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(54) **Electrically Driven Oil Pressured Power Steering Apparatus**

(57) An electrically driven oil pressured power steering apparatus comprises an oil pump 6 driven by an electric motor 20 for supplying a working oil to a power cylinder 1, a control valve 7 for controlling the supply of the working oil, and a sensing means 28 and an electronically operated on-off means 27 which, in common, control a power supply to the electric motor 20. In the apparatus, a state of power steering is shifted to a state of manual steering when the electric motor is de-energised by the electronically

operated on-off means.

The sensing means 28 comprises a vehicle speed sensor 25 and a drive sensor 29 receiving a signal from a steering wheel, accelerator, brake or clutch pedal.

A valve 10 interconnects lines leading to power cylinder chambers 1a, 1b when the electric motor is de-energised.

A pressure relief valve, Figures 9 and 10, interconnects supply and return lines of pump 6 when the steering apparatus reaches its full lock position.

Power-assistance to steering may be reduced or eliminated above a predetermined vehicle speed.

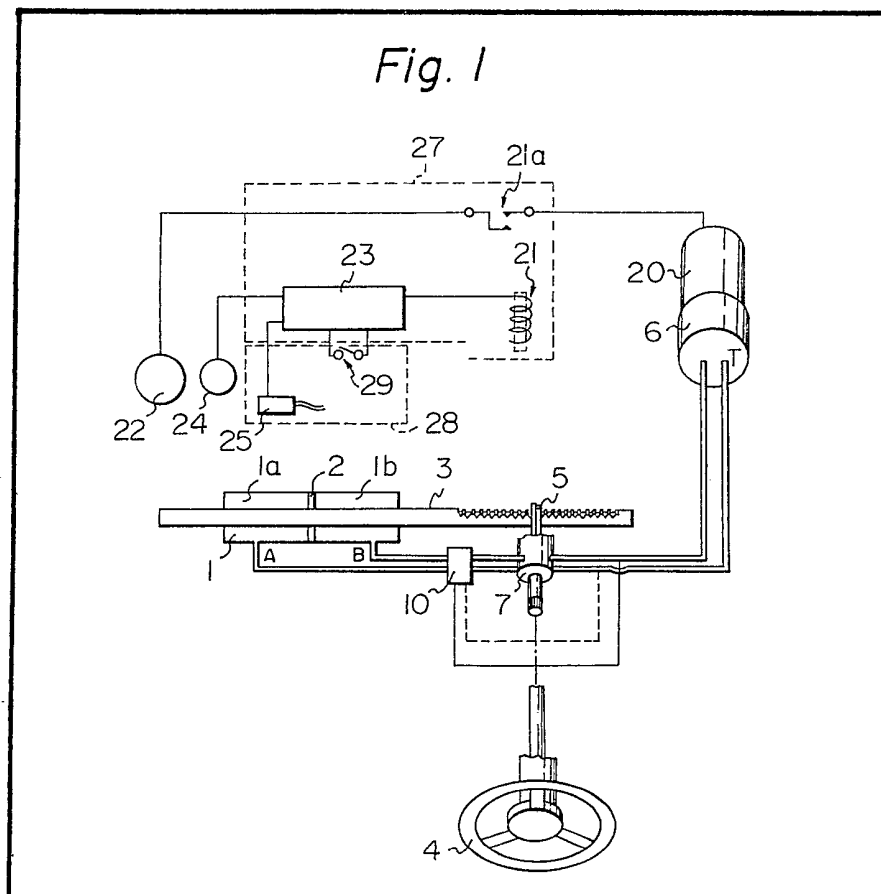


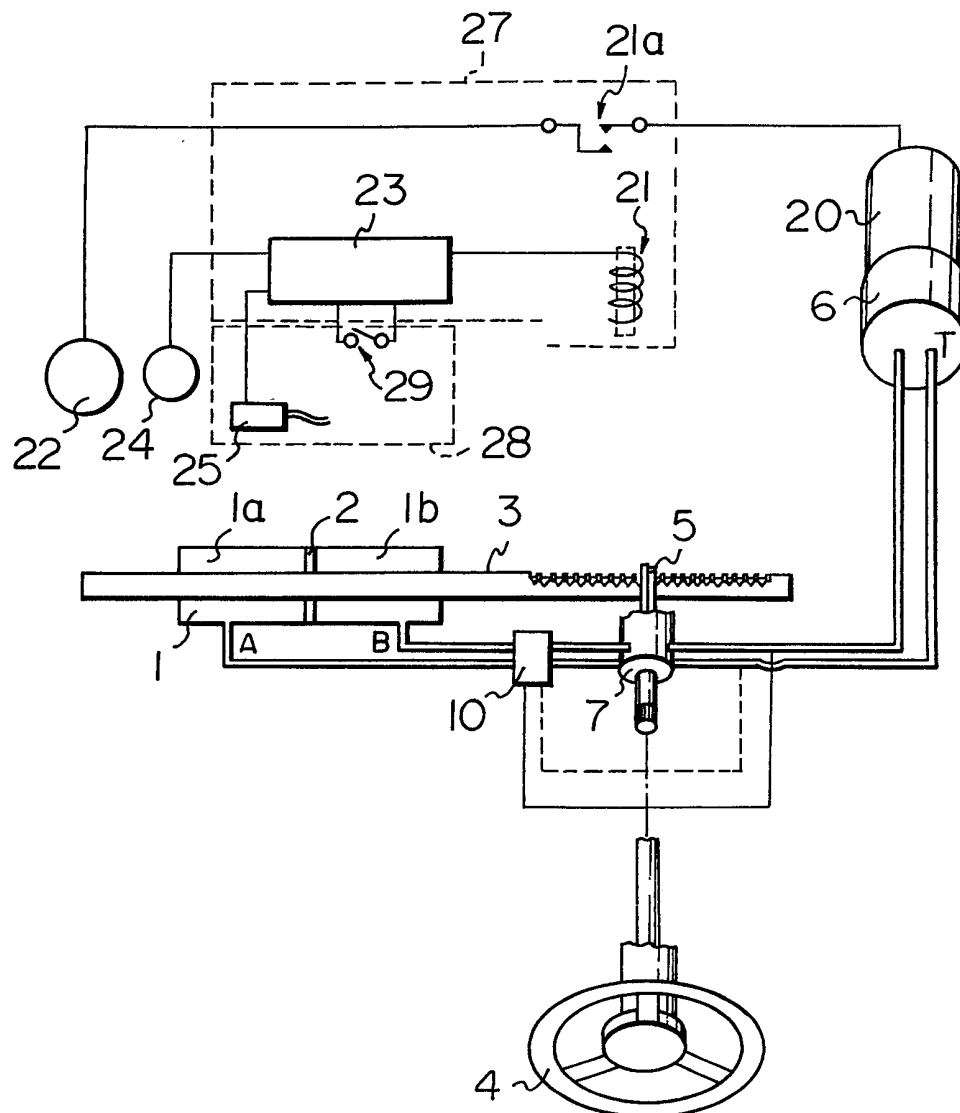
Fig. 1

Fig. 2

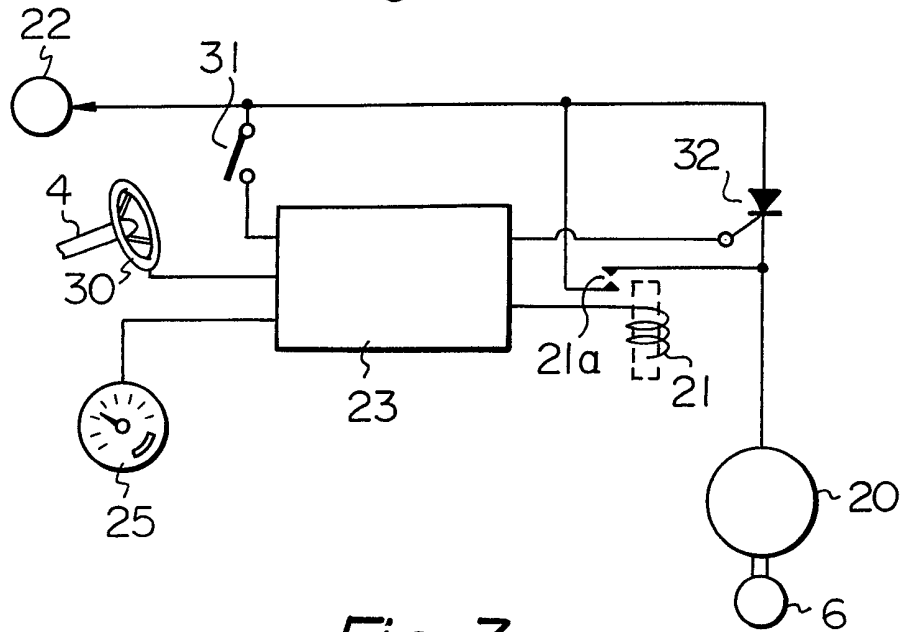


Fig. 3

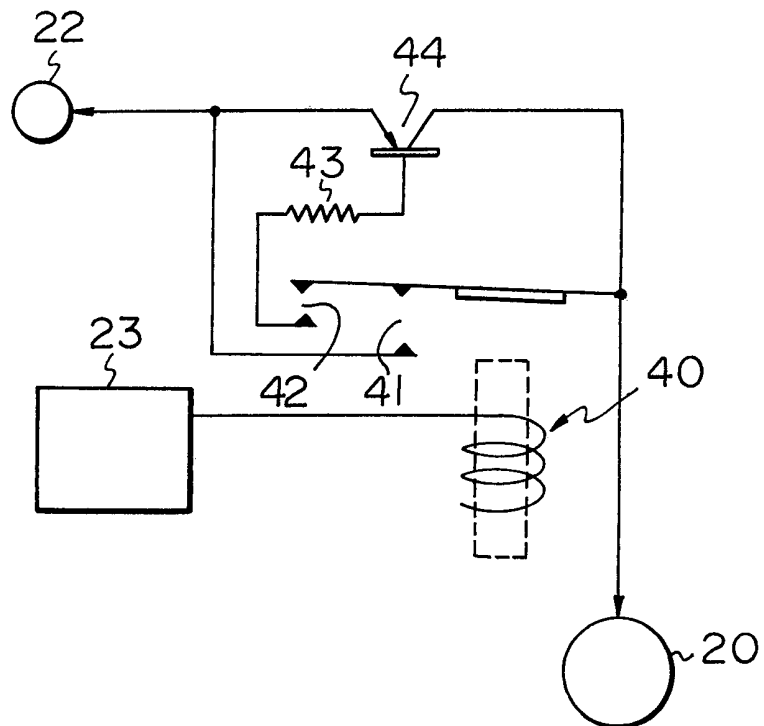


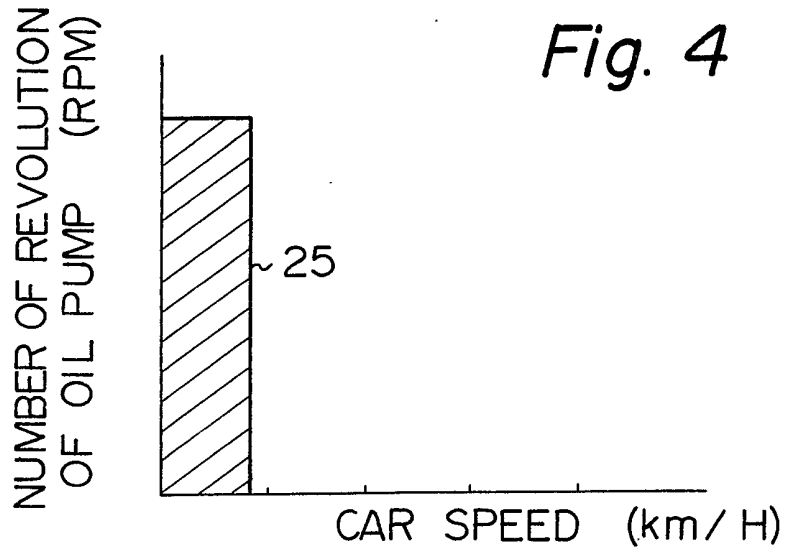
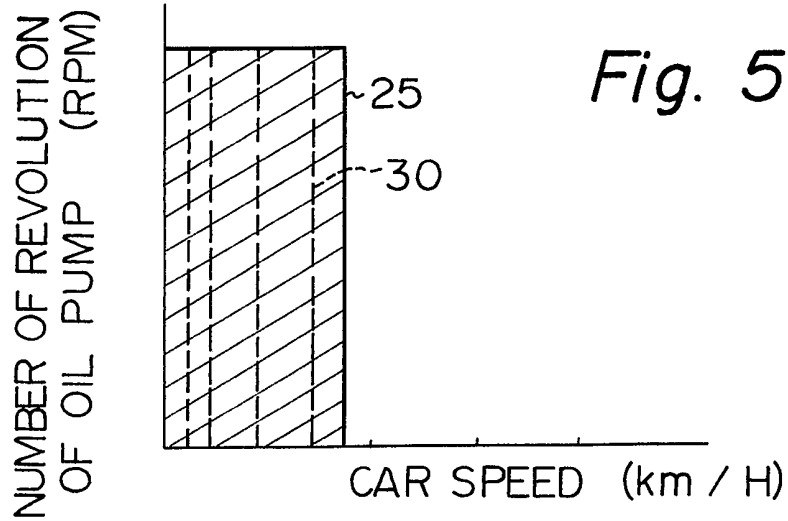
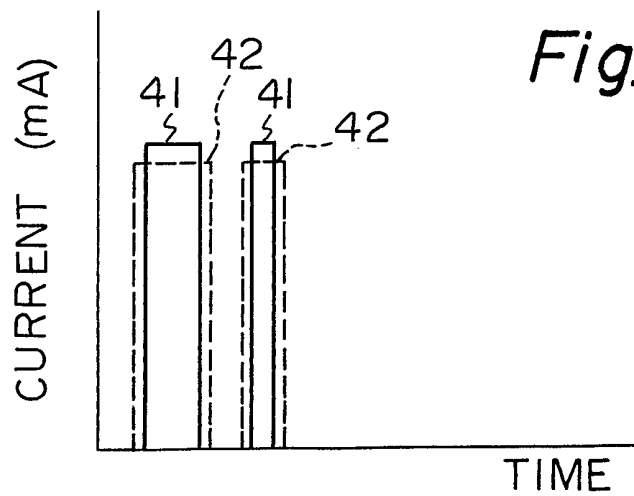
Fig. 4*Fig. 5**Fig. 6*

Fig. 7

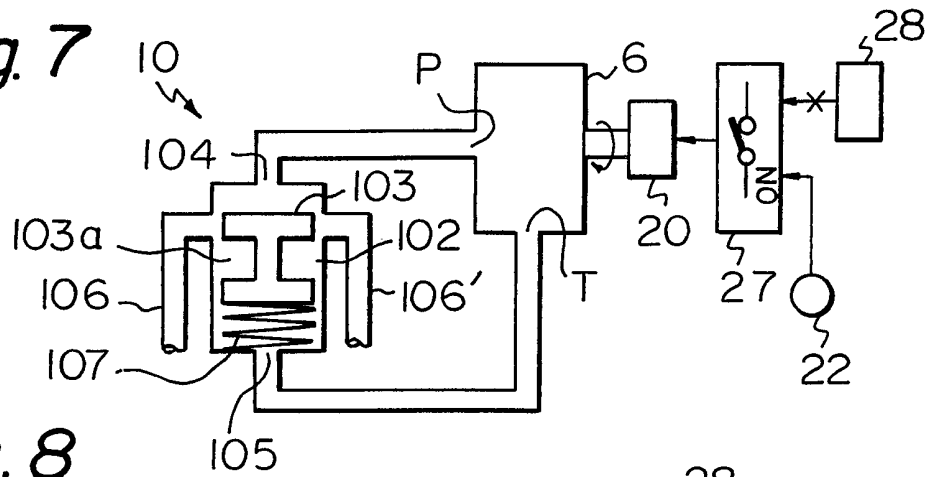


Fig. 8

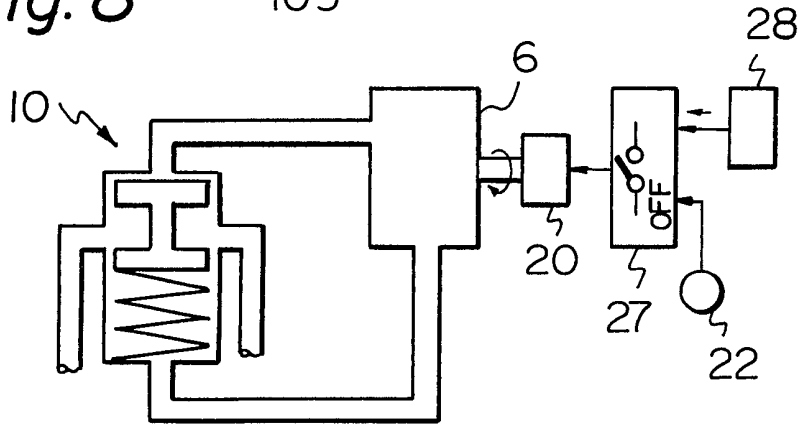


Fig. 9

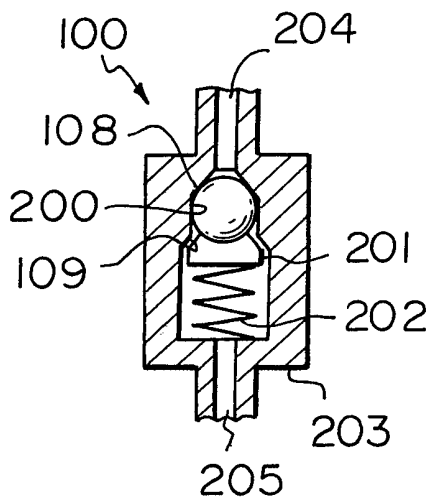


Fig. 10

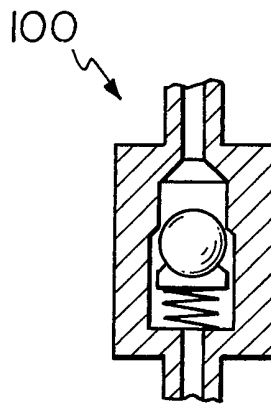


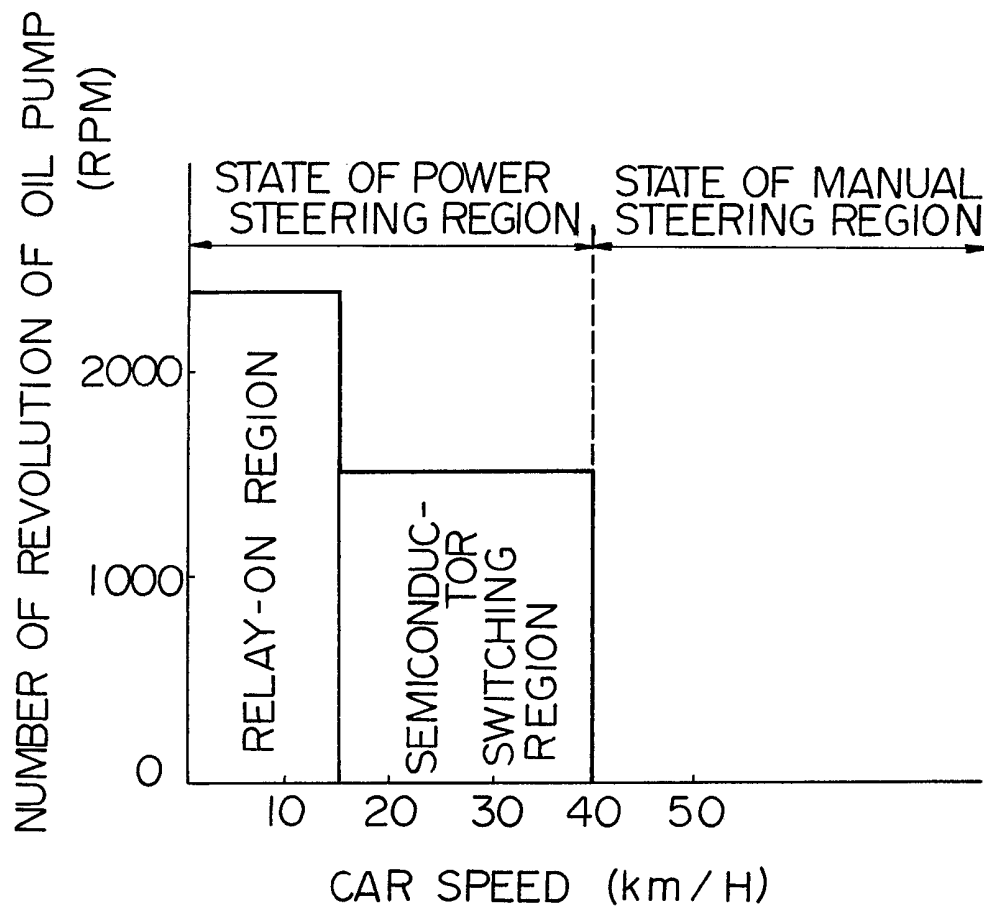
Fig. 11

Fig. 12

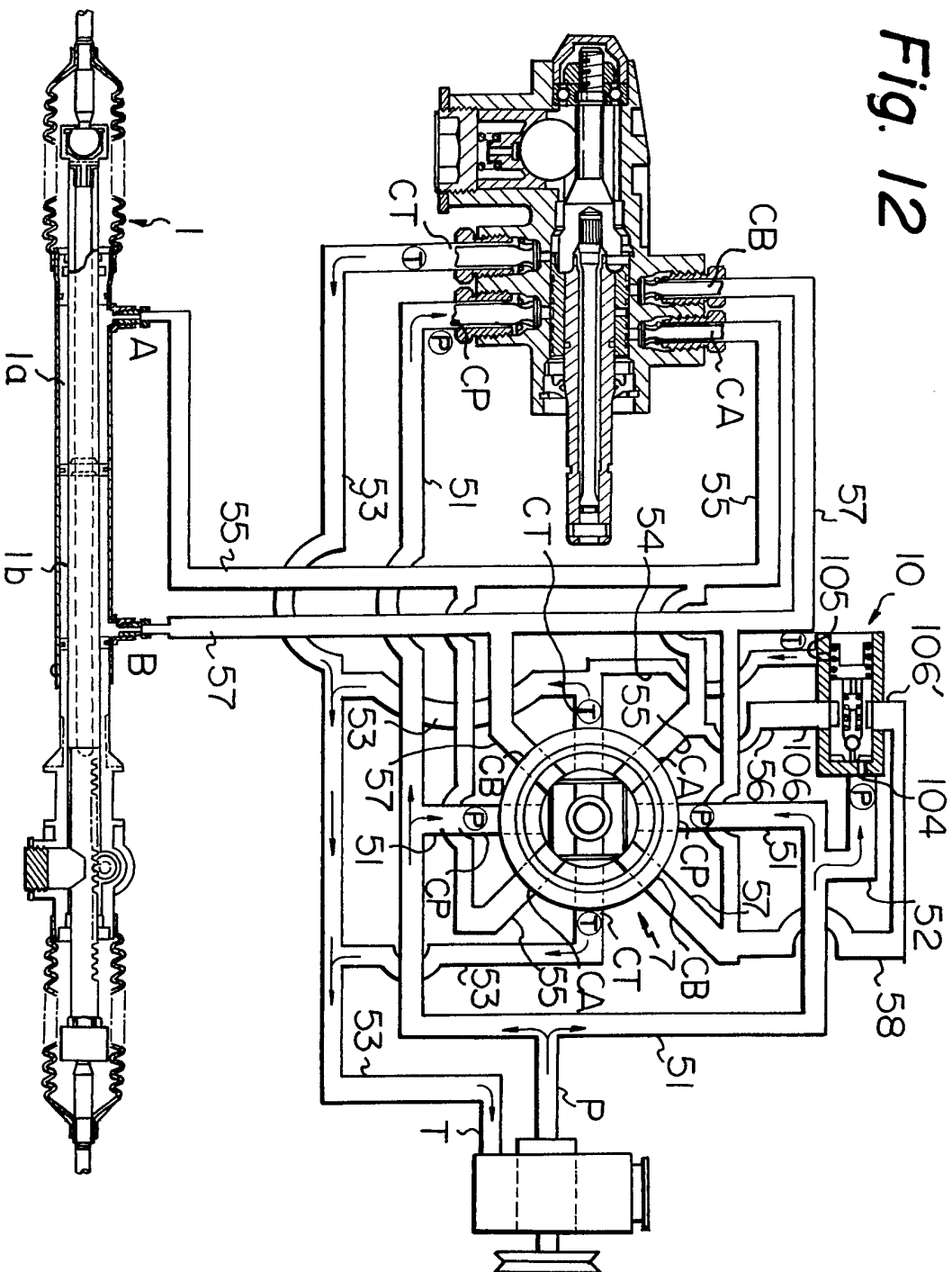
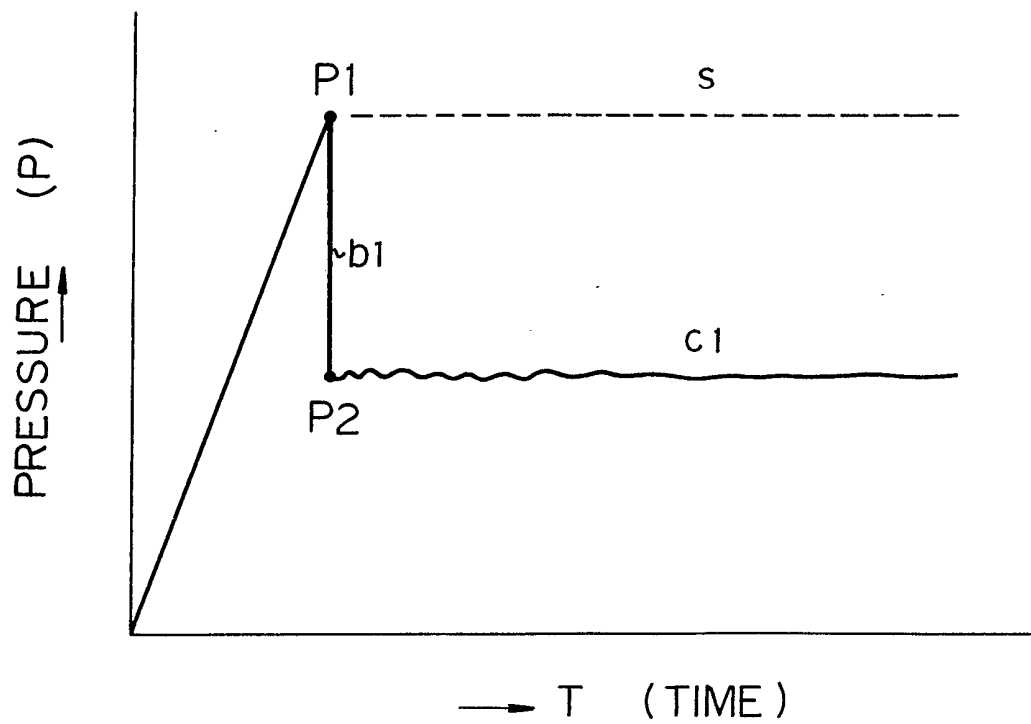


Fig. 14

SPECIFICATION

Electrically Driven Oil Pressured Power Steering Apparatus

This invention relates generally to an

5 electrically driven oil pressured power steering apparatus and, more particularly, to an electrically driven oil pressured power steering apparatus in which an electric motor is started or stopped by means of an electronically operated on-off means
10 which is controlled in response to the speed of a car and either a state of power steering or a state of manual steering can selectively be obtained in accordance with the operation of an oil pump driven by the electric motor. This invention further relates to an electrically driven oil pressured
15 power steering apparatus in which a bypass valve is provided across both ports of paths for supplying working oil sent forth from the oil pump to a power cylinder and the supply path can be communicated by the bypass valve. This invention
20 further relates to an electrically driven oil pressured power steering apparatus in which a relief valve is provided in order to reduce the pressure output from the oil pump.

25 Increased number of times in which the steering, such as parking automobiles, garaging cars, zero-speed steering, inchmeal widthwise moving or switch back advancing, is performed, is more and more frequently demanded when the
30 speed of the cars is nearly zero or is at low and a large steering force is needed. According to a need for providing the larger steering force, a power steering apparatus is equipped with large-sized cars as well as small-sized cars. On the
35 contrary, it is necessary to reduce the oil volume and pressure of the working oil by decreasing an assisting power brought about by the larger steering force when the cars run at a high speed.

The important function of the power steering is
40 to settle properly a steering force and it is desirable at the time when the cars run at a high speed to maintain a state of manual steering within a range of minimum steering in order to obtain a proper torque against the steering force
45 to reduce the steering force when a large steering is needed and to prevent the steering force from being too light to be manipulated and it is also desirable at the time when the cars run at a low speed or the cars stop to solve the heavy
50 manipulation of the handle by providing the steering force with the assisting power. Such a power steering apparatus is known in that the manipulation of the steering wheel is made easy at the low speed run by increasing the quantity of
55 supplying the working oil and the manipulation is made difficult at the high speed run by decreasing the same so that a stable run can be obtained.

In the prior power steering apparatus, a working oil to be supplied to a power cylinder is
60 controlled by adding it a reaction pressure of an oil pump or by bypassing it by means of a solenoid type electro-magnet valve. The efficiency of using the working oil becomes worse due to an over circulation of the working oil at a high speed

65 running state to waste energy and an electro-magnet is used to actuate a changing-over valve for controlling the bypass way of the working oil from the oil pump to the power cylinder so that the electro-magnet does not last long and
70 becomes expensive to keep it in a better condition. These were recognized as principal defects.

The constant pressure control of the relief apparatus for the working oil in the prior power steering apparatus may cause a temperature rise
75 of the working oil since the oil pump, in general, operates under the maximum oil pressure by keeping a valve near to the maximum relief pressure due to the locking of steering at the steering extremities in the left and the right
80 directions to waste also the energy. This is also recognized as a defect.

Such a power steering apparatus has been expected in which an inherent performance of
85 power steering is maintained in that the steering force is made light at stop or at a low speed and that the steering force is prevented from being too light at a high speed and in which an over-circulation of the working oil due to the bypass valve and a disadvantage of the electric apparatus
90 to operate the bypass valve are solved.

Such a power steering apparatus has, further, been expected in which a state of power steering at a high speed can easily be changed into a state
95 of power steering at a low speed at the time when the state of power steering at the high speed terminates or in which the state of power steering can easily be shifted into a state of manual steering, without accompanying some special
100 instruments.

An object of this invention is to provide an electrically driven oil pressured power steering apparatus in which either a state of power steering or a state of manual steering can be
105 selected by starting and stopping of an electric motor, which drives an oil pump, by means of an electronically operated on-off means, which is controlled in response to the speed of a car, to solve the defects and the disadvantages in the prior art.

A further object of this invention is to provide an electrically driven oil pressured power steering apparatus in which an over pressure condition due to the oil pump is reduced by a relief valve
115 through applying a pilot pressure on the spool of a bypass valve.

In order to achieve the objects stated above, this invention is characterized in that the state of power steering is shifted to the state of manual steering by opening and closing the
120 communication path of the working oil by means of the operation of the bypass valve in conjunction with the manipulation of the oil pump derived from the starting and the stopping of the electric motor.

125 This invention is further characterized in that electrical contacts in the electrically operated on-off means are protected by reducing the load current in the electric motor generated when a

steering condition is locked at the ends of the manipulation of the steering wheel by using a reducing relief valve which is to be connected to the oil pump and in that saving in energy can be attained by decreasing the electrical capacity of semiconductor elements carrying transient current of the electric motor.

This invention is further characterized in that the electric power is fully supplied through relay contacts in a region of large steering current wherein a large assisting power is needed under a condition from stopping to a low speed running (this is referred to as a relay-on region in the state of power steering region, in Fig. 11), in that the electric power is variably supplied under a condition of reduced electric potential carried out by switching of the semiconductor element in a region of small steering current when the assisting power is reduced at a medium speed running (this is referred to as a semiconductor switching region in the state of power steering region, in Fig. 11), in that no electrical power is supplied to the electric motor at a high speed running (this is referred to as a state of manual steering region, in Fig. 11) and in that the switching over between the state of power steering and the state of manual steering is effected without a sensible discontinuity.

According to a construction of this invention, the electric motor can be controlled to shift the state of power steering to the state of manual steering through the manipulation of the oil pump by opening and closing a relay by means of a manipulator means including a car speed sensor or a drive sensor, by opening and closing a relay by means of a signal coming from a steering sensor provided at the rotating part of a steering wheel or by opening and closing a semiconductor element with a quick response by means of a relay with a main contact and an auxiliary contact.

According to a construction of this invention, in supplying a working oil which is sent forth from an oil pump driven by an electric motor to a power cylinder through a control valve, a bypass valve is provided so as to form a parallel circuit with the control valve. When the bypass valve is manipulated to close a bypass circuit between the left and the right path of the power cylinder, the steering force can be assisted through the power cylinder to obtain the state of power steering and, on the contrary, when the bypass valve is manipulated to communicate the bypass circuit the state of manual steering is obtained irrespective of the situation of the power cylinder.

The foregoing objects and other objects as well as the characteristic features of this invention will become more apparent and more readily understandable by the following description and the appended claims when read in conjunction with the accompanying drawings.

Figure 1 is a skeleton drawing showing a whole assembly of the construction of an embodiment of the electrically driven oil pressured power steering apparatus of this invention,

Figure 2 is a skeleton drawing in which a whole assembly of the construction of another embodiment of the same apparatus is shown,

Figure 3 is a skeleton drawing in which a whole assembly of the construction of a further embodiment of the same apparatus is shown,

Figures 4 to 6 show, respectively, the performance of the circuits shown in Figures 1 to 3,

Figures 7 and 8 explain the construction and the operation of an embodiment of a bypass valve,

Figures 9 and 10 explain the construction and the operation of an embodiment of a reducing relief valve,

Figure 11 shows the performance of a circuit partially modified,

Figure 12 is an explanatory drawing in which the relation of connection of the pipe arrangement of an embodiment between an electrically driven oil pump, a control valve, a power cylinder, a bypass valve and a reducing relief valve of the electrically driven oil pressured power steering apparatus of this invention is illustrated,

Figure 13 is a skeleton drawing showing the relative position for arranging the constituent elements illustrated in Figure 12, and

Figure 14 is a curve explaining the operation of the reducing relief valve.

In Figure 1, a piston rod 3 extends through a power cylinder 1 which is divided by a piston 2 into two chambers 1a and 1b and a rack and pinion gear mechanism 5 which is provided at one end of piston rod 3 is operably connected to a steering wheel 4 through a control valve 7. A port A of chamber 1a (as shown in the left side in Figure 1) and a port B of chamber 1b (as shown in the right side in Figure 1) of power cylinder 1 are connected either a supply port P or a return port T of an electrically driven oil pump 6 so as to communicate with oil pump 6 through a bypass valve 10 or a control valve 7. Bypass valve 10 is constructed to communicate with chambers 1a and 1b of power cylinder 1 and is of a mechanism in which bypass valve 10 operates due to a pressure difference existing between a line pressure port of the bypass valve which is connected to the supply port P of the oil pump and a tank port of the bypass valve which is connected to the return port T of the oil pump, when a working oil is supplied from electrically driven oil pump 6 to bypass valve 10.

The construction and the operation of bypass valve 10 are, here, briefly explained in Figures 7 and 8. Bypass valve 10 is provided with a spool 103 which freely slides within a cylinder 102. A BP line pressure port 104 provided at one end of cylinder 102 is connected to a supply port P of oil pump 6 and a BT tank port 105 provided at the other end is connected to a return port T of oil pump 6, said oil pump 6 being driven by an electric motor 20 which is excited by an electrical source 22 through an electronically operated on-off means 27 and by a manipulator means 28. A

BA port 106 and a BB port 106', respectively, connected to a port A and a port B, which are connected to power cylinder 1, are provided nearly at the center part of cylinder 102 to

5 communicate therewith. BA port 106 and BB port 106' are communicated with each other by a slot 103a provided at the outer periphery of spool 103 and this communication may be cut off due to the sliding of spool 103. Spool 103 is normally urged
10 toward BP line pressure port 104 by a spring 107 encased in cylinder 102 to be in the position shown in Figures 7 and 8.

As oil pump 6 does not rotate when electrical motor 20 stops and no working oil exists nor
15 pressure is applied to BP line pressure port 104 from supply port P. Spool 103 is pushed up to the position shown in Figure 8 by spring 107 to make a communication between BA port 106 and BB port 106'. Under this condition, ports A and B of
20 power cylinder 1 are bypassed to release the power and a state of manual steering is provided.

Oil pump 6 rotates when electric motor 20 is operating and the pressure of the working oil is applied to BP line pressure port 104 from supply
25 port T as a pilot pressure to push spool 103 down to the position when in Figure 7 against spring 107. Accordingly, the communication between BA port 106 and BB port 106' is disconnected. Under this condition, as the ports A and B of
30 power cylinder 1 are not bypassed, the pressure of the working oil coming from oil pump 6 acts directly on cylinder 1 to provide state of power steering.

An electric motor 20 which drives electrically driven oil pump 6 is electrically connected to an
35 electric source 22 which is mounted on the car through an electronically operated on-off means 27 and on-off means 27 includes a relay 21 which close a relay contact 21a upon being energized and a controller 23 which is electrically
40 connected to an alternator signal 24 and a manipulator means 28 so as to receive electrical signals therefrom. Manipulator means 28 includes a car-speed sensor 25 and a drive sensor
45 29. Car-speed sensor 25 detects the speed of the car and supplies controller 23 electrical voltages which are generated in response to the speed. The car-speed sensor is exemplified as a pulse encoder, a small sized alternator or a speedmeter
50 and etc. Drive sensor 29 supplies an electrical signal to controller 23 to control it in an on or off condition.

The operation of the embodiment shown in Figure 1 is explained as follows:—

55 When the operations of the engine and the alternator are completed after the engine is started, an alternator signal 24 is supplied to controller 23 to activate the controller. Alternatively, after the operations of the engine
60 and the alternator are completed, a time lag is set to shift the time when an alternator signal 24 is supplied to controller 23 so that a time delay is provided between the start of engine and the activation of controller. Then, signals from car-
65 speed sensor 25 and drive sensor 29 are applied

to controller 23 so that controller 23 energizes relay 21 to close relay contact 21a. Electric motor 20 is started by being excited from electric source 22 to rotate oil pump 6 and the working oil sent
70 forth from oil pump 6 is supplied to chamber 1a or chamber 1b through the port A or the port B from the supply port P through control valve 7. Piston 2 of power cylinder 1 moves in either direction toward chamber 1a or chamber 1b with
75 piston rod 3 and the movement may assist the steering of steering wheel 4 through rack and pinion gear mechanism 5.

The electrical voltage which is generated by car-speed sensor 25 in response to the speed of
80 the car is applied to controller 23 and when the electrical voltage reaches a predetermined fixed level, in other words, when the speed of the car increases to a predetermined fixed level, controller 23 opens relay contact 21a to stop
85 excitation to electric motor 20 and, therefore, to stop rotation of oil pump 6 so that the supply of the working oil to power cylinder 1 is also stopped. Thereafter, when the speed of the car decreases and the electrical voltage generated by
90 car-speed sensor 25 drops from the predetermined fixed level, relay contact 21a is again closed to reopen the supply of the working oil.

In the embodiment stated above, the speed of the car when controller 23 opens relay contact
95 21a is set at a relatively low speed, for example at a speed of about 30 km/hr order. Alternatively, controller 23 may be set to excite electric motor 20 only at the time of forward moving under a low speed and of backward moving by detecting
100 the signal coming from manipulator means 28 from the power missionary mechanism of the engine. Further, the electric motor 20 may be operated after a predetermined fixed time, for example after 1 or 2 seconds, after the engine of
105 the car is started.

In the embodiment stated above, drive sensor 29 may be set to excite electric motor 20 by
110 controller 23 after receiving signals coming from the steering wheel, the power missionary mechanism, the accelerator, the brake pedal or the clutch pedal and etc. or may be set to stop the excitation to electric motor 20 after a
115 predetermined fixed time by means of a timer, in which case the timer may be constructed to operate after receiving the signals referred to above.

As stated above, in Figure 1, the car speed when controller 23 stops excitation of electrical
120 motor 20 is set low. A state of power steering or manual steering can easily be effected by the communication of bypass valve 10, through the full rotation of oil pump 6 by the excitation of electric motor 20 at the low speed or through the
125 stop of oil pump 6 by the no excitation of electric motor 20 at the high speed.

In summarizing the explanation of the figures, Figure 1 exemplifies relay 21 and relay contact
130 21a as elements constructing electronically operated on-off means 27 while Figure 2

exemplifies a thyristor 32 in combination therewith and Figure 3 does a combination of a relay 40 with a main contact 41 and an auxiliary contact 42 and a transistor 44.

5 In Figure 2, a thyristor 32 is combined in addition to the construction shown in Figure 1. An electric motor 20 is electrically connected to an electric source 22 through thyristor 32 and the gate of thyristor 32 is electrically connected to a controller 23 to be controlled thereby. Controller 23 is electrically connected to a steering sensor 30 which is provided at the rotating part of a steering wheel 4, to be controlled thereby. The steering sensor is preferably exemplified as a touching switch, a pulse encoder, a small sized alternator or a torque sensor and etc. Controller 23 is also electrically connected to a pressure switch 31 for the engine oil to be activated thereby. It is naturally noted that thyristor 32 may be replaced by a semiconductor element.

The operation of the embodiment shown in Figure 2 is explained as follows: Manipulation of steering wheel 4 generates an electrical signal in steering sensor 30 and controller 23 applies an electrical voltage of the gate of thyristor 32 according to the electrical signal to being thyristor 32 in a conductive state. Electric motor 20 is excited with a quick response to be started and then relay 21 closes relay contact 21a to complete a circuit which can excite electric motor 20 in parallel to thyristor 32.

As stated above, in Figure 2, controller 23 receives a signal from steering sensor 30 to excite electric motor 20 and a full rotation of oil pump 6 is brought about as shown by the broken lines in Figure 5, that is the state of power steering is brought about. Alternatively, if car-speed sensor 25 is arranged to activate controller 23 with a priority to steering sensor 30, oil pump 6 will effect an operation or non-operation as shown in the area given by the oblique lines and the full lines. The fact that the state of power steering or the state of manual steering can be attained through the communication of bypass valve 10 is the same as the fact obtained in the embodiment shown in Figure 1.

In Figure 3, a relay 40 with a main contact 41 and an auxiliary contact 42 as well as a transistor 44 are combined in addition to the construction shown in Figure 1. An electric motor 20 is electrically connected to an electric source 22 through the collector to emitter circuit of transistor 44. One contact point of main contact 41 is electrically connected to electric source 22 and the other contact point of main contact 41 is electrically connected to electric motor 20, directly. One contact point of auxiliary contact 42, which closes prior to main contact 41 closure and opens after main contact 41 opening, is electrically connected to the base of transistor 44 through a resistor 43 and the other contact point of auxiliary contact 42 is electrically connected to the other contact point of main contact 41. It is naturally noted that transistor 44 may generally

be replaced by a semiconductor element.

The operation of the embodiment shown in Figure 3 is explained as follows: The signal coming from controller 23 energizes relay 40 to first close auxiliary contact 42 to reduce the electric potential at the base of transistor 44 through the drop in resistor 43. Transistor 44 turns into a conductive state and electrical motor 20 is excited with a quick response to be started. Then, main contact 41 is second closed to complete a circuit which can excite electric motor 20 in parallel to transistor 44. When electric motor 20 is stopped by controller 23, relay 40 opens first main contact 41 only. The current exciting electric motor 20 flows in a circuit from electric source 22 to the emitter to collector circuit of transistor 44 as well as in a circuit from electric source 22 through the emitter to base circuit of transistor 44 to auxiliary contact 42. Thereafter, when auxiliary contact 42 opens, the electric potential at the base of transistor 44 becomes zero to open the emitter to collector circuit of transistor 44. Under this condition, the current flowing through auxiliary contact 42 is smaller than the current flowing through the emitter to collector circuit due to the existence of resistor 43. This means that less damage arising from any spark is given to the main contact as well as the auxiliary contact. It is also well noted that a semiconductor switch is simply used to control the electric motor without using any relay and its associated contacts.

As stated above, in Figure 3, the current in main contact 41 is intermittent as shown by the full lines in Figure 6 and the current in auxiliary contact 42 is also intermittent as shown by the broken lines in the same figure, by using two kinds of contacts and the state of power steering can be obtained with a quick response and less wear and tear in the contact points.

As explained in Figure 1 to Figure 3, there is recognized that a benefit is obtained in which the cost is less expensive when the relay is only used as the element which constitutes the electrically operated on-off means, a benefit is obtained in which the response is good when a combination of the relay and the thyristor is used as the elements referred to above and a benefit is obtained in which the quick response is obtained and a long life operation is gained when a combination of the relay with two kinds of contact points and the transistor is used as the elements referred to above.

The circuits shown in Figures 1 to 3 provide the performances as shown in Figures 4 to 6. In these performances, the electric motor stops at the time when the car speed reaches a previously determined value to decrease the rotation of the oil pump to zero and, as stated above, the state of power steering is directly shifted to the state of manual steering. If the circuits are partially modified, for example, in a manner that the voltage to be applied to the electric motor is reduced to about 50 to 60% of the full potential of the electrical source by means of a

semiconductor, the number of rotation of the oil pump will accordingly be reduced. Therefore, if the circuits thus modified are actually used, the performance will be modified as that shown in Figure 11. More particularly, when the car speed reaches a previously determined value, such as 15 km/H, after the electric motor is started by using the relay, the voltage applied to the electric motor is reduced to decrease the number of rotation of the oil pump from 2500 RPM to 1500 PRM and the state of power steering will be shifted to the semiconductor switching region from the relay-on region. After the car speed is increased, when the electric motor is completely stopped at another previously determined car speed, such as 40 km/H, the state of power steering is then completely shifted to the state of manual steering. As explained above, the shock to be generated in the pipe arrangement from the full rotations of the electric motor and the oil pump to the complete stop thereof will be moderated by providing the semiconductor switching region between the relay-on region of the state of power steering region and the state of manual steering region.

The construction and the operation of reducing relief valve 100 are, here, briefly explained in Figures 9 and 10. Reducing relief valve 100 has a housing 203 and in housing 203 are provided an RP line pressure port 204 connected to the supply port P of oil pump 6 and an RT tank port 205 connected to the return port T of oil pump 6, said RT tank port 205 being located opposite said RP line pressure port 204. A first relief part 108 is formed near RP line pressure port 204 and a second relief part 109 is formed in continuation with first relief part 108. The inner diameter of second relief part 109 is made larger than the inner diameter of first relief part 108. A sphere 200 is accommodated within first relief part 108 and is normally urged toward RP line pressure port 204 by means of a spring 202 through a guide 201, as shown in Figure 9.

When the pressure of the working oil applied to RP line pressure port 204 of reducing relief valve 100 from the supply port P of oil pump 6 increases to result in an over pressure to reach point P1 of Figure 14, due to some extraordinary causes, for example, steering wheel 4 is halted to be held at the extremity of steering in the rack ends or an overload is applied to power cylinder 1 to hold power cylinder at a locking state, ball 200 displaces downward in the figure against spring 202 and enters into the interior of second relief part 109. A path will be, thus, generated between ball 200 and second relief part 109 and the pressure at point P1 which is applied to RP line pressure port 204 is led to RT tank port 205 to be reduced to a point P2 along a line b1.

An embodiment of the connection between the oil pump, the control valve, the power cylinder, the bypass valve and the reducing relief valve given in the embodiments shown in Figures 1 to 3 is illustrated in Figure 12.

In Figure 12, a supply port P of electrically driven oil pump 6 is connected to a supply port

CP of control valve 7 via a pipe 51 and is connected to a BP line pressure port 104 of bypass valve 10 via a pipe 52. A return port T of electrically driven oil pump 6 is connected to a return port CT of control valve 7 via a pipe 53 and is connected to a BT tank port 105 of bypass valve 10 via a pipe 54. A port A which leads to chamber 1a of power cylinder 1 is connected to a port CA of control valve 7 via a pipe 55 and is connected to a BA port 106 of bypass valve 10 via a pipe 56. A port B which leads to chamber 1b of power cylinder 1 is connected to a port CB of control valve 7 via a pipe 57 and is connected to a BB port 106' of bypass valve 10 via a pipe 58.

In Figure 13, is shown an embodiment of the arrangement between control valve 7, bypass valve 10 and reducing relief valve 100, all illustrated in Figure 12. Control valve 7 is provided with the supply port CP, the return port CT, the port CA and the port CB and while bypass valve 10 is mounted within control valve 7 in the embodiment, so that all the ports of control valve 7 can be utilized as the respective port of bypass valve 10, bypass valve 10 is, in general, mounted independent of control valve 7. While reducing relief valve 100 is accommodated within spool 103 of bypass valve 10 in the embodiment, reducing relief valve 100 is, in general, mounted also independently of bypass valve 10. Reducing relief valve 100 is provided so as to reduce the over pressure brought about when the manipulation of the steering wheel is held at the rack end in the state of power steering and RP line pressure port 204 and RT tank port 205 of reducing relief valve 100 are, respectively, mounted near BP line pressure port 104 and BT tank port 105, said ports 104 and 105 communicating with each other through the interior of reducing relief valve 100.

The overall operations of control valve 7, bypass valve 10 and reducing relief valve 100 are now explained in putting them together.

Under a normal state of power steering, a working oil of a prescribed pressure is supplied to supply port CP and BP line pressure port 104 from supply port P and the pressure of the working oil will increase with the rotation of oil pump 6. When the pressure exceeds the compression pressure of spring 107, spool 103 displaces toward BT tank port 105 and the communication between BA port 106 and BB port 106' is disconnected. Manipulation of steering wheel 4 leads the working oil at supply port CP to port CA or port CB in accordance with the direction steering wheel 4 is manipulated. The working oil is applied to chamber 1a or chamber 1b to act on piston 2 and action of piston 2 assists the manipulation of steering wheel 4.

Next, when electric motor 20 and oil pump 6 stop under the control of controller 23 a state of the manual steering initiates. If steering wheel 4 is manually manipulated, the working oil, then being supplied to supply port CP, must flow a rather narrow path, which is determined by the manual manipulation, to reach port CA or port CB

and the relatively high resistivity due to the narrowness makes steering wheel 4 rather difficult to be handled. Under this condition the pressure of the working oil acting on BP line pressure port 104 is decreasing gradually from the prescribed pressure, spool 103 returns toward BP line pressure port 104 by the compression force of spring 107 and the communication between BA port 106 and BB port 106' restores.

Steering wheel 4, then, can easily be manipulated due to the communication as the working oil will receive only the resistivity inherent to the pipe the working oil is actually flowing through.

Last, when the load to oil pump 6 is abruptly increased owing to the road situation to a limit which cannot be adjusted by controller 23 or electronically operated onoff means 27, electric motor 20 may be overload. The pressure of the working oil at supply port P may reach a pressure indicated by a point P1 as shown in Figure 14, such as 70 kg/cm² and if the pressure is long maintained along a line s as shown in Figure 14, electric motor 20 may possibly be burnt to be destroyed. When the pressure indicated by point P1 is applied to RP line pressure port 204, sphere 200 will displace toward RT tank port 205 with first relief part 108 and second relief part 109 open. The pressure indicated by point P1 reduces to a pressure indicated by a point P2 as shown in the same figure along a line b1 and is maintained along a line c1 as shown in the same figure. Under this condition, reducing relief valve 100 naturally works so that the pressure of the working oil is set at a limit which is allowable by the ability for keeping the steering power, in other words, the pressure of the working oil is only reduced with the steering state maintained as it was.

It will be noted here that reducing of the pressure due to the reducing relief valve of the present invention is effectively obtained by the hysteresis performance of the relief means and, therefore, the reducing relief operation can be effected extreme stably.

As explained above, in the electrically driven oil pressure power steering apparatus of this invention, the following operational effect can be noted as explained below.

1. The state of power steering can be shifted to the state of manual steering by manipulating the bypass valve in conjunction with the pressure of the working oil sent forth from the oil pump by the on-off operation thereof.

2. The selection of the two states of steerings is extremely simple as the selection is effected by the manipulation of the electric motor. As the communication of the working oil in the bypass valve is linked to the on-off operation of the electric motor, the whole construction of the apparatus is quite simple, the resistivity in the path, the working oil is actually flowing, is low so that the damage due to the flow resistance is made less and a safe operation can be obtained.

3. When the pressure of the working oil is extraordinary increased at the over steering lock

in the end of the rotation of the steering wheel, the current in the electric motor is decreased by the reducing relief valve to protect the contacts in the electronically operated on-off means and to decrease the capacity of the semiconductor element to the effect that the energy consumed in the electric motor, as the power source of the oil pump, can be saved.

4. The performance of the reducing relief valve can be stabilized by decreasing the oil pressure output of the oil pump to the limit, the steering holding ability may allow, by providing a hysteresis function with the relief operation of the reducing relief valve.

5. The over pressure of the working oil due to the sudden increase of the load in the oil pump is decreased by providing the reducing relief valve between the supply port and the return port of the oil pump and the temperature of the working oil is, accordingly, decreased so that the coil of the electric motor is prevented from being burnt.

6. The switching over between the state of power steering and the state of manual steering can be effected without any sensible discontinuity by changing the power supply to the electric motor in accordance with the car speed.

Claims

1. An electrically driven oil pressured power steering apparatus of an automobile comprising an oil pump which is driven by an electric motor and supplies a working oil to a power cylinder, a control valve which controls the supply of the working oil and a manipulating apparatus and an electronically operated on-off means which, in common, control a power supply to the electric motor, characterized in that a state of power steering is shifted to a state of manual steering in accordance with a stop of the electric motor effected by the electronically operated on-off means.

2. An electrically driven oil pressured power steering apparatus as recited in Claim 1, further comprising a bypass valve which is provided in the paths, through which the working oil is supplied to the power cylinder so as to communicate the paths.

3. An electrically driven oil pressured power steering apparatus as recited in Claim 2, further characterized in that the state of power steering is established at a time when the bypass valve closes and the state of manual steering is established at a time when the bypass valve opens.

4. An electrically driven oil pressured power steering apparatus as recited in Claim 2, further comprising a reducing relief valve which is connected between a supply port of the oil pump and a return port of the oil pump.

5. An electrically driven oil pressured power steering apparatus as recited in Claim 2, characterized in that the bypass valve is constructed so that the working oil supplying paths can be communicated in conjunction with

the operations of the manipulating apparatus and the electronically operated on-off means.

6. An electrically driven oil pressured power steering apparatus as recited in Claim 5, further characterized in that the communication is meant by a closure of the bypass valve effected at a time when the oil pump is rotating and by an opening of the bypass valve effected at a time when the oil pump stops.

7. An electrically driven oil pressured power steering apparatus as recited in Claim 1, further characterized in that the manipulating apparatus and the electronically operated on-off means operate the electric motor in accordance with the manipulation of a steering wheel.

8. An electrically driven oil pressured power steering apparatus as recited in Claim 1, further characterized in that the manipulating apparatus and the electronically operated on-off means operate the electric motor in accordance with a detection of forward moving of the automobile at a low speed or of backward moving of the automobile, by means of signals from transmission of the automobile.

9. An electrically driven oil pressured power steering apparatus as recited in Claim 1, further characterized in that the manipulating apparatus and the electronically operated on-off means operate the electric motor in accordance with manipulations of various kinds of pedals.

10. An electrically driven oil pressured power steering apparatus as recited in Claim 1, further characterized in that the manipulating apparatus and the electronically operated on-off means control to operate the electric motor under a condition that the speed of the automobile is in a range which does not exceed a previously determined speed and the manipulating apparatus and the electronically operated on-off means control not to operate the electric motor under a condition that the speed of the automobile reaches in a range which exceeds the previously determined speed.

11. An electrically driven oil pressured power steering apparatus as recited in Claim 1, further characterized in that the electric motor is controlled by the manipulating apparatus and the electronically operated on-off means in conjunction with starting of the engine of the automobile.

12. An electrically driven oil pressured power steering apparatus as recited in Claim 11, further characterized in that "in conjunction with starting" means that the starting is completed.

13. An electrically driven oil pressured power steering apparatus as recited in Claim 11, further characterized in that "in conjunction with

starting" means "after a certain time from the start".

14. An electrically driven oil pressured power steering apparatus as recited in Claim 1, further characterized in that the electronically operated on-off means comprises relays.

15. An electrically driven oil pressured power steering apparatus as recited in Claim 14, further characterized in that the electronically operated on-off means further comprises semiconductor elements.

16. An electrically driven oil pressured power steering apparatus as recited in Claim 4, further characterized in that a pilot pressure applied to the spool of the bypass valve is additionally applied to the line pressure port to thereby apply an over pressure condition.

17. An electrically driven oil pressured power steering apparatus as recited in Claim 16, characterized in that the reducing relief valve holds a hysteresis characteristic in that the over pressure condition is decreased to a limit that a power for holding the steering of the steering wheel admits.

18. An electrically driven oil pressured power steering apparatus as recited in Claim 4, further characterized in that the reducing relief valve is provided within the bypass valve.

19. An electrically driven oil pressured power steering apparatus as recited in Claim 15, further characterized in that the electronically operated on-off means is provided with a circuit element through which a reduced source voltage is applied to the electric motor by switching control of the semiconductor elements.

20. An electrically driven oil pressured power steering apparatus as recited in Claim 19, further characterized in that the control circuit of the semiconductor elements becomes active upon the fact that the speed exceeds a previously determined speed to thereby apply a reduced source voltage to the electric motor.

21. An electrically driven oil pressured power steering apparatus as recited in Claim 19, further characterized in that the control circuit of the semiconductor elements becomes inactive upon the fact that the speed exceeds another previously determined speed to thereby stop the electric motor and the performance is shifted to a state of the manual steering region through a semiconductor switching region in a state of power steering region from a relay-on region in the state of power steering region.

22. An electrically driven oil pressured power steering apparatus for an automobile substantially as herein described with reference to and as illustrated in Figures 1, 2, or 3 and Figures 4 to 14 of the accompanying drawings.