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GB 2290511 A **EP 0665157 A1**

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(54) Electronic controlled steering system with hydraulic power assistance for motor vehicles

(57) The steering wheel 17 actuates a desired-value generator 18 which is operatively connected via an electronic controller 19 to an actuating motor 10, which may be electric. The motor 10 rotates a worm 8 which steers the vehicle guiding wheels 2 via a worm gearwheel 7, and rack 4 and pinion 5 steering gear. As soon as the steering actuating forces exceed a threshold value, axial displacement of the worm 8 from its normal position counter to a resilient force (27, Figs 2 to 4) actuates a closed centre servovalve arrangement 12 connected to a hydraulic servomotor in the form of a piston/cylinder assembly 13, to provide hydraulic power assistance.

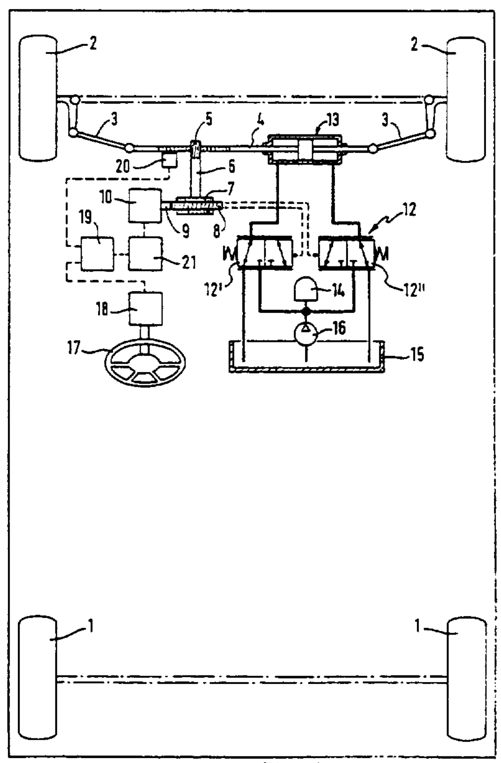

Fig. 1

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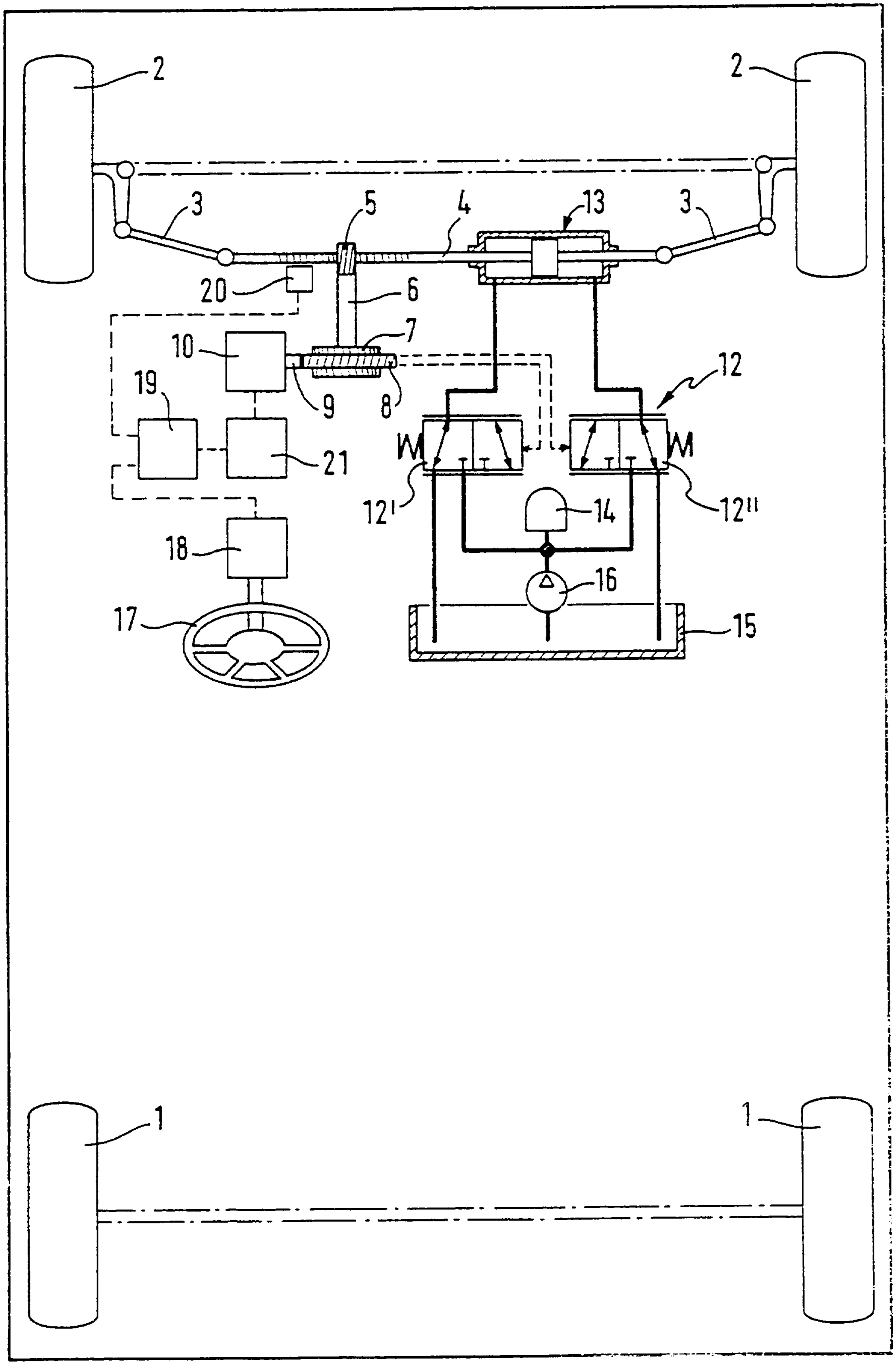

Fig. 1

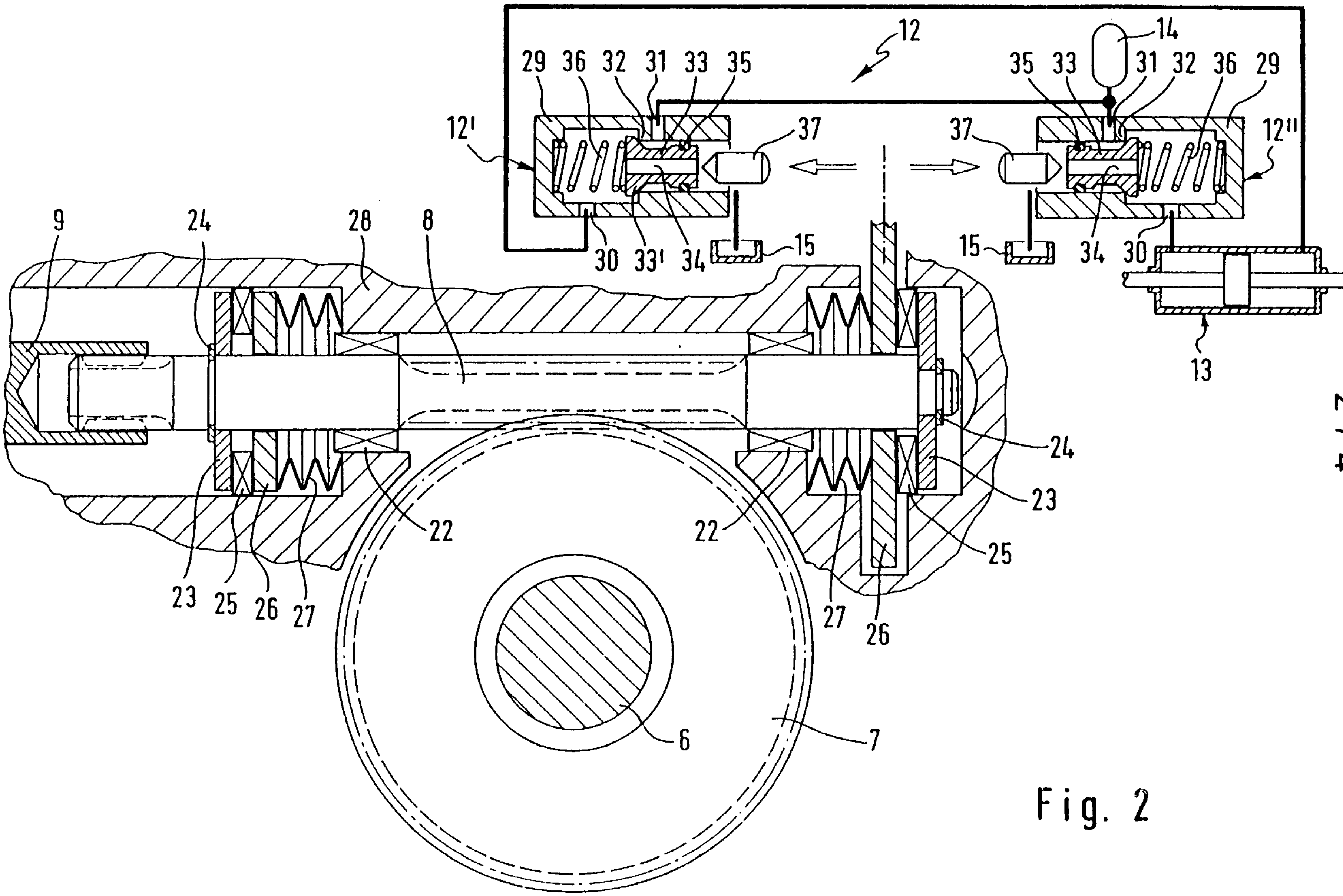
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Fig. 2

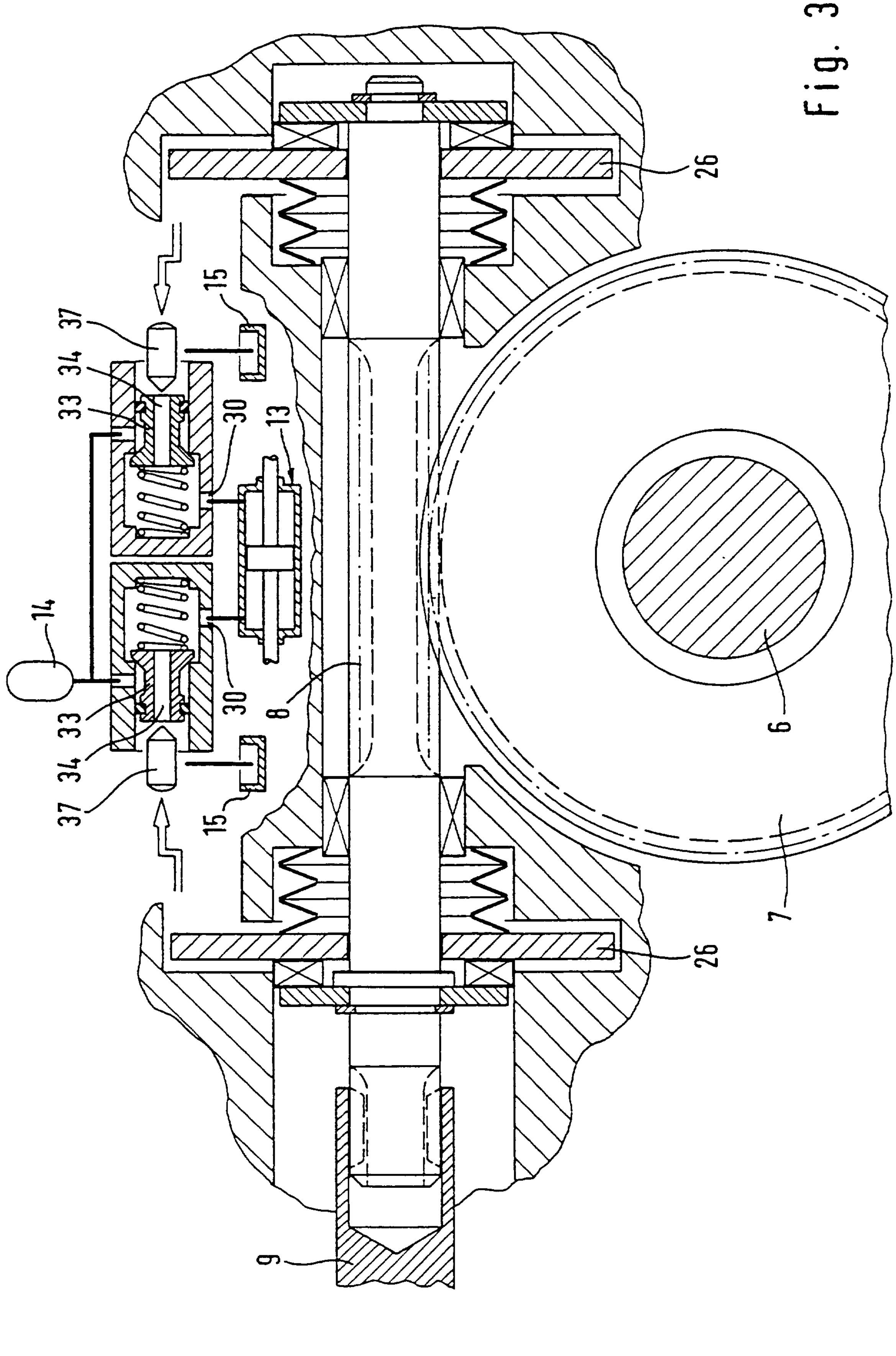

Fig. 3

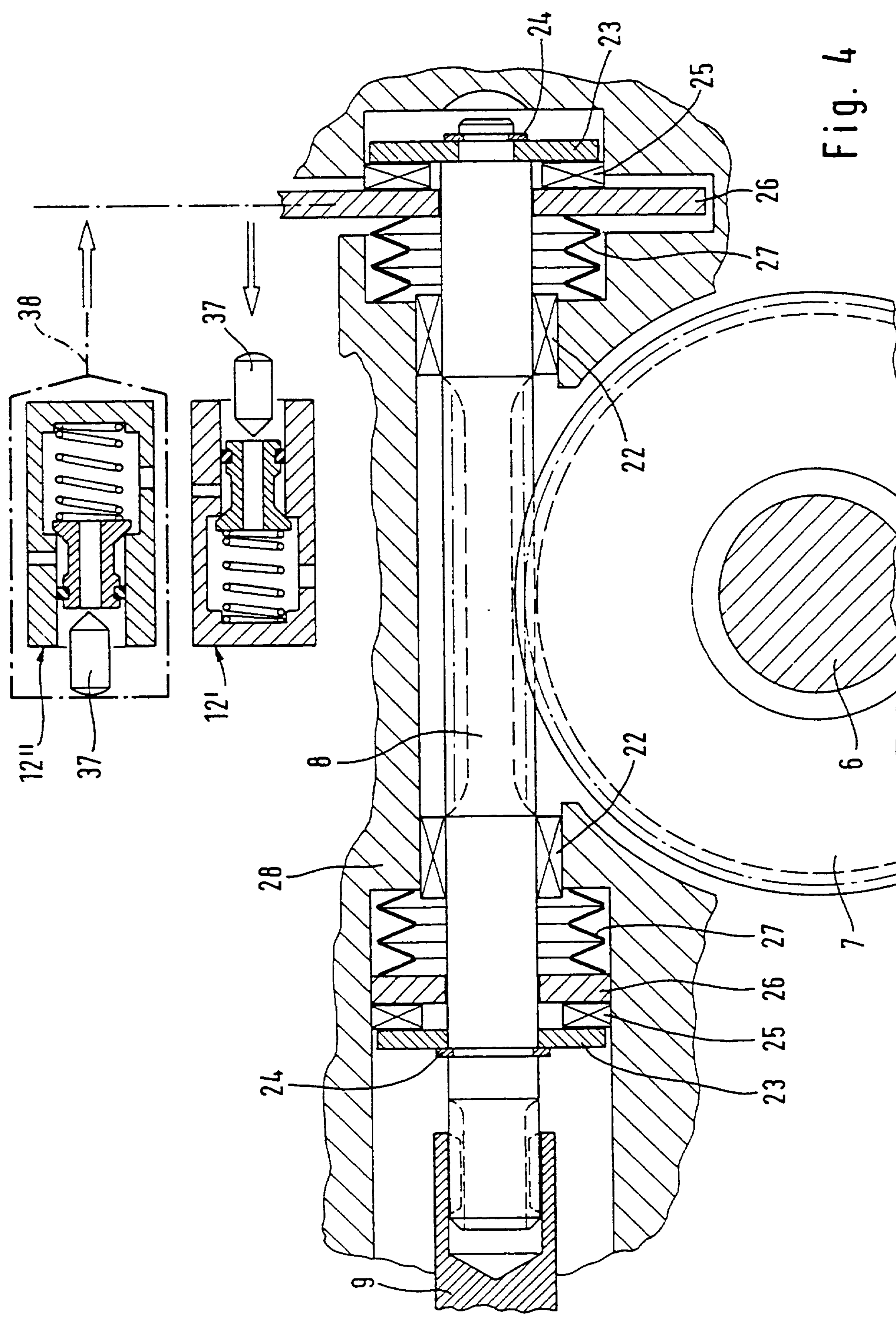

Fig. 4

Hydraulic power steering for motor vehicles

The invention relates to a hydraulic power steering system for motor vehicles, with a steering gear arranged as a mechanical drive connection between an actuating member and vehicle guiding wheels and having an element which can be disengaged from a normal position counter to spring force and the position of which can be changed as a function of the forces transmitted between the vehicle guiding wheels and the actuating member, with a servovalve arrangement capable of being controlled by means of changes in position of the said element, and with a hydraulic servomotor which is controlled by the servovalve and which is operatively drive-coupled to the vehicle guiding wheels.

Power steering systems of this type are generally known and are arranged as standard in motor vehicles. In this case, the actuating member is formed by a steering wheel (or other steering handle) actuated by the driver. The servomotor is then correspondingly actuated as a function of the forces transmitted between the steering wheel and vehicle guiding wheels, with the effect of reducing the manual force to be exerted on the steering wheel.

In known vehicle steering systems, the servovalve arrangement is conventionally designed with a so-called open centre, that is to say hydraulic pressure medium flows continuously through the servovalve arrangement even when the steering is in the straight-ahead position, and there is no need for any manual force on the steering wheel in order to maintain this position. Power is therefore constantly required for maintaining the stream of pressure medium.

Admittedly, servovalve arrangements with a so-called closed centre are also known, in which no stream of pressure medium can occur when the steering is in the straight-ahead position and manual force disappears, so that, also, no power is required in operating states of this type. Only when a greater or lesser manual force is applied to the steering wheel can the servovalve arrangement open and make a connection between the servomotor and pressure source or pressure accumulator. However, systems of this kind have not proved acceptable hitherto. This would seem to be because, up to now, the opening behaviour of servovalve arrangements with a closed centre presents some problems and causes the power assistance of the servomotor to cut in comparatively abruptly.

In all conventional power steering systems, a mechanical through-drive in the form of a mechanical positive coupling is provided between the steering handle or steering wheel and the vehicle guiding wheels, in order to ensure maximum safety.

In principle, however, it is also known to actuate by means of a handle only a desired-value generator which then, in turn, cooperates via a controlled system with an actuating drive, the actuating stroke of which is regulated by desired-value/actual-value comparison and is essentially similar to the actuating stroke of the control handle. Control concepts of this kind, in which electronic controlled systems are employed, are used, for example, in aircraft for the actuation of wing flaps and horizontal and vertical tail units. These control systems, also referred to as "fly by wire", have since become so reliable that they are used not only in military aircraft, but also in civil passenger aircraft.

The present invention seeks, then, to implement a concept of this kind in vehicle steering, too, and, whilst using as many tried and tested parts of conventional power steering systems as possible, also to ensure a low energy requirement of the power steering according to the invention.

According to the invention there is provided a hydraulic power steering system for motor vehicles, with a steering gear arranged as a mechanical drive connection between an actuating member and vehicle guiding wheels and having an element disengageable from a normal position counter to a resilient force and the position of which is changeable as a function of the forces transmitted between the vehicle guiding wheels and the actuating member,

- a servovalve arrangement capable of being controlled as a result of changes in position of the said element, and
- a hydraulic servomotor controlled by the servovalve and which is operatively drive-coupled to the vehicle guiding wheels, wherein
- a manually operable steering device actuates a desired-value generator which cooperates via a control system with an actuating motor arranged as an actuating member,
- only in the event of transmitted forces or torques greater than a threshold value does the disengageable element execute a displacement sufficient for adjusting the servovalve arrangement, and
- the servovalve arrangement is normally closed.

The invention is based on the general notion of separating the hitherto conventional mechanical positive coupling between the steering handle or steering wheel and the vehicle guiding wheels and of actuating, by means of the steering handle or steering wheel and the controlled system, an actuating motor which is arranged at a distance and which then, in turn, takes over the steering actuation of the vehicle guiding wheels, the actuating motor being capable of being assisted by the servomotor. At the same time, however, the control of the servovalve arrangement is designed in such a way that the servovalve arrangement can be deflected out of its normal position only when forces exceeding a predetermined threshold value are transmitted between the actuating motor and the vehicle guiding wheels. If only low forces are transmitted between the actuating motor and vehicle guiding wheels, the actuating motor alone performs the steering work. The result of this is that a servovalve arrangement with a closed centre can be readily employed. This is because even a possibly relatively "abrupt" response of the servomotor is not critical in the case of higher forces transmitted between the actuating motor and vehicle guiding wheels. By virtue of the regulating means, fluctuations in the load on the actuating motor, which is already under a predetermined load when the power assistance of the servomotor cuts in, can be readily compensated.

As a result, therefore, the actuating motor is coupled to the vehicle guiding wheels in fundamentally the same way as the steering wheel is in conventional power steering, so that, altogether, a very close analogy to conventional power steering systems is obtained.

Substantially less installation space is required since the steering column usually otherwise present between the steering wheel and steering gear is dispensed with, and at the same time a multiplicity of friction-affected rotary bearings become unnecessary.

According to a preferred embodiment of the invention, the said threshold value can be dimensioned in such a way that power assistance cuts in essentially only in the case of steering manoeuvres at very low speed, for example during parking manoeuvres, that is to say when relatively high steering forces have to be generated. In contrast, "normal" steering manoeuvres are executed essentially only by the actuating motor.

In a way which is preferred from the point of view of design, the actuating motor is drive-coupled to the vehicle guiding wheels via a worm and a worm wheel meshing with the latter, the worm actuated by the actuating motor having, for example, axial movability counter to a resilient force and controlling the servovalve arrangement.

Advantageous embodiments of the invention will now be described by way of example with reference to the drawings, in which:-

Figure 1 shows a general diagrammatic representation of the power steering according to the invention,

Figure 2 shows a first embodiment of a drive coupling between an electric motor and the steering gear and of the control of the servovalve arrangement,

Figure 3 shows a modified embodiment of the arrangement according to Figure 2, ad

Figure 4 shows a further modified embodiment.

According to Figure 1, a motor vehicle, not shown in any more detail, possesses a rear axle with wheels 1 non-steerable in the example shown and a front axle with steerable wheels 2. These are coupled in a basically known way to a rack 4 via track rods 3, in such a way that, in the event of longitudinal displacements of the rack 4 in one direction or the other, a steering lock of the front wheels 2 in one direction or the other is brought about.

The rack 4 meshes with a pinion 5 which is connected fixedly in terms of rotation to a worm gearwheel 7 via a pinion shaft 6. The worm gearwheel 7 is drive-connected to a worm 8 which is connected axially movably, but fixedly in terms of rotation, to the output shaft 9 of an electric motor 10 and which is urged into an axial mid-position by a spring arrangement not shown in Figure 1. Depending on the direction and magnitude of the torque transmitted between the worm 8 and worm gearwheel 7, the worm 8 is axially displaced in one direction or the other to a greater or lesser extent counter to the abovementioned spring arrangement.

This axial stroke of the worm 8 controls a valve assembly 12 which, in a way shown further below, connects a double-acting piston/cylinder assembly 13 arranged as a servomotor to a hydraulic pressure accumulator 14 or to a relatively pressureless hydraulic reservoir 15 in a controllable manner. The piston rod of the piston/cylinder assembly 13 is formed by a non-toothed portion or extension piece of the rack 4.

The pressure accumulator 14 is charged, as required, by means of a hydraulic pump 16 which is connected on the suction side to the reservoir 15.

An electrical or electronic desired-value generator 18 is actuated by means of a steering wheel 17, the output of the said desired-value generator being connected to the input of an electrical or electronic controller 19, the actual-value input of which is connected to the output of an actual-value generator 20 which cooperates with the rack 4 and the signals of which represent the actual position of the rack and therefore the steering angles of the front wheels 2. On the output side, the controller 19 is connected via a driver circuit 21 to the electric motor 10 for the control of the latter.

The steering illustrated works as follows:

The driver actuates the steering wheel 17 in the usual way. The desired-value generator 18 thereby predetermines a desired value of the steering angle to be set on the front wheels 2. The controller 19 compares the desired value supplied by the desired-value generator 18 with the actual value supplied by the actual-value generator 20 and activates the electric motor 10 according to the desired-value/actual-value comparison via the driver circuit 21, in such a way that the actual value of the steering angle is set to the desired value. During steering manoeuvres of this type, the worm 8 is axially displaced in one direction or the other to a greater or lesser extent according to the forces or torques transmitted between the worm 8 and the worm gearwheel 7. In the case of low transmitted forces or torques, this axial displacement is sufficiently small that the valve assembly 12 remains in its position shown, in which both sides of the piston/cylinder assembly 13 are connected to the hydraulic reservoir 15 and are shut off from the pressure accumulator 14. Thus, when low forces or torques are transmitted between the worm 8 and worm gearwheel 7, the guiding wheels 2 are controlled solely by the electric motor 10. As soon as higher forces or torques are transmitted between the worm 8 and worm gearwheel 7, the worm 8 is displaced sufficiently far in one direction or the other to ensure that either the valve 12′ or the valve 12" of the valve assembly 12 is displaced out of the normal position shown in the direction of its other position. The result of this is that, in each case, one side of the piston/cylinder assembly 13 is connected to the pressure accumulator 14 or to the delivery side of the pump

16, this connection having greater or lesser throttle resistance. The other side of the piston/cylinder assembly 13 remains connected to the reservoir 15. The piston/cylinder assembly 13 consequently generates a hydraulic actuating force which assists the electric motor 10 in its steering work.

In the arrangement according to the invention, a comparatively low-power and therefore compact electric motor 10 can be provided. As soon as higher forces become necessary for the steering actuation of the front wheels 2, the electric motor 10 is assisted hydraulically by means of the piston/cylinder assembly 13 provided as a servomotor. Also conducive to the small size of the electric motor 10 is the fact that a higher step-up ratio occurs between the worm 8 and worm gearwheel 7, that is to say, in comparison with the worm gearwheel 7, the worm 8 executes a large number of revolutions during a steering adjustment of the front wheels 2.

According to Figure 2, the worm 8 is rotationally mounted so as to be axially displaceable in radial bearings 22 at both axial ends of its worm toothing. Annular discs 23 arranged on the worm shaft serve for axial mounting and are retained axially, on their end face facing away from the worm 8, in each case on a support ring 24 fixed axially on the worm shaft. Axial bearings 25 are arranged on those sides of the annular discs 23 which face one another and are in each case inserted between one of the annular discs 23 and one of two bearing discs 26 which are clamped by means of cup springs 27 against those end faces of the annular discs 23 which face the said bearing discs. These cup springs 27 are supported on stationary housing parts 28.

In the event of axial displacements of the worm 8, the bearing discs 26 also execute a corresponding axial displacement. Accordingly, in Figure 2, one of the bearing discs, the right-hand bearing disc 26 in the example shown, can be used for controlling the valve assembly 12.

In the example shown, the valves 12′ and 12" of the valve assembly 12 are designed as seat-controlled valves which each have a valve housing 29 with a stepped axial blind bore. The valve housing 29 possesses two radial bores 30 and 31 which are spaced from one another in the axial direction of the housing 29, there being arranged between these radial bores 30 and 31 an annular step 32, at which the axial blind bore in the housing 29 widens towards its closed end. This annular step 32 cooperates as a seat with a valve body 33, through which an axial bore 34 passes and which has a cone-like closing part 33′ cooperating with the seat formed by the annular step 32. At its axial end remote from the closing part 33′, the valve body 33 is sealed off slide-displaceably relative to the inner circumference of the blind bore of the valve housing 29 by means of a sealing ring 35. The valve body 33 has a relatively small outside diameter axially between the sealing ring 35 and the closing part 33′, in such a way that an annular space is formed within the valve housing 29 in the region of the radial bore 31. The valve body 33 is clamped against the annular step 32 by means of a spring 36. Arranged coaxially relative to the axial bore 34 is a tappet-like closing body 37 which can be advanced towards that mouth of the axial bore 34 which faces the said closing body, in order to shut off this axial bore 34.

The closing bodies 37 normally assume their open position. Only in the event of a pronounced displacement of the bearing disc 26 coupled to the closing bodies 37 is one of the closing bodies 37 in each case urged up against the associated valve body 33, so that, on the one hand, this valve body 33 lifts off with its closing part 33′ from the annular step 32 and, on the other hand, the axial bore 34 is closed.

Whilst, in the normal position shown in Figure 2, the radial bores 30, in each case connected to one side of the piston/cylinder assembly 13, are connected to the hydraulic reservoir 15 via the axial bores 34 of the valve bodies 33, in the event of sufficient displacement of the worm 8 the radial bore 30 of one of the valves 12′ and 12″ is therefore connected to the radial bore 31 of this valve, since its valve body 33 lifts off with its closing part 33′ from the annular step 32 and the connection to the hydraulic reservoir 15 is shut off by the closing body 37.

The arrangement of Figure 3 differs from the arrangement according to Figure 2 essentially only in that each of the bearing discs 26 in each case actuates one of the valves 12′ and 12″ of the valve assembly 12.

In principle, according to Figure 4, a single one of the two bearing discs 26 can also actuate both valves 12′ and 12″ if these are arranged on the same end face of the respective bearing disc 26. For this purpose, in Figure 4, the closing body 37 of the valve 12″ is drive-connected to the bearing disc 26 via a coupling element 38.

Should the valve assembly 12 (see especially Figure 1) jam, a normally closed shut-off valve can be arranged between the connections of the piston/cylinder assembly 13. This shut-off valve is opened automatically in the event of a malfunction of the valve assembly 12, so that the piston/cylinder assembly, if it is designed as a synchronous assembly, is switched to free-wheel and the guiding wheels 2 are actuated solely by the electric motor 10.

If appropriate, the shut-off valve, in its open position, may connect the two chambers of the piston/cylinder assembly 13 not only to one another, but also to the reservoir 15. In this case, the piston/cylinder assembly 13, even if it is not designed as a synchronous assembly, is switched to free-wheel when the shut-off valve is opened.

Claims

1. A hydraulic power steering system for motor vehicles, with a steering gear arranged as a mechanical drive connection between an actuating member and vehicle guiding wheels and having an element disengageable from a normal position counter to a resilient force and the position of which is changeable as a function of the forces transmitted between the vehicle guiding wheels and the actuating member,
- a servovalve arrangement capable of being controlled as a result of changes in position of the said element, and
- a hydraulic servomotor controlled by the servovalve and which is operatively drive-coupled to the vehicle guiding wheels, wherein
- a manually operable steering device actuates a desired-value generator which cooperates via a control system with an actuating motor arranged as an actuating member,
- only in the event of transmitted forces or torques greater than a threshold value does the disengageable element execute a displacement sufficient for adjusting the servovalve arrangement, and
- the servovalve arrangement is normally closed.

2. A power steering system according to Claim 1, wherein the disengageable element and the servovalve arrangement are coupled to one another with free play.

3. A power steering system according to Claim 1 or 2, wherein the disengageable element is biassed by means of resilient prestress into the normal position.

4. A power steering system according to any one of Claims 1 to 3, wherein the actuating motor is drive-coupled to the vehicle guiding wheels via a worm gear and the worm of the worm gear is arranged so as to be axially displaceable counter to resilient force.

5. A power steering system according to any one of Claims 1 to 4, wherein the servovalve arrangement has seat-controlled valves.

6. A power steering system according to any one of Claims 1 to 5, wherein an electric motor is provided as an actuating motor.

7. A hydraulic power steering system for motor vehicles, substantially as described herein with reference to, and as illustrated in, the accompanying drawings.

The Patent Office

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Application No: GB 9701063.1
Claims searched: 1 to 7
Examiner: Robert Crowshaw
Date of search: 9 April 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B7H (HHA, HHD, HHM, HHT)

Int Cl (Ed.6): B62D 5/04, 5/06, 5/08, 5/087, 5/10, 5/12, 5/22, 5/24

Other: Online database: EDOC, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2290511 A	(MERCEDES-BENZ AG) Note the vehicle steering system with both hydraulic and electric motors.	
A	EP 0665157 A1	(FIAT) Note the hydraulic power steering system.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		