 18 is manually rotated and thereby the drop arm 12. It is thus evident that the direction of movement of valve 64 as well as its extent, is a function of the extent of relative movement between the shafts 17 and 18. If the shafts move in unison, then valve 64 remains in its inactive or neutral position, whereas relative movement of the shafts in either direction causes a movement of valve 64.

Although any well-known form of mechanical connection may be provided between the shaft 18 and the drop arm 12, we prefer to utilize a worm and wheel connection, including a worm 81 on shaft 18, and a worm wheel 82 fastened to the drop arm shaft 50. In order to illustrate this connection in a diagrammatic manner, the dot-dash line 83 is used. This drive may be made reversible by making the worm 81 of sufficient great pitch, so as to permit wheel 82 to drive the worm. However, it may be left irreversible; that is, in order to permit arm 12 to move, the worm 81 must be rotated by a force at least great enough to overcome the friction between it and the wheel 82, after which the shaft 50 is free to rotate this wheel. How this affects the operation of the device may become evident from a brief review of the various steps in the steering control.

Let us assume that the wheel 11 is rotated in such a direction that the valve member 64 moves counterclockwise from the neutral position shown. At the same time, valve 42 moves to establish communication between cylinder 34 and cylinders 22 and 23. The piston rod 25 has then a tendency to move to the left, since manifold 58 is connected to the intake manifold 56 through valve 60. This places the fluid in cylinder 22, pipes 43, and 38, and chamber 39 in cylinder 34 under pressure, and a torque is exerted to move arm 12 in a counterclockwise direction. However, this movement may be temporarily prevented in case worm 81 on shaft 18 forms an irreversible drive. This shaft 18 is at present stationary, and locks the worm wheel 82 against movement. This condition continues until the steering wheel 11 is moved far enough to cause rollers 76 to reach their limit of movement; from this point on the shaft 18 may be moved by the wheel 82, and it is kept in step with shaft 17. In case the pitch of worm 81 is great enough, the shaft 18 is driven even before the rollers 76 reach the end of the slots 75; in this way the shaft will ultimately bring the rollers and slots to a position where the valves 60 and 42 are closed as in the figure.

Then no further movement of shaft 18 can take place, because the oil cylinder spaces 41 and 39 are dead-ended, and the oil is trapped therein. The wheels 14 are thus maintained in position, until such time as steering wheel 11 is again moved, when the same series of operations will occur as just described.

We claim:

1. In a fluid pressure control system, a member the movement of which is to be controlled, a fluid pressure device for moving the member, movable means for controlling the operation of said device, means whereby the extent of movement of the controlled member is limited by the extent of movement of the controlling means and means for creating the fluid pressure, comprising a pair of fluid pressure cylinders, means whereby one of the cylinders is caused to exert a force so as to produce a fluid pressure in the other cylinder, and means connecting the other cylinder with the fluid pressure device.

2. In a fluid pressure control system, a pair of fluid pressure cylinders, one of said cylinders being arranged to supply the power to produce fluid pressure in the other cylinder, means whereby said fluid pressure may serve to produce a mechanical movement, and means for simultaneously controlling the passageways for both cylinders, whereby there will be an interruption in the passageways between the pressure cylinder and the seat of mechanical movement, simultaneously with the interruption of the power cylinder operation.

3. In a fluid pressure control system, a vacuum cylinder adapted to be connected to the intake manifold of an internal combustion engine, a pressure cylinder operated by the vacuum cylinder, means for utilizing the pressure thus created in the pressure cylinder for producing a mechanical movement, and means for simultaneously controlling the passageways for both cylinders, whereby there will be an interruption in the passageways between the pressure cylinder and the seat of mechanical movement, simultaneously with the interruption in the operation of the vacuum cylinder.

4. In a fluid pressure control system for controlling the movement of a member, a fluid pressure device for moving the member, a pair of fluid pressure cylinders, one arranged to operate the other to produce in said other cylinder the fluid pressure for moving the member, and means for controlling the movement of the member, comprising a plurality of valves controlling the passageways from both cylinders, means for simultaneously operating said valves, and means, operated in response to the movement of the member to return the valves

to their inactive or neutral positions, whereby the extent of movement of the member is determined by the extent of movement of the valve operating means,

5 and whereby there will be an interruption in the passageways between the pressure cylinder and the seat of mechanical movement, simultaneously with the interruption in the operation of the force exerting cylinder.

10 5. In a fluid pressure power steering mechanism for a vehicle, operated by an internal combustion engine, a vacuum cylinder adapted to be connected to the intake manifold of the engine, a pressure cylinder operated by the vacuum cylinder, a steering arm operated by the fluid pressure created in the pressure cylinder, and means for simultaneously controlling the passageways for both cylinders, whereby there will be an interruption in the passageways between the pressure cylinder and the steering arm, simultaneously with the interruption in the operation of the vacuum cylinder.

25 6. In a fluid pressure power steering mechanism for a vehicle, a steering arm, a fluid pressure device for moving the arm, a pair of fluid pressure cylinders, one arranged to operate the other to produce in said other cylinder the fluid pressure for moving the steering arm, and means for controlling the movement of the arm, comprising a plurality of valves controlling the passageways from both cylinders, a steering wheel arranged to operate said valves simultaneously, and means, operated in response to the movement of the steering arm to return the valves to their inactive or neutral positions, whereby the extent of movement of the arm is determined by the extent of movement of the steering wheel, and whereby there will be an interruption in the passageways between the pressure cylinder and the fluid pressure device, simultaneously with the interruption in the operation of the force exerting cylinder.

45 7. In a fluid pressure power steering mechanism, a pair of coaxially mounted shafts, a steering arm mechanically connected to one of the shafts, means for manually rotating the other shaft, a fluid pressure cylinder, a valve for connecting either side of the cylinder with a source of fluid pressure, means whereby the relative movement between the shafts determines the di-

rection and extent of operation of the valve, so as to determine the direction of operation of the cylinder, and fluid pressure means operated by the cylinder for moving the steering arm.

80 8. In a power steering mechanism for a vehicle operated by an internal combustion engine, a pair of coaxially mounted shafts, a steering arm mechanically connected to one of the shafts, a steering wheel connected to the other shaft, a vacuum cylinder, a valve for connecting either side of the cylinder with the intake manifold of the engine, means whereby the relative movement between the shafts determines the direction and extent of operation of the valve, so as to determine the direction of operation of the cylinder, a cylinder operated by the vacuum cylinder to produce a fluid pressure, and a fluid pressure device connected to the fluid pressure cylinder for moving the steering arm.

9. In a power steering mechanism for a vehicle operated by an internal combustion engine, a pair of coaxially mounted shafts, a steering arm mechanically connected to one of the shafts, a steering wheel connected to the other shaft, a vacuum cylinder, a valve for connecting either side of the cylinder with the intake manifold of the engine, means whereby the relative movement between the shafts determines the direction and extent of operation of the valve, so as to determine the direction of operation of the cylinder, a cylinder operated by the vacuum cylinder for creating a fluid pressure, a fluid pressure device operated by the fluid pressure to move the steering arm, and means connected to the valve for interrupting communication between the fluid pressure cylinder and the fluid pressure operated device when the valve is in its inactive position corresponding to no relative displacement between the coaxial shafts.

10. In a fluid pressure device, an air cylinder, partitions in the cylinder forming separated cylinder chambers, a piston rod extending through all the chambers, pistons in the chambers, a pair of liquid cylinders, one at each end of the air cylinder, and pistons for the cylinders fastened to the rod.

In testimony whereof, we have hereunto set our hands.

JAMES W. SUMNER.
ALDEN G. RAYBURN.