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D E C I S I O N
of 6 July 2005

Case Number: T 0834/03 - 3.2.1

Application Number: 95307363.2

Publication Number: 0708006

IPC: B60T 7/04, G05G 1/14

Language of the proceedings: EN

Title of invention:

Improvements in pedal assemblies for vehicle braking systems

Patentee:

Lucas Industries Limited

Opponents:

Robert Bosch GmbH
Continental Teves AG + Co. oHG

Headword:

-

Relevant legal provisions:

EPC Art. 54, 56

Keyword:

"Novelty (yes)"
"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 0834/03 - 3.2.1

D E C I S I O N
of the Technical Board of Appeal 3.2.1
of 6 July 2005

Appellant: Lucas Industries Limited
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Respondent: Robert Bosch GmbH
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Representative: -

Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 27 May 2003
revoking European patent No. 0708006 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: S. Crane
Members: J. Osborne
S. U. Hoffman

Summary of Facts and Submissions

- I. The appeal is directed against the decision posted 27 May 2003 to revoke European patent No. 0 708 006.
- II. The Opposition Division was of the opinion that the subject-matter of claim 1 as granted was not new in the light of the prior art document:

D17: DE-A-31 24 755.

The following prior art documents also played a role during the appeal:

D8: DE-A-2 327 508

D10: W. Krause et al, "Konstruktionselemente der Feinmechanik", Hanser Verlag, 1989, 307-09.

- III. During oral proceedings held 6 July 2005 the appellant requested that the decision under appeal be set aside and that the patent be maintained as granted (main request) or in the alternative maintained in amended form on the basis of the claims submitted as first and second auxiliary requests with the statement of grounds of appeal or the claim submitted as the third auxiliary request with a letter dated 30 June 2005. The respondents requested that the appeal be dismissed.
- IV. Claim 1 according to the appellant's main request (as granted) reads:

"An electronic braking system of the brake-by-wire type for a vehicle which includes a pedal assembly

comprising a brake pedal (3) and a master cylinder which includes a piston, said brake pedal acting upon the piston (76) of said hydraulic master cylinder through a push-rod (71), and further comprising a linear displacement transducer (80) which is adapted to produce a signal to an ECU in response to displacement of the brake pedal in a brake applying direction, characterised by further comprising a variable rate spring which in combination with the hydraulic master cylinder defines a feedback reaction means (10) so that feedback to the driver through the pedal provides a comfortable pedal feel."

Claim 1 according to the main request is followed by two claims defining features additional to those defined in claim 1.

V. The appellant's arguments in respect of the main request may be summarised as follows:

In the prior art according to D17 no linear transducer is present; the component indicated by means of chain-dotted lines in figure 1 is not referred to in the text and it is unclear what it is intended to represent. The conical spring illustrated in D17 furthermore does not clearly and unambiguously exhibit a variable rate as required by claim 1.

Claim 1 requires that the combination of the variable rate spring and hydraulic master cylinder act in combination to provide a comfortable pedal feel. As defined in the description of the patent specification "comfortable pedal feel" requires at least two of three components to be present in the braking assembly,

namely damping, hysteresis and variable system stiffness as displacement of the pedal increases. The damping and/or hysteresis requires movement of the piston in the master cylinder. In the prior art according to D8 the master cylinder is blocked during brake operation and is therefore unable to provide either damping or hysteresis.

As regards inventive step the closest prior art is that disclosed by D17. A pressure transducer for feeding a signal to the ECU is an essential feature of the system according to D17 and various embodiments relate to variations in the form of this transducer. The skilled person would have no incentive to overturn the detailed teaching of this document and replace the pressure transducer with a linear displacement transducer.

VI. In respect of the main request the respondents countered essentially as follows:

The document D17 discloses all features of claim 1. In particular, it is clear for the skilled person that the component indicated in chain-dotted lines in figure 1 is a linear transducer. It is stated in the description that the conical spring provides feel and the skilled person is aware that, as indicated in D10, a conical spring provides a variable rate.

Contested claim 1 has no feature which relates to either damping or hysteresis and the text to which the appellant refers in the description of the specification of the contested patent refers only to the prior art. D8 clearly discloses that a spring provided between the brake pedal and the master

cylinder should have a variable rate. There is no basis in D8 for the appellant's assertion that the pistons of the master cylinder are blocked during normal operation.

As regards inventive step, even if a linear displacement transducer is not disclosed in D17 it is a well known feature, for example in D8, and is a technical equivalent of the pressure transducer in D17. The pressure transducer is an indirect form of measuring pedal travel and, unlike a linear displacement transducer, has the disadvantage that it functions only when the system is pressurised. Moreover, the chain-dotted lines in figure 1 of D17 indicate a linear transducer as an alternative.

Reasons for the Decision

1. During operation of a conventional vehicle hydraulic braking system, the force applied to the brake pedal is transmitted directly by the hydraulic system fluid to the brake actuators and thus determines the applied braking effort. The pedal effort required from the operator therefore varies in proportion to the degree of braking required and can normally be sensed satisfactorily from the feel of the pedal. According to the description of the contested patent a good conventional hydraulic braking system is arranged to provide the driver with a comfortable pedal feel, action, and braking response, the feel comprising at least three distinct components, although any combination of two of them would also be effective. Firstly the driver feels a change in system stiffness as the demand or pedal displacement increases. Secondly,

the driver feels damping in the pedal action as the pedal is moved progressively through its travel. Finally the driver experiences hysteresis in the response of the system as the pedal is applied and released. These three elements are, within a conventional system, generated by a combination of hydraulic restrictions and damping as well as actuator stiffness and built-in hysteresis.

2. The present patent relates to an electronic braking system. In such systems when the brake pedal is depressed a sensor provides a signal to an electronic control unit (ECU) which operates valves to supply high pressure hydraulic fluid to the brake actuators. As a result, there is no feed-back from the brake to the pedal and it is desirable to build in resistance to operative movement which corresponds as closely as possible to the applied braking effort. According to the present patent the braking system comprises a variable rate spring which in combination with a hydraulic master cylinder defines a feedback reaction means so that feedback to the driver through the pedal provides a comfortable pedal feel.

Main request

Novelty with respect to D17

3. D17 discloses an electronic braking system for a vehicle in which the brake pedal is connected to a conventional master cylinder in a primary circuit. Upon depression of the pedal the master cylinder causes an increase in the pressure of the hydraulic fluid in the primary circuit. This pressure is measured by a

pressure transducer and the resultant signal is supplied to an ECU which controls a valve for delivery of fluid from a high pressure source to a secondary circuit containing the brake actuators. The pressure in the secondary circuit is also measured and a corresponding signal is supplied to the ECU which compares the two signals and on the basis of the comparison operates the valve to provide a brake servo action. The pressure of the hydraulic fluid in the master cylinder is transmitted to a travel path simulator in the form of a piston whose movement is opposed by a conical spring. According to the description the travel path simulator provides the driver with an improved braking feel and ensures a gentle ("gefühlvoll") increase in pressure. In figure 1 of D17, which is a schematic drawing of the braking system, chain-dotted lines show a symbol which is similar to one used elsewhere in the same drawing for an electrical pressure sensor but which additionally has a part apparently sensing movement of the pedal. The symbol is the only part of the drawing shown in chain-dotted lines, has no reference numeral, is not referred to in the text and is absent from the only other drawing which illustrates a pedal assembly.

- 3.1 The only disclosure in D17 relating to the spring in the travel path simulator is its illustration in the drawing which shows a conical spring. Whether a conical spring exhibits a variable rate depends on any variation in pitch and the possibility for the coils to nest. D10 does indicate that a conical compression spring may exhibit a progressive spring rate but there is neither consideration of other parameters of the spring nor any statement applicable to all conical

compression springs. Although it may be common that conical springs do exhibit a variable rate this is not necessarily the case and it cannot be determined with certainty whether the spring shown in D17 would exhibit a variable rate. The only stated performance requirement of the spring, to provide the "gentle" increase in pressure in the master cylinder, and therefore also in pedal force, could be achieved by means of a spring exhibiting a linear rate. Although the travel path simulator is intended to provide the driver with an "improved" braking sensation, this must be regarded in the light of the fact that during normal operation of the braking system according to D17 the hydraulic line fed by the master cylinder is closed by the valve and isolated from the brake actuators. As a result, in the absence of the travel path simulator the master cylinder would be effectively blocked and the driver would experience essentially no feel in the brake pedal. The use of the expression "improved braking sensation" therefore does not necessarily imply the same degree of feel as may be present in a conventional system. Moreover, it cannot be derived from D17 that its author intended the illustration of a conical spring to signify a variable rate since, as one of the respondents admits, one possible reason for providing a conical spring may be to ensure maximum travel of the piston of the travel path simulator by allowing the coils to nest. It therefore is not directly and unambiguously derivable from D17 that the conical spring exhibits a variable rate.

- 3.2 D17 also does not disclose that the pedal assembly comprises a "linear displacement transducer which is adapted to produce a signal to an ECU". The symbol in

chain-dotted lines is the only part of the drawing depicted in this way and there is no information available to the skilled person as to whether it is intended to form part of the braking system according to D17 and, if so, as to either its intended function or its association with the remainder of the system. Indeed, whereas in the system according to the contested patent the linear displacement transducer signals depression of the brake pedal to the ECU, in the system according to D17 this function is performed by sensing the rise in pressure in the primary circuit resulting from operation of the master cylinder, possibly in addition to a signal from a switch indicating movement of the pedal away from its rest position, and there remains no apparent need to additionally sense the travel of the pedal. The Opposition Division took the view that the term "linear displacement transducer" may be understood to mean simply a transducer for measuring a linear displacement which therefore comprises the pressure transducer in D17 which senses the pressure created by the master cylinder. However, displacement of the pedal could not be measured by the pressure transducer alone but only as part of a system also comprising the master cylinder. Contested claim 1, on the other hand, requires a linear displacement transducer in addition to the feedback reaction means formed by the spring and master cylinder in combination. It follows that the pressure transducer according to D17 cannot form a linear displacement transducer within the meaning of present claim 1.

- 3.3 On the basis of the foregoing the Board concludes that the subject-matter of claim 1 is novel with respect to the disclosure of D17.

Novelty with respect to D8

4. According to contested claim 1 the variable rate spring "in combination with the hydraulic master cylinder" defines a feedback reaction means so that the driver experiences a "comfortable pedal feel". It is clear from this wording that the master cylinder contributes to the provision of feel. As set out in 1 above "comfortable pedal feel" within the meaning of the term as used in the present patent comprises three components, namely damping, hysteresis and variable stiffness. Moreover, according to the description of the specification of the present patent, in the system of figures 6 and 7, which is the only one which falls within the scope of protection as sought, "the hydraulic master cylinder 75 builds in hydraulic damping, and hysteresis". It follows that, according to the subject-matter of present claim 1, and in consistency with the description, the master cylinder contributes to the provision of at least one component of feel in addition to the variable stiffness resulting from the variable rate spring.

4.1 D8 relates to an electronic braking system in which the pedal acts by means of a variable rate spring on the piston rod of a master cylinder. A linear displacement transducer senses compression of the spring and supplies a signal to an ECU which operates valves to supply high pressure hydraulic fluid to the brake actuators. Pistons in the master cylinder are held in their rest position by compression springs. During normal operation the high pressure fluid is in communication with, and therefore acts together with

the springs to essentially block, the master cylinder which is operative only in the event of a failure of the system to supply high pressure fluid. As a result of the combined action of the high pressure fluid and the springs in the master cylinder the pistons would undergo no significant movement and feel in the system of D8 is provided essentially only by the variable rate spring. It follows that in the system according to D8 the requirement of contested claim 1 that the spring acts in combination with the master cylinder to provide feel is not present.

4.2 The respondents reason that the only component of feel required by contested claim 1 is variable stiffness. This view ignores the fact that the claim itself requires that the master cylinder also contributes towards the provision of feel. Also in the single embodiment according to the invention the master cylinder provides two components of feel and the definition of "comfortable pedal feel" in the description supports the statement in claim 1 that feel is not restricted to the provision of variable stiffness.

4.3 The respondents further argue that the definition of "comfortable pedal feel" in the description of the contested patent relates only to the prior art and should not be used to interpret the claim. Whilst the expression "comfortable pedal feel" in the description of the contested patent is defined in the light of conventional systems there is no reason to place a different interpretation on the same expression when used elsewhere in the same patent specification.

4.4 The Board disagrees with the respondents' assertion that there is no basis in D8 for the conclusion that the pistons in the master cylinder are blocked during normal operation. In the penultimate paragraph of the description there is an explanation of the operation of the system as a conventional braking system in the event of failure of the system to supply high pressure fluid. In the final sentence of the paragraph it is stated that movement of the pistons comes about after a predetermined movement of the pedal has taken place, when the linear displacement transducer approaches the end of its travel and therefore when the variable rate spring has been compressed and is transmitting a relatively high load. It follows that no movement of the pistons would take place under normal operation during which pressurised fluid is supplied to the master cylinder as soon as the linear displacement transducer senses movement of the pedal.

4.5 On the basis of the foregoing the Board concludes that the subject-matter of claim 1 is novel also with respect to the disclosure of D8.

Inventive step

5. If D17 is considered as being the closest prior art for consideration of inventive step the subject-matter of claim 1 contains the following novel features:

- a linear displacement transducer which is adapted to produce a signal to an ECU in response to displacement of the brake pedal in a brake applying direction; and

- a variable rate spring which in combination with the hydraulic master cylinder defines a feedback reaction means so that feedback to the driver through the pedal provides a comfortable pedal feel.
- 5.1 As set out in 3 above, in the system according to D17 the valve is operated on the basis of a comparison of the pressures in the primary and secondary circuits. The pressure in the primary circuit is representative of driver demand. The prior art used as the starting point for D17 was that according to D8 in which, as already discussed in respect of novelty, the master cylinder normally is inactive and a linear displacement transducer is employed to provide a control signal representative of driver demand whilst an accelerometer provides a feedback signal to the ECU. D17 aims to simplify the system according to D8 by employing a master cylinder which is operative also in normal use to create pressure in the primary circuit which then serves as the control parameter representative of driver demand. A feedback signal representative of the pressure in the secondary circuit is also supplied to the ECU. Alternative embodiments provide various arrangements for the pressure transducers.
- 5.2 It would not be an obvious act for the skilled person aware of D17 and D8 to replace the pressure sensor in the primary circuit by a linear displacement transducer since that would reverse the teaching of D17. This is particularly so as the linear displacement transducer employed in D8 measures the relative movement between the pedal and the piston of the master cylinder, which movement does not exist in the system according to D17. The respondents take the view that the skilled person

acting on his general technical knowledge would replace the pressure transducer in the primary circuit according to D17 by a linear displacement transducer because the latter is a more direct measure of driver demand and therefore more reliable. However, creation of pressure in the primary circuit is a fundamental requirement of the braking system according to D17 and is necessary for operation of the braking system both normally and in the event of failure of the system to supply high pressure fluid to the brake actuators. Sensing movement of the pedal rather than the resultant increase in pressure therefore would not improve reliability of the system. The respondents also see the chain-dotted illustration in D17 as a suggestion that a linear displacement transducer may be employed as an alternative to the pressure transducer in the primary circuit. However, neither this illustration nor any other part of D17 provides any teaching as regards the significance of the symbol and its relationship with the remainder of the system. The skilled person unaware of the present patent therefore would derive no teaching as regards the provision of a linear displacement transducer adapted to supply a signal to the ECU.

6. The respondents alternatively argue that the subject-matter of contested claim 1 would be rendered obvious by a combination of D8 as closest prior art and D17. The subject-matter of claim 1 differs from the braking system according to D8 by the following feature:
 - the variable rate spring in combination with the master cylinder defines a feedback reaction means so

that feedback to the driver through the pedal provides a comfortable feel.

- 6.1 As already discussed in respect of novelty, the above feature requires that the master cylinder contributes towards the provision of feel. This is not the case in the system according to D8 because the master cylinder during normal use is blocked by the high pressure fluid and operates only in the event that the system fails to supply high pressure fluid. The novel feature solves the problem of improving the sensation of feel which the driver experiences through the pedal.
- 6.2 Although it may be that in the system according to D17 the master cylinder would contribute towards the provision of feel, the document is totally silent in this respect. As a result, the skilled person would receive no encouragement from D17 to modify the system according to D8. Indeed, since D8 forms the prior art for the teaching of D17, if the skilled person were to consider the teaching of the latter he would be encouraged not to modify the system of D8 but to discard it in favour of the system according to D17.
7. On the basis of the foregoing the Board concludes that the subject-matter of claim 1 according to the main request involves an inventive step (Article 56 EPC). Since claims 2 and 3 contain all features of claim 1 the same conclusion applies to those claims also.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The patent is maintained as granted.

The Registrar:

The Chairman:

A. Vottner

S. Crane