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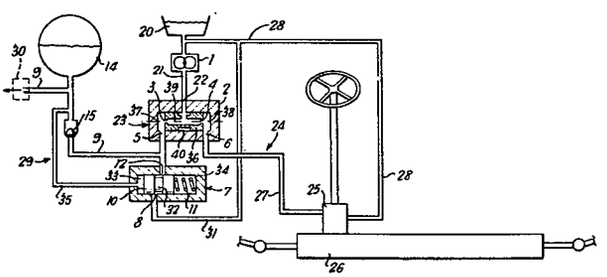
(54) Hydraulic systems comprising open and closed centre valves.

(57) An hydraulic actuation or control system for vehicles has a first system part (24) which includes an open centre valve (25) which may control operation of a power assisted steering gear (26) and a second system part (29) which has a closed centre valve (30) which may control actuation of power assistance braking or hydraulic suspension. The system parts (24 and 29) communicate with the common pump (1) by way of outlets (5 and 6) from a flow divider valve (2) which has a spool (36) displaceable in response to fluid pressure differentials detected in chambers (37 and 38) through the respective outlet ports (5 and 6) from the system parts (29 and 24 respectively).

Outlet port (5) can communicate with exhaust (reservoir 20) through a biased relief valve (7) which is responsive to pressure in the system part (29) to close off communication between the outlet port (5) and exhaust when fluid pressure in the system part (29) decreases sufficiently.

The system part (29) can include an accumulator (14) which is charged from outlet port (5) by way of a non-return valve (15) and the relief valve (7) is responsive to pressure in the accumulator.



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DESCRIPTION

This invention relates to hydraulic systems comprising open and closed centre valves.

Open centre valves and closed centre valves are well known in the art of hydraulic engineering where the former has its porting arranged so that in a normal or neutral condition fluid under pressure is directed through the valve to exhaust (reservior). With closed centre valves the porting is generally arranged so that in a normal or neutral condition of the valve communication is closed off between the fluid under pressure and exhaust. Many systems are known which incorporate both open and closed centre valves and it is usual where these valves are used in a common installation for discrete systems or circuits to be provided, one system being for the closed centre valve or valves and the other for the open centre valve or valves and each system having a discrete fluid pressure source such as an engine driven pump. Such discrete systems are well known for hydraulic actuation of

control systems in vehicles where an open centre valve may be incorporated as part of a power assisted steering system to control the flow of hydraulic fluid to, for example, a power assistance ram while closed centre valves may be incorporated in a separate system to provide a power braking facility or a suspension system. The use of separate systems as aforementioned in a common installation such as a vehicle can be expensive but it ensures that adequate flow of fluid under pressure is available in each system to effect the operation which is required of that system and it is an object of the present invention to provide an hydraulic system which includes both open and closed centre valves, is economical and simple to manufacture and which can be arranged to provide flow of fluid under pressure to the respective valves from a common source to an extent which is sufficient to effect the operation or control which is normally intended of those valves.

According to the present invention there is provided an hydraulic system which comprises a first system part having an open centre valve; a second system part having a closed centre valve; flow divider valve means having two outlets which communicate one with each system part and by which is divided fluid flow from a common source of hydraulic fluid under pressure is directed to the respective system parts; said flow divider valve means being responsive to fluid pressure in the respective system parts and reacting to maintain substantially constant the fluid flow to the outlets respectively associated with the first and second system parts irrespective of the pressure differential developed between the fluid pressures in the first and second system parts and wherein the second system part includes relief valve means which is responsive to fluid pressure in that

system part to open that system part to exhaust at a predetermined fluid pressure.

While not being specifically directed to vehicle control or actuation systems, the present invention was primarily developed for such use where, for example, the open centre valve in the first system part may be used to control flow of fluid under pressure to an hydraulic ram of a power assisted steering gear while the closed centre valve of the second system part may be used to control the flow of hydraulic fluid under pressure to a pressure braking system or an hydraulic suspension. To effect the desired operation, the flow divider valve means will usually include a displaceable valve component which controls the divided fluid flow to the outlets. Preferably the divided fluid flow to the outlets is by way of respective restrictors which are carried by the displaceable valve component and associated one with each outlet so that the fluid flow to that outlet is achieved through the restrictor respectively associated with that outlet. In many applications it is envisaged that one or other of the first and second system parts will generally require a greater flow of hydraulic fluid under pressure than that which is provided for the other part and as a particularly advantageous optional feature of the present invention the two restrictors through which the divided fluid flow communicates with the respective outlets can be of relatively different sizes to provide a ratio which is other than one of the relative volumes of the divided fluid flow from the common pressure source for operating the respective first and second system parts. For example, in the aforementioned arrangement where a power assisted steering system and power braking system are provided it is likely that the power assistance facility which is incorporated in the

first system part will require greater flow of fluid under pressure than will the braking assistance facility provided by the second system part and thus the restrictor associated with the outlet for the first system part can be arranged to have less restriction characteristics than the restrictor associated with the outlet of the second system part to provide a required fluid flow ratio to the respective system parts. This ratio in fluid flow which is available, be it a ratio of one to one or otherwise, is maintained constant irrespective of operation of the flow divider valve means.

Generally the second system part will include an hydraulic accumulator which communicates with the closed centre valve, the accumulator being charged from the outlet associated with the second system part and by way of a non-return valve. In such a system the relief valve means will be responsive to fluid pressure in the accumulator and will react to open the second system part to communication with exhaust (reservior) at a position upstream of the non-return valve.

Conveniently the relief valve means is actuated by pressure differential and has a valve member which is responsive to fluid pressure in the second system part to react against a biasing force so that such reaction will open that system part to exhaust when the predetermined fluid pressure in that system part is attained. The biasing force of the valve member can simply be provided by a spring; alternatively or in addition the biasing of the valve member can be provided by fluid pressure which is derived from the second system part at a position in that system part which is opened by the relief valve means to communication with exhaust. In this latter arrangement and where the valve

member is responsive to fluid pressure in the accumulator as aforementioned, the biasing of the valve member may be provided by fluid pressure which is derived from the second system part at a position upstream of the non-return valve.

One embodiment of an hydraulic system constructed in accordance with the present invention and as applied to a vehicle control and/or actuating system will now be described, by way of example only, with reference to the accompanying illustrative drawings in which:-

FIGURE 1 schematically illustrates the system where the first system part is utilised in a power assistance steering facility and the second system part is utilised to provide an auxilliary service facility such as hydraulic braking assistance or suspension control, and

FIGURE 2 illustrates a modified relief valve which can be substitued for the relief valve which is incorporated in the system of Figure 1.

The hydraulic system illustrated has a constant flow engine driven pump 1 which draws fluid from a reservoir 20. The output of pump 1 passes by way of passage 21 to an input port 22 of a flow divider valve 23 having outlet ports 5 and 6 between which the fluid flow is divided within the valve 23. The outlet port 6 communicates with a first system part 24 which includes an open centre valve indicated generally at 25 forming part of a power assisted steering gear 26. The relationship between the valve 25 and gear 26 may be regarded as conventional whereby in a neutral condition of the valve 25 the power assistance steering gear is inoperative and fluid flow is permitted through the open centre valve from the port 6 by way of passage 27, the valve 25 and passage 28 to return to the reservoir 20.

The outlet port 5 communicates with a second system part 29 which includes a closed centre valve shown generally at 30. The port 5 communicates with the valve 30 by way of a passage 9 and this valve 30 controls flow of hydraulic fluid to actuate auxilliary services on demand, for example a brake booster system or a suspension control system of the vehicle. Since the closed centre valve 30 is normally closed to flow of hydraulic fluid therethrough there is included in its associated system an hyraulic accumulator 14 which is charged from the outlet port 5 through the passage 9 and by way of a non-return ball valve 15. Also included in the second system part 29 is a pressure relief valve 7 having an inlet port 12 which communicates with the outlet port 5 by way of passage 9 at a position upstream of the non-return valve 15. The relief valve 7 has an outlet port 8 which communicates by way of passage 31 with the passage 28 of the first system part and thereby with the reservoir 20. Communication between the inlet and outlet ports 12 and 8 of the relief valve 7 is controlled by an annular recess 32 in a spool 10 of the valve. The spool 10 is axially slidable in a spool cylinder and forms therewith opposed spool chambers 33 and 34 the former of which is in constant communication by way of passage 35 with the hydraulic accumulator 14 at a position in the passage 9 downstream of the non-return valve 15. Located in the spool chamber 34 is a biasing spring 11 which normally biases the spool 10 to a position in which the port 12 is closed by a spool land to communication with the port 8 and thereby with the reservoir or exhaust 20. The spool chamber 33 is responsive to variations in hydraulic pressure in the accumulator 14 and when this pressure attains a predetermined value the spool 10 will be displaced against the biasing of spring 11 so that the

the inlet port 12 opens to communication with the outlet port 8 by way of annular recess 32 and thereby with the reservoir 20. Consequently, when the accumulator 14 is fully charged the fluid flow from outlet port 5 can return to the reservoir 20; however, during or following a demand for fluid pressure from the accumulator 14, for example, by actuation of the braking system, and pressure in the accumulator decreasing, hydraulic pressure in the spool chamber 33 decreases accordingly so that the spool 10 closes port 12 under the biasing of spring 11 and the fluid flow from the outlet port 5 is available to recharge the accumulator 14 by way of non-return valve 15.

The flow divider valve 23 comprises a spool 36 which is axially slidable in a spool cylinder formed by a housing 2. The spool 36 forms with its cylinder axially opposed spool chambers 37 and 38 one with each of which, for practical purposes, the respective outlet ports 5 and 6 may be regarded as being in substantially constant communication. The spool 36 has an internal passage 39 which is in constant communication by way of annular recess 40 with the inlet port 22 and it is this passage which effects the division of fluid flow from the output of pump 1. The passage 39 includes a restrictor 3 through which it is in constant communication with the spool chamber 37 and also includes a restrictor 4 through which it is in constant communication with the spool chamber 38. It will be apparent that if the spool 36 is subjected to alternating fluid pressure differentials in the chambers 37 and 38 whereby the spool is caused to reciprocate, the chambers 37 and 38 will alternately and repeatedly expand and contract respectively.

In the use of the system and with both outlet ports 5 and 6 communicating with the reservoir 20,

fluid pressure in the spool chambers 37 and 38 will be substantially equal and the spool 36 will be centralised as shown. If it is now assumed that the open centre valve 25 is operated to actuate the power assistance steering gear 26 a demand for fluid pressure develops in the passage 24 to operate, say, the hydraulic ram of the gear 26. This demand causes fluid pressure to develop in the spool chamber 38 while spool chamber 37 maintains communication with the reservoir 20 so causing the spool 36 to be displaced leftwardly in the drawing to progessively close outlet port 5 until the pressure in chamber 37 equalises that in chamber 38 and the ratio of fluid flow is maintained through outlet ports 5 and 6. If however the power assistance steering gear is inoperative and the accumulator 14 discharges by operation of the closed centre valve 13, then port 12 of the relief valve 7 closed as previously described and there is demand for fluid pressure from the outlet port 5; this demand develops fluid pressure in the spool chamber 37 while port 6 communicates with the reservoir 20 so causing the spool 36 to be displaced rightwardly in the drawing to progressively close outlet port 6 until the pressure in chamber 38 equalises that in chamber 37 and the ratio of fluid flow is maintained through outlet ports 5 and 6. For practical purposes the spool 36 may be regarded as never fully closing either the outlet port 5 or the outlet port 6; the reason for this is that when one or other of these ports is being closed by the spool 36 the hydraulic pressure in the spool chamber 37 or 38 which is associated with the near closed port rises to an extent where it is approximately equal to the hydraulic fluid pressure which is available in the spool chamber associated with the fully opened outlet port and so the spool is no longer subjected to a fluid pressure differential and ceases its axial displacement. It will

be apparent that when the demand for fluid pressure by one or other of the systems parts is satisfied and both outlet ports 5 and 6 are again opened to communication with the reservoir 20, the fluid pressure in the spool chambers 37 and 38 will equalise as the spool centralises.

In the hydraulic system as above described it is realised that the volume demand for fluid flow to the power assistance steering gear 26 will likely be greater than the volume demand for such flow to actuate the auxilliary services by way of the closed centre valve 30. For this reason the normally required ratio of fluid flow between the two system parts can be determined by appropriate selection of the sizes of the restrictors 3 and 4 and it will be noted from the drawing that the restrictor 4 provides a far less restriction to fluid flow therethrough than does the restrictor 3. This ratio of fluid flow which is available through the restrictors 3 and 4 is maintained constant as required by the characteristics of the system and irrespective of the operation of the flow divider valve 23.

When both system parts 24 and 29 are operated simultaneously to meet respective fluid pressure demands the spool 36 of divider valve 23 will be displaced in the appropriate direction and in response to a fluid pressure differential in chambers 37 and 38 to make available greater fluid pressure in whichever of the system parts may require the greater demand.

The modified form of relief valve 7 shown in Figure 2 has a stepped diameter spool 10 with opposed end faces 16A and 16 of different effective pressurised areas of which the end face 16A with the larger effective area communicates with spool chamber 33 and the end face 16 with a smaller effective area communicates with the spool chamber 34 (within which is located the spring 11).

In addition the spool chamber 34 is in constant communication by way of branch passage 9a with the outlet port 5 and communicates with that port through passage 9 at a position upstream of the non return valve 15. Both spool chambers 33 and 34 are therefore responsive to hydraulic fluid pressure while chamber 34 is additionally biased by the spring 11. The modified relief valve 7 when substituted for the relief valve in the system of Figure 1 serves the same purpose as that valve. In the Figure 2 arrangement the port 5 communicates by way of annular recess 32 in the spool 10 with the passage 31 and thereby with the reservoir 20 and this is consistent with the accumulator 14 being fully charged since the hydraulic pressure in that accumulator reacts on spool end face 16A to retain the spool rightwardly in the Figure against the biasing spring 11 while spool chamber 34 communicates with the reservoir 20. When the accumulator 14 discharges to a predetermined extent there is a corresponding decrease in pressure in the spool chamber 33 which permits the spool 10 to be displaced leftwardly under its spring biasing to close port 12 and thereby effect pressurisation of the accumulator 14 as previously described. When the stepped diameter spool closes port 12 it will be apparent that the spool chamber 34 is pressurised by fluid flow at the outlet port 5 so additionally biasing the spool leftwardly in a sense to maintain the port 12 closed. Upon a predetermined pressure being attained in the accumulator 14 such pressure is applied to the spool chamber 33 causing the spool to be displaced rightwardly against the spring and hydraulic pressure in the spool chamber 34 (by virtue of the

differential areas of the spool end faces). During such rightward displacement of the spool the port 12 will again open to the recess 32 and thereby to exhaust (reservoir) to simultaneously open both the outlet port 5 and the spool chamber 34 to exhaust. The effect of this latter displacement and consequent de-pressurisation of the spool chamber 34 reduces the leftward biasing on the spool causing it to be displaced rightwardly in the Figure at a greater speed than that which would otherwise be achieved. Upon opening of the port 12 to the reservoir 20 it is possible to arrange for the stepped diameter spool 10 to snap to the right in Figure 2 thereby giving a relatively clean opening of the relief valve and alleviating fluid throttling; this should also alleviate possible hunting of the spool 10 as may occur in the relief valve of the Figure 1 arrangement.

CLAIMS

1. An hydraulic system which comprises a first system part having an open centre valve; a second system part having a closed centre valve; flow divider valve means having two outlets which communicate: one with each system part and by which divided fluid flow from a common source of hydraulic fluid under pressure is directed to the respective system parts; said flow divider valve means being responsive to fluid pressure in the respective system parts and reacting to maintain substantially constant the fluid flow to the outlets respectively associated with the first and second system parts irrespective of the pressure differential developed between the fluid pressures in the first and second system parts, and wherein the second system part includes a relief valve means which is responsive to fluid pressure in that system part to open that system part to exhaust at a predetermined fluid pressure.

2. A system as claimed in Claim 1 in which the flow divider valve means comprises a displaceable valve component which controls the divided fluid flow to the two outlets, and wherein two restrictors

are carried by said valve component so that the two streams of divided fluid flow communicate with the respective two outlets one through each of the two restrictors.

3. A system as claimed in Claim 2 wherein the restrictors are of relatively different sizes to provide a constant ratio other than that of one to one of the volume of fluid flow from the pressure source which is available to the respective outlets for the first and second system parts.

4. A system as claimed in any one of the preceding claims in which the flow divider valve means comprises a spool which is axially displaceable in a spool cylinder and has two axially opposed spool chambers which respectively expand and contract alternately in response to alternate fluid pressure differentials developing in the two spool chambers to impart axial reciprocation of the spool; said spool chambers being in constant communication with the divided flow from the fluid pressure source and the two outlets being associated one with each spool chamber, and wherein said outlets communicate with their respectively associated spool chambers under control of the spool so that when one spool chamber expands the outlet which is associated therewith is open to that chamber and the outlet which is associated with the contracting spool chamber is progressively closed and vice versa.

5. A system as claimed in Claim 4 when appendant to Claim 2 in which the divided flow communicates with the respective spool chambers by way of passage means in the spool and the two restrictors are carried by the spool to communicate with said passage means.

6. A system as claimed in any one of the preceding claims in which the second system part comprises an hydraulic accumulator which communicates with the closed centre valve and the outlet of the flow divider valve means to the second system part communicates with the accumulator by way of a non-return valve, and wherein the relief valve means is responsive to fluid pressure in the accumulator and reacts to open the second system part to communication with exhaust at a position upstream of the non-return valve.

7. A system as claimed in any one of the preceding claims in which the relief valve means is actuated by pressure differential and has a valve member which is responsive to fluid pressure in the second system part to react against a biasing force whereby that system part is opened to exhaust when the predetermined fluid pressure in that system part is attained.

8. A system as claimed in Claim 7 in which the biasing force on the valve member is provided by a spring.

9. A system as claimed in either Claim 7 or Claim 8 in which the biasing of the valve member is provided by fluid pressure derived from the second system part at a position in that system part which is opened by the relief valve means to communication with exhaust.

10. A system as claimed in Claim 9 when appendant to Claim 6 in which the valve member is responsive to fluid pressure in the accumulator and the biasing of that member is provided by fluid pressure derived from a position in the second system part which is located upstream of the non-return valve.

11. A vehicle which includes an hydraulic system as claimed in any one of the preceding claims in which the open centre valve of the first system part controls actuation of a power assisted steering gear and the closed centre valve of the second system part serves to actuate or control auxilliary hydraulic services such as power assisted braking or suspension.

12. A vehicle as claimed in Claim 11 when appendant to Claim 3 wherein the restrictor associated with the first system part provides less restriction to fluid flow therethrough than does the restrictor associated with the second system part.

Fig. 1

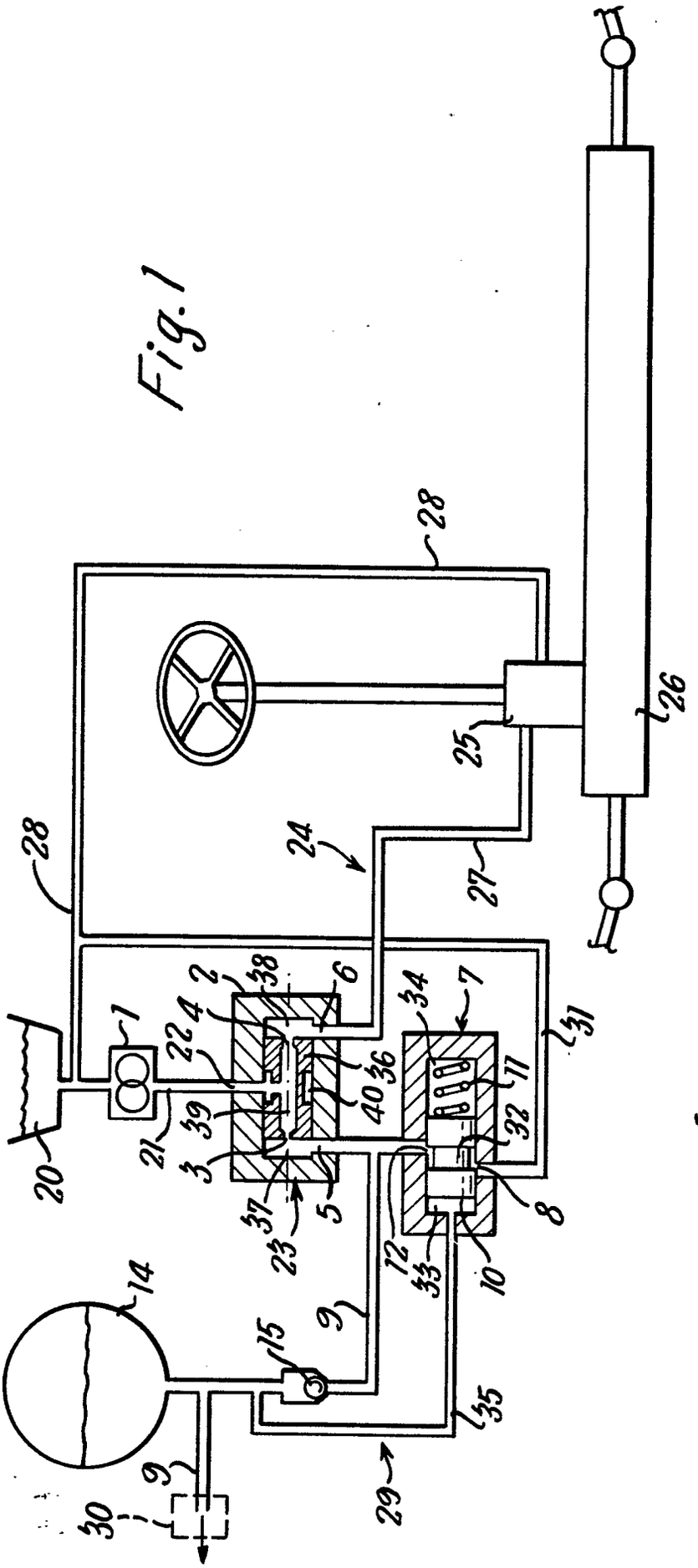
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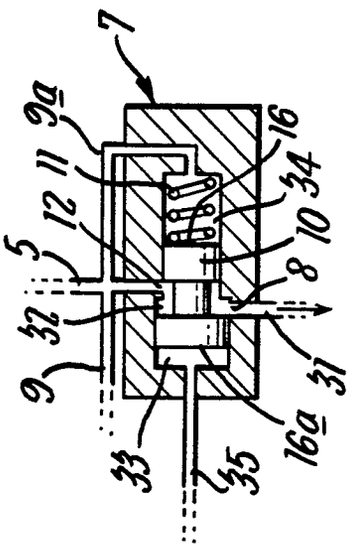
Fig. 2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European Patent Office

EUROPEAN SEARCH REPORT

0022661

Application number

EP 80 30 2344

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	FR - A - 2 329 879 (TRW) * The whole document * --	1-5,7, 8,11,12
	US - A - 2 799 996 (VAN METER) * Column 4, lines 3 to 38 * --	1-4, 6-8,11, 12
	US - A - 3 841 095 (BAKER) * Abstract * --	1-12
	GB - A - 1 414 114 (AISIN) * Page 1, lines 10 to 60 * --	1-12
	US - A - 3 640 301 (ZBIGNIEW) * Abstract * ----	1-12

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

F 15 B 11/16
13/02

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

F 15 B

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	08.09.1980	KNOPS

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