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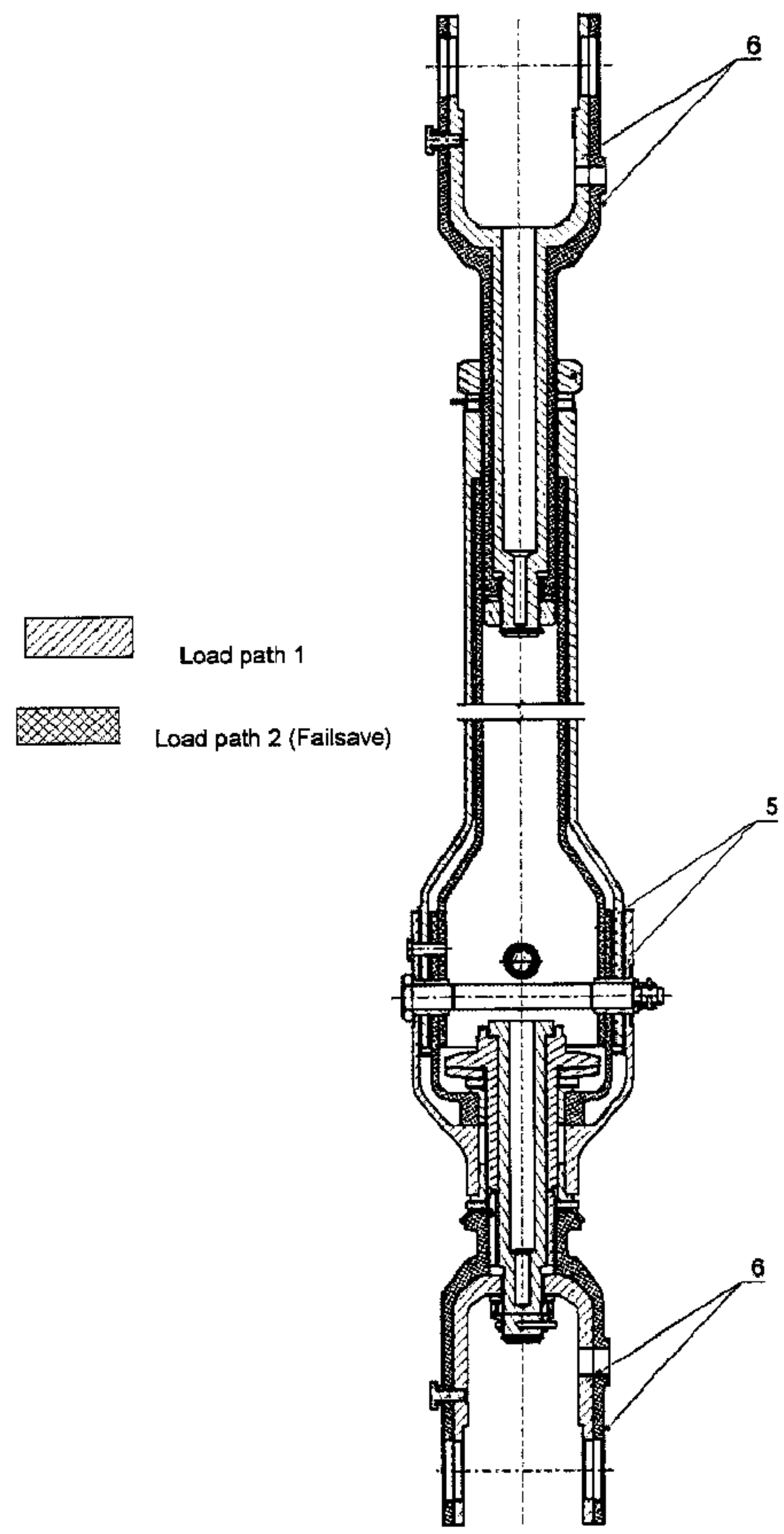
(54) **Titre : DETECTION DE DEFAILLANCE DE BARRES DE TRACTION-COMPRESSION AVEC CHEMIN DE CHARGE DE RESERVE**

(54) **Title: FAILURE DETECTION FOR PUSH-PULL RODS HAVING A RESERVE LOAD PATH**



(57) **Abrégé/Abstract:**

The invention relates to a fail-safe push-pull rod having two load paths that are separate from each other, of which always only one takes on the force transmission, which push-pull rod independently detects possible damage to or the functional failure of the first

(57) **Abrégé(suite)/Abstract(continued):**
load path, such that in such a case the second load path then takes over the force transmission, wherein the function switch from the first load path to the second load path can be detected during the routine maintenance checks by means of a checking bore that irreversibly indicates the damage to or the failure of the first load path.

Abstract

The invention relates to a fail-safe push-pull rod hawing two load paths that are separated from each other, of which always only one takes up the power transmission and which automatically detects possible damage to or functional failure of the first load path so that in such a case then the second load path takes over the power transmission, whereby the functional change from the first to the second load path can be determined during the routine maintenance inspection by an inspection hole irreversibly showing the damage or the failure of the first load path.

Failure detection for push-pull rods having a reserve load path

Description

In aircraft construction, components are required for a wide range of applications in safety-relevant areas, especially in the wings, which are fault-free and fail-safe or, in the event of damage, have replacement devices which, automatically recognising the failure of the damaged part of the component, will automatically and safely replace it, i.e. the function of which must be designed according to the "fail-safe" principle. In this context, "fail-safe" means that the component in question contains at least two equivalent systems which can fulfil the specified task of the component, whereby only one of the two systems may ever come into play. If the first system fails, its function must be automatically taken over by the second system on an equivalent basis. It is particularly important here that the failure of the first system can be automatically detected and repaired by the component.

These requirements apply in particular for the push-pull rods which are frequently used in aircraft construction and which are subject to particular stress because of the strong and frequently changing loads, so that total failures as a result of material fatigue or overloading must be excluded.

At the moment, these requirements are met by the fact that, with frequent maintenance intervals, as a precaution after a defined period of use, the push-pull rods are routinely replaced or removed, disassembled, tested, re-assembled and re-installed which, however, naturally involves considerable effort and cost.

The push-pull rods that are common in particular in aircraft construction are available in various versions, such as those described, for example, in DE 202004016321. As a rule, these tubular single-wall bodies are made from light alloy, titanium or carbon-fibre reinforced plastic, provided at each end with a single-layer yoke or eye made from light alloy.

The task of the invention was therefore to provide a fault-free and fail-safe push-pull rod with an initially non-effective back-up system which automatically detects damage or function failures and automatically repairs them on the one hand and on the other hand displays the assumption of function by the back-up system clearly and easily recognisably so that during routine maintenance inspections it can be checked for function with little expenditure of time and money and replaced if necessary. This task was solved as follows.

Because, according to the logic of the fail-safe principle this can only, by its very nature, be achieved if in each case only one defined load path takes up the loads, the push-pull rod must be designed in such a way that it has two load paths working separately from each other which are placed in relation to each other in such a way that only one load path takes over the power transmission in each case and that the second load path only assumes this task if the first load path fails. The term "load path" under the terms of the invention is understood to be the totality of the separate parts of the push-pull rod which are intended to take the forces working on it. These are the tubular body and the yoke ends affixed on both sides of the body.

The aim of the invention, i.e. on the one hand to ensure failure safety by automatic detection of damage and automatic repair thereof and on the other hand to make the failure of the first system detectable externally is achieved by the fact that the tubular body and both yokes are given a double-wall (double-layer) construction. Both walls (layers) can be made from the same usual materials such as light alloy, titanium or carbon-fibre reinforced plastic. The layout of the two walls or two layers must be such that the layer forming the load path 1 is positioned in the yoke inside but in the tubular body outside, whereas for the layer forming load path 2 (component 2), it is exactly the reverse. The layer in the yoke outside forming load path 2 separates, in the transition area between the tube and yoke, the layer of load path 1 (component 1) in the yoke inside from the layer of load path 1 (component 1) in the tube outside. This layout has been chosen in this way because by choosing the inside of the yoke for load path 1, this can easily be detected in the event of failure. The same applies for the choice of the outside of the tubular body for load path 1.

To guarantee that only one load path is ever used, the connection of the power transmission must be carried out as follows. In both yokes and in the tubular body of the push-pull rod on both sides diagonally a hole D1 (7) and D2 (8) is made in each case through the load paths 1 and 2 (components 1 and 2) through which on both sides a bolt 9 passes which serves to transmit power and the thickness of which depends on the likely load. The hole 7 is made with a slightly smaller diameter (approx. 0.5-1mm) than hole 8 so that the forces arising are transmitted firstly only via hole 7 with the smaller diameter through the force-fitting contact to load path 1 (component 1). This structure is absolutely essential since only in this way is the detection of any later failure of the first load path (component 1) possible, with the (back-up) load path 2 (component 2) initially not being subjected to any load.

After the automatic detection of the failure of load path 1 (component 1) as a result of damage, the deployment of load path 2 (component 2) is carried out by the system automatically. Through the failure of the power take-up by load path 1 (component 1), the application of the force F on hole 7 means that component 1 shifts in relation to component 2. The movement is ended as soon as the diameter of hole 7 has reached the diameter of hole 8 with the result that now only component 2 i.e. load path 2 takes up the force through the force-fitting contact with hole 8.

A further important part of the invention is now that, in the regular maintenance inspections, the failure of the component or load path 1 can also be detected by the maintenance engineer, so that the replacement then required can be carried out. This is done in a surprisingly simple way by means of inspection hole 3 with a diameter of approx. 4-6mm and using the test mandrel 4, which is necessarily part of the maintenance engineer's tool kit. Through the displacement of component 1 in relation to component 2, the application of force F deforms inspection hole 3 such that the test mandrel 4, which fits the inspection hole precisely in the undamaged condition, can no longer be inserted by the maintenance engineer into the inspection hole 3 of components 1 and 2 because of the irreversible deformation.

The precondition for this is that the inspection hole 3 is made as a sleeve with a very small wall thickness, Furthermore, this must consist of a very ductile material (such as grade 1 titanium or austenitic stainless steel) with a low strength. This thus ensures that even under a low force application F a permanent deformation of inspection hole 3 occurs which can be detected from outside by a test device.

In this way, the failure of load path 1 can be clearly detected from outside during maintenance and the replacement of the push-pull rods because of the failure of load path 1 can be arranged.

The invention is explained in the following in more detail using a preferred embodiment.

Figure 1 shows a complete push-pull rod, consisting of the tubular body 5 and the yokes 6, these in turn consisting of the components 1 and 2, each forming load path 1 and load path 2 respectively. For easier recognition, the components of load path 1 are diagonally hatched in the yoke and tubular body, and those of load path 2 are cross-hatched.

Figure 2 shows yoke 6 with hole D1 (7) and hole D2 (8) together with the power-transmitting bolt 9, which is connected with hole D1 (7) preferably via a force-fitting clearance fit. Here, the hole D1 (7) is slightly smaller than hole D2 (8). In addition, Figure 2 shows inspection hole 3, which serves to show that component 1 is damaged and thus the failure of load path 1.

Figure 3 shows the structure of tubular body 5, together with hole D1 (7) which also has a slightly smaller diameter than hole D2 (8), however with the proviso that now component 1 (load path 1) is outside and component 2 (load path 2) is inside. In addition, Figure 3 shows inspection hole 3, which serves to show that component 1 is damaged and thus the failure of load path 1.

Figure 4 shows inspection hole 3 in the damaged state. Here, because of the failure of load path 1, D1 is pushed over to hole D2. This causes the permanent deformation of inspection hole 3.

Figure 5 shows inspection hole 3 in the damaged state together with the test mandrel 4 during the inspection. It can now be seen here that the test mandrel 4 can no longer be inserted into inspection hole 3. The failure of load path 1 is thus clearly detected.

Figure 6 shows inspection hole 3 in the undamaged state. Here, the test mandrel 4 can be inserted into inspection hole 3 as far as it will go. This ensures that load path 1 has not been damaged.

Legend

1. Component 1 (load path 1)

2. Component 2 (load path 2)

3. Inspection hole

4. Test mandrel

5. Tubular body

6. Yoke

7. Hole D1

8. Hole D2

9. Bolt of hole D1/D2

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CLAIMS:

1. Double-wall push-pull rod made from light alloy, titanium or carbon fibre-reinforced plastic with a layer forming load path 1, which is located in the yokes of the push-pull rod inside and in the tubular body outside, and a layer forming load path 2, which is located in the yokes outside and in the tubular body inside, whereby the layer located in the yokes outside forming load path 2 separates, in the transition area between the tubular body and the yokes, the layer of the load path 1 located in the yokes inside from the layer of load path 1 located in the tubular body outside, and in the yokes and the tubular body of the push-pull rod on both sides diagonally a hole is made through both layers in each case of the push-pull rod through which bolts lead with the purpose of power transmission, wherein the hole D1 has a 0.5 to 1 mm smaller diameter than the hole D2 and the bolt in the original stage has only force-fitting contact with the hole.

2. Push-pull rod according to Claim 1 wherein in addition, alongside the holes D1 and D2 in the tubular body and in the yokes of the push-pull rod, an inspection hole is inserted through both layers as a sleeve with a very low wall thickness made from very ductile material such as titanium or low-strength steel and thus, even with a small application of force, is irreversibly so deformed that a precisely fitting test mandrel can no longer be inserted into the inspection hole.

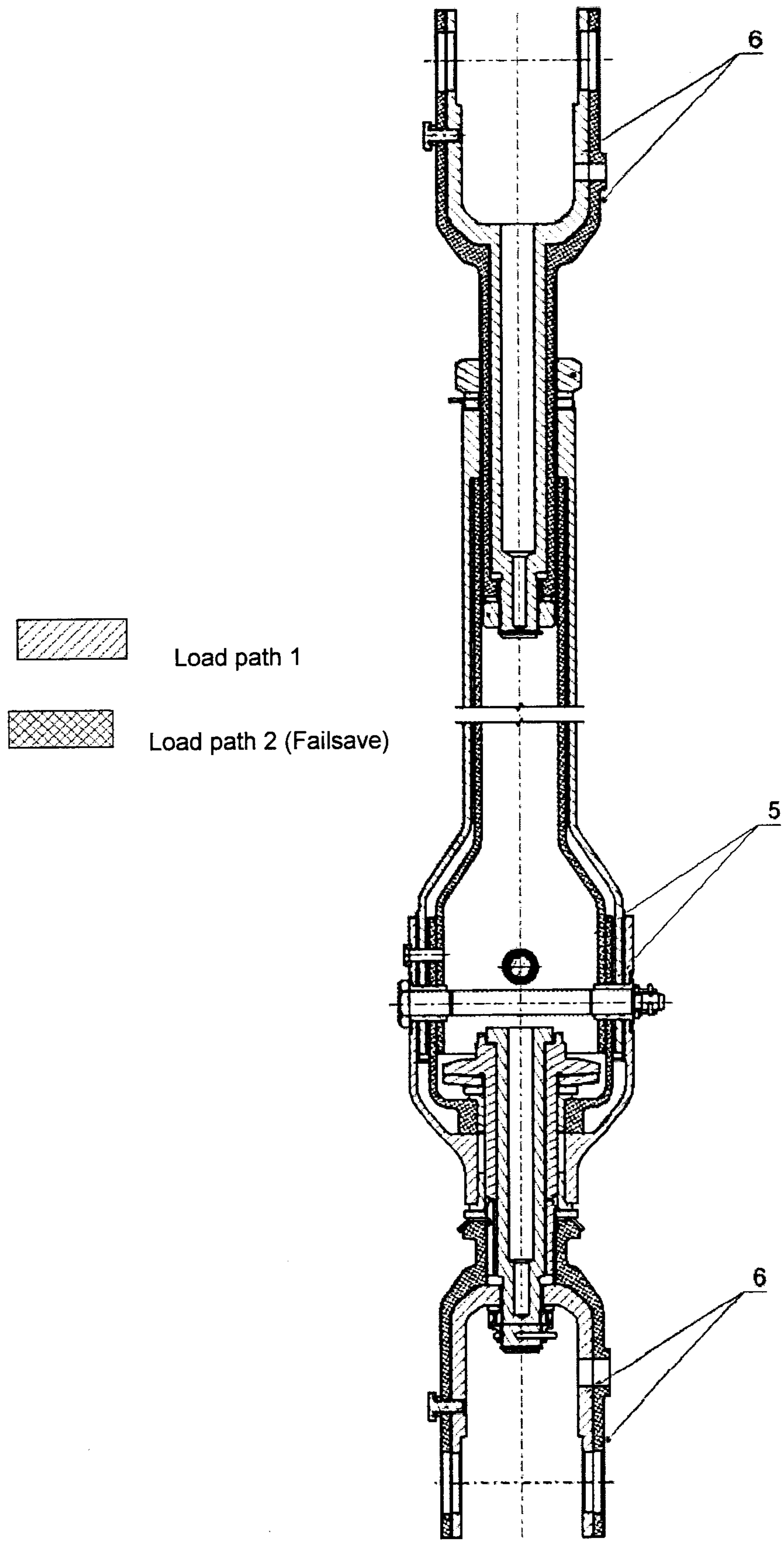


Figure 1

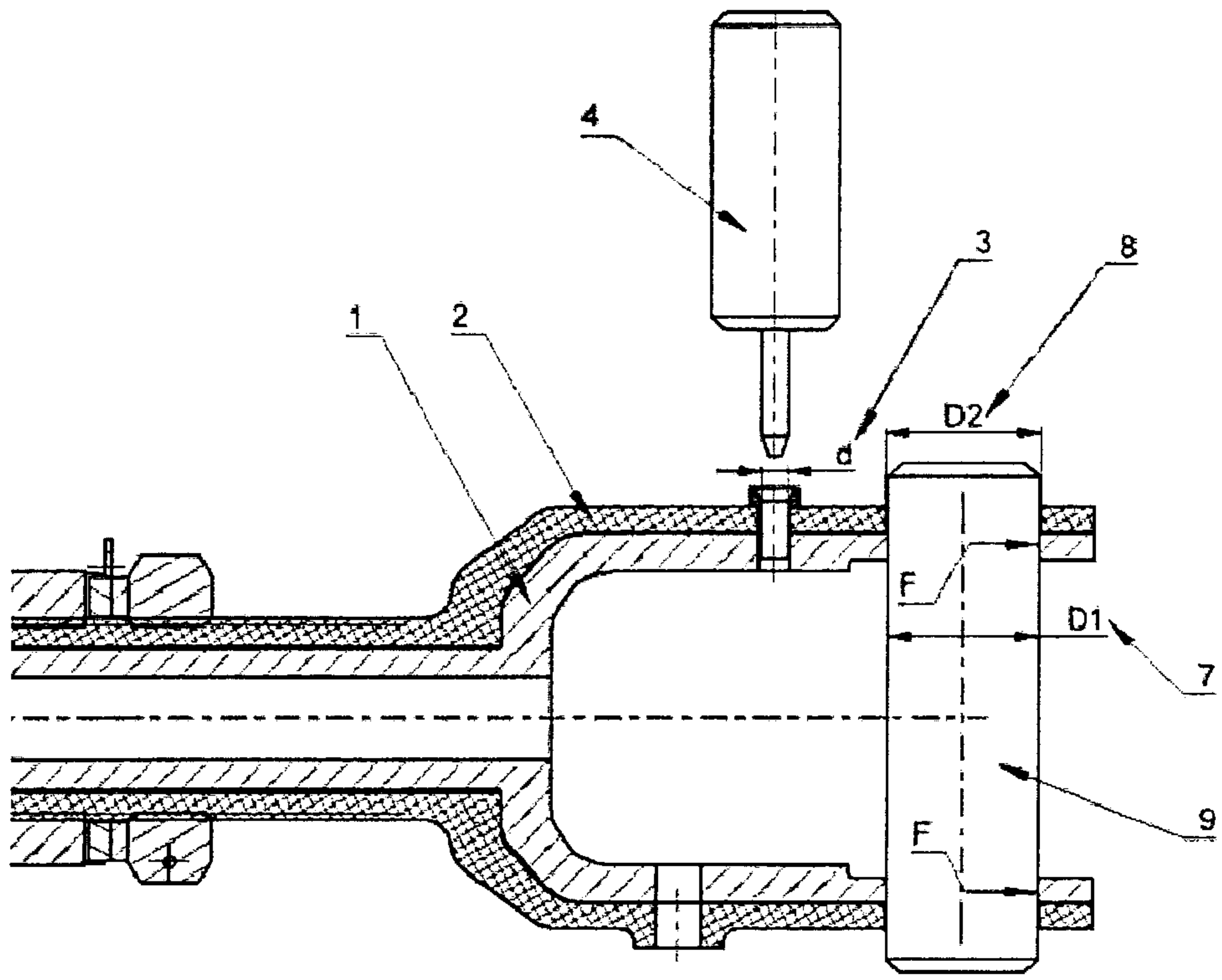


Figure 2

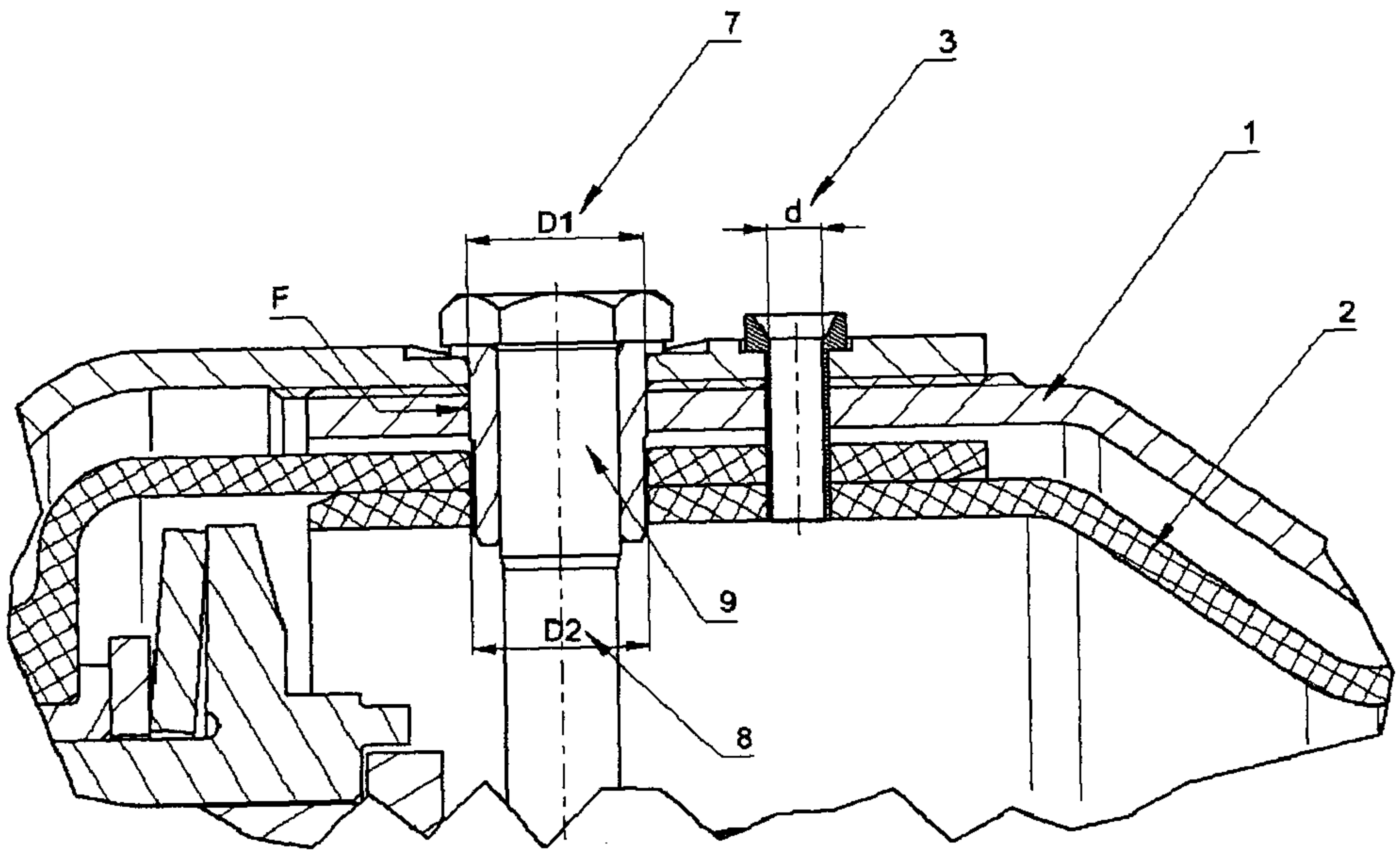


Figure 3

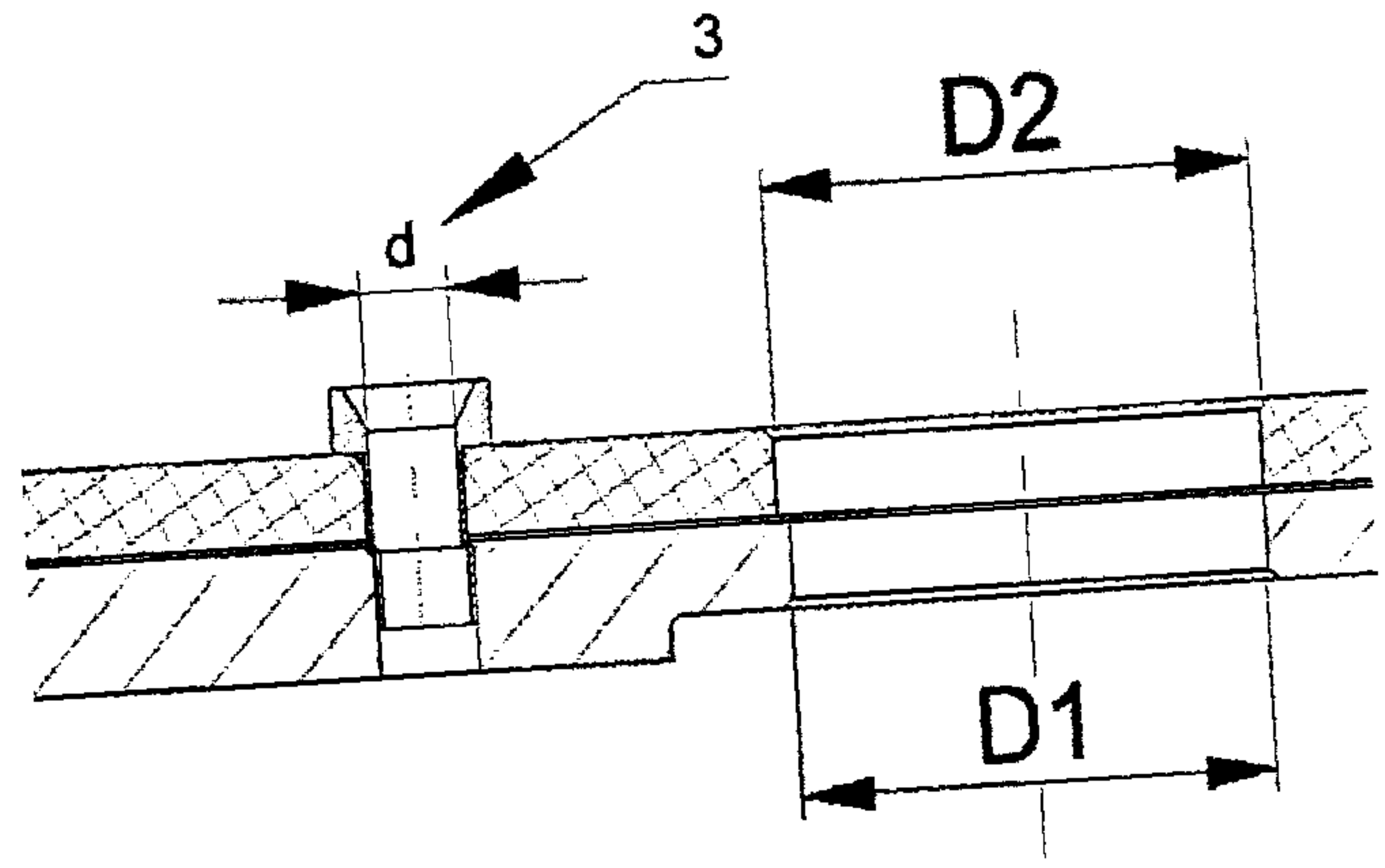


Figure 4

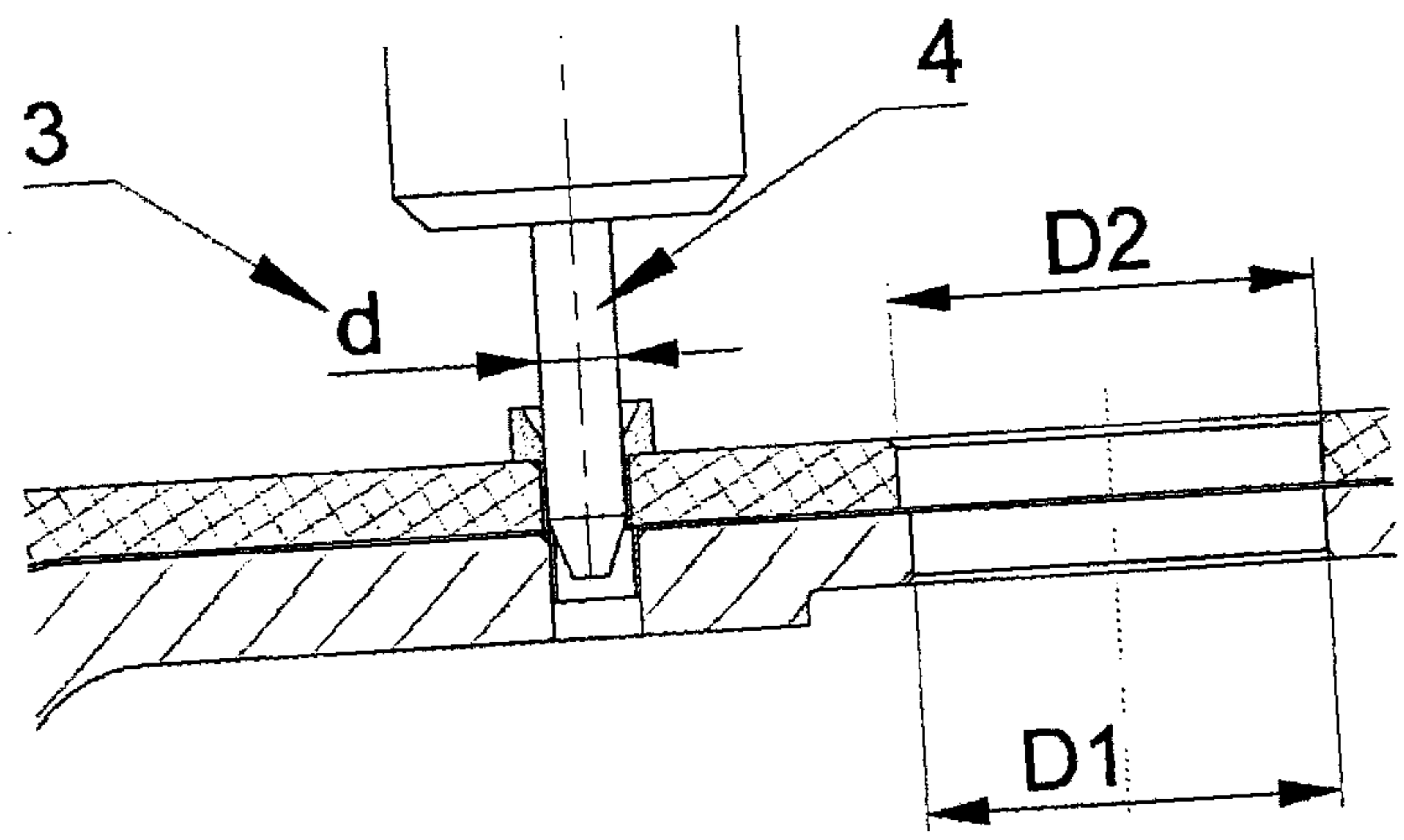


Figure 5

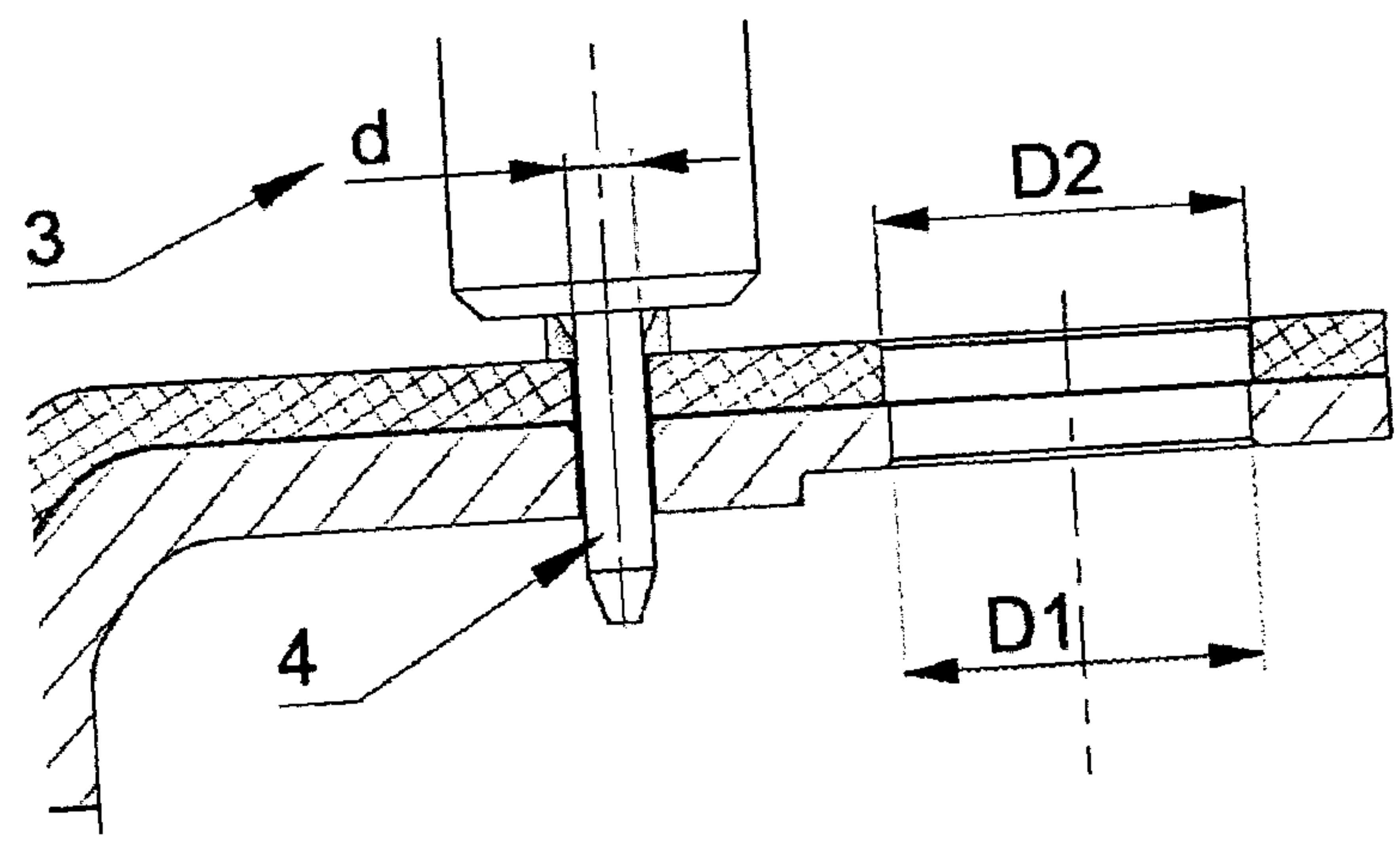
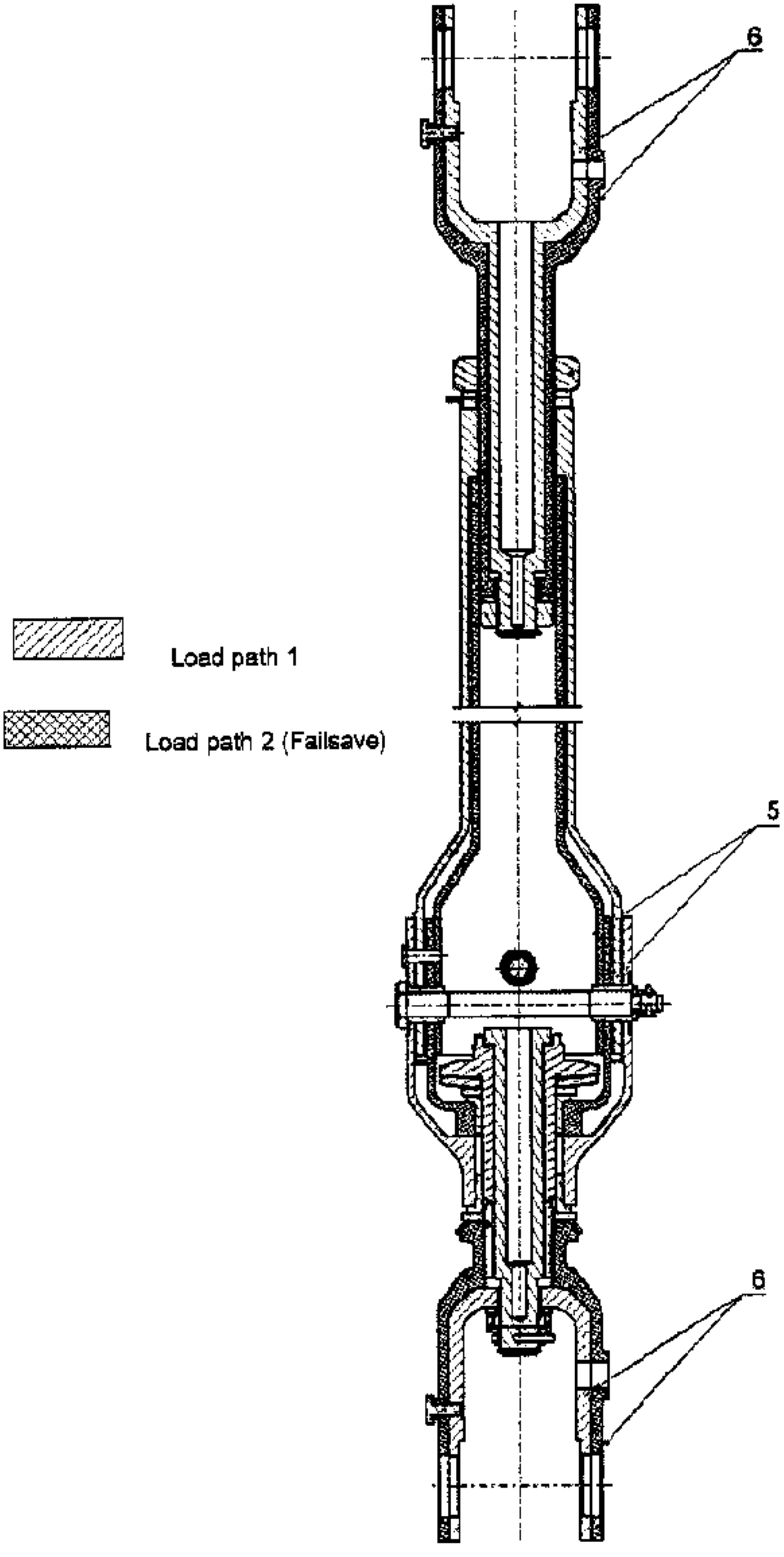


Figure 6


6
Load path 1
Load path 2 (Failsave)
5
6