(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 133 704**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 84109483.2

(51) Int. Cl.⁴: B 21 D 39/00

(22) Date of filing: 09.08.84

(30) Priority: 10.08.83 JP 144960/83

(43) Date of publication of application:
06.03.85 Bulletin 85/10

(84) Designated Contracting States:
CH DE FR GB IT LI NL SE

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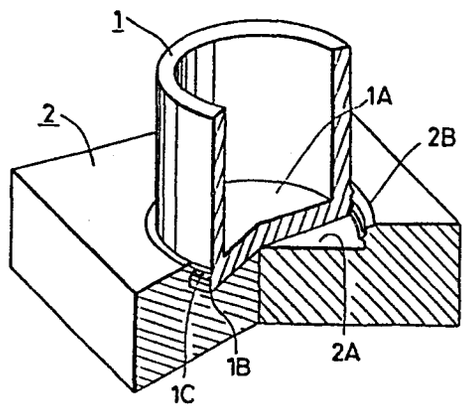
(54) Connecting structure for two members.

(57) A cylindrical member (1) is fitted into a recess formed in a surface of a flat member (2) which is placed opposite one end of said cylindrical member.

Preferably, a plurality of annular grooves (1B) are formed in the surface of one end portion of the cylindrical member (1) and the bottom of the grooved portion is provided with knurled portion (1C). A portion of the flat portion placed in the vicinity of the grooved portion is pressed in the axial direction of the cylindrical member (1) and a portion of the flat member (2) is plastically deformed into the grooved and knurled portion of the cylindrical member (1), whereby the cylindrical member (1) is connected to the flat member (2) with a butt joint.

FIG. 1



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Title of the Invention

Connecting Structure for Two Members

Background of the Invention

(Field of the Invention)

This invention relates to a structure of connecting two members, and more particularly to a structure of connecting two members which is suitable for use in connecting a preferably cylindrical member and a preferably surface-contact member to each other with a butt joint.

(Prior Art of the Invention)

Butting a cylindrical member against a flat member and then plastically deforming some metal interposed therebetween to connect these members together is also known, it is disclosed in Japanese Patent Laid-open No. 150,761/1979. According to this prior art, an annular groove of a width greater than the wall thickness of the cylindrical member is formed in the butting surface of the flat member, and annular connection grooves are formed in the inner circumferential surface of the groove in the flat member and the outer circumferential surface of the joint portion of the cylindrical member. A metal piece which has a deformation resistance lower than those of the materials of the two members being connected together is inserted into the connection grooves, and local deformation pressure is

applied thereto in the vertical direction to plastically deform the metal piece and thereby combine the two members. This kind of method increases the strength with which the members are sealed together, so that a comparatively good effect can be obtained easily when attaching a base cover, etc. However, the use of a support block holding the outer circumferential surface of the base cover is necessary, but this is inconvenient in that it reduces productivity, so this structure is not suitable for connecting a cylindrical part perpendicularly to another member.

Summary of the Invention

(Object of the Invention)

An object of the present invention is to provide a structure of connecting two members which enables the economy of materials to be used and the improvement of the gastightness between members.

Another object of the present invention is to provide a structure of connecting two members which enables the easy and reliable connection of a cylindrical member perpendicularly to a flat or cylindrical member.

(Feature of the Invention)

The present invention is characterized in that a first member is fitted into a recess formed in a surface of a second member which is placed opposite one end of said first

member, at least one annular groove is formed on a surface of either of said first member or said second member, and a portion of said first member or said second member is plastically deformed into said at least one annular groove by pressing locally in the axial direction the connecting portion of said first and second members, whereby said first and second members are connected together by the binding force generated in that the section of said one of said members surrounding said grooved portion.

Brief Description of the Drawings

The accompanying drawings show embodiments of the present invention, wherein:

Fig. 1 is a partially-cutaway view of a flat plate and a bottomed cylindrical part connected together;

Fig. 2A is a section through the parts of Fig. 1, illustrating the method of their connection;

Fig. 2B is an enlarged view of a principal portion of Fig. 2A;

Fig. 3 is a partially-cutaway view of a bottomed cylindrical part used in another embodiment of the present invention;

Fig. 4 is a partially-cutaway view of parts connected by a third embodiment of the part-connection method of the present invention;

Fig. 5 is a section through a crankshaft to which the present invention is applied;

Detailed Description of the Preferred Embodiment

Figs. 1 and 2 show an embodiment of the structure of connecting two members according to the present invention, by which a bottomed cylindrical part and a flat part are connected together with a butt joint.

Referring to the drawings, a first cylindrical part 1 is provided with a bottom 1A and is formed in the shape of a cup by, for example, cold pressing an iron blank. The first member 1 is provided with at least one continuous groove 1B annularly around the outer circumferential surface of an end portion thereof. The bottom of the groove is provided with a plurality of continuous bumps and indentations 1C and the grooves are preferably formed to be positioned in the portion of the outer circumferential surface of the part 1 which is between the upper and lower surfaces of the bottom 1A thereof. The bumps and indentations 1C are formed by making annular grooves (of a W-shaped cross section) of an angle of incidence of about 30° in that portion of the first member 1, and then knurling the crest of the ridge defined by the grooves. A second member 2 is made of an aluminum material (with a deformation resistance of 8-10 kg/mm^2) or a copper material, for example, the deformation resistance of which

is less than that of the first member 1 (which has a deformation resistance of 40-60 kg/mm^2). A recess 2A of a diameter d_1 (with a fitting tolerance of 1/100-5/100 mm), substantially equal to the outer diameter D_1 of the first part 1, is provided in an end surface of the second member 2.

The two members of this structure are connected together in the following manner. The bottom 1A of the first member 1 is first fitted into the recess 2A in the second member 2, as shown in Fig. 2(A). When the members 1, 2 are arranged in this way the annular grooves 1B face an inner circumferential surface 2B of the recess 2A, so that the outer circumferential portion of the joint portion of the first member 1 is surrounded and held by the second member 2.

A cylindrical metal mold 3, which is moved down by a press (not shown), is then slid down over the outer circumferential surface of the first part 1 so that a male tooth 3A thereof presses into the upper surface of the second member 2 in the vicinity of the inner circumference thereof, as shown in Fig. 2(B). Consequently, the second member 2, made of a softer material, flows plastically into the spaces formed by the grooves 1B. In other words, the bumps provided on the harder member such as the first member eat into the softer member such as the second member, so that the softer member is deformed plastically and locally by the bumps, and is connected with the harder member with a large binding

force, because of the elastic stresses generated in the softer member. The metal mold 3 is then removed to complete the operation. As shown in Fig. 2(b), the male tooth 3A is so formed that the inner surface thereof extends linearly along the outer circumferential surface of the first member, with the outer surface thereof inclined at an angle θ of about 6° with respect to the direction in which the metal mold 3 is slid along the first member. The outer surface of the male tooth 3A is inclined at the angle θ to enable the easy removal of the metal mold 3, but this is unnecessary if the male tooth is narrow.

As shown in Fig. 2(A), each portion is formed so as to meet following equations:

$$L \geq H \qquad (1)$$

$$0.6W \leq b \leq W \text{ , preferably } b = 0.8W \qquad (2)$$

$$0.8b \leq h \leq b \qquad (3)$$

$$0 \leq S \leq \frac{3}{4}b \qquad (4)$$

Wherein

L : width of the bottom portion of the first member

H : depth of the recess formed in the second member

b : width of the recess

W : width of the groove

h : depth of the recess

ℓ : length of the end portion of the groove from the bottom portion of the first member

S : distance between the end portion of the groove and the bottom surface of the recess

The depth "h" over which the second member is pressed varies with the pressure, but it should preferably be pressed as far as a position close to the inner edge ℓ of the grooves 1B, and it should not be pressed beyond the ridges.

$$h \leq \ell$$

According to a preferred embodiment of the invention, first and second members are connected in following steps:

Connecting two member wherein a first cylindrical member and a second member placed opposite one end of said first member are connected together, fitting an end portion of said first member into a recess formed in a surface of said second member, in such a manner that outer and inner circumferential surfaces of said end portion of said first member are substantially held by said recess in said second member or by said first and second members; and pressing locally in the axial direction a portion of either said first or second member which is in the vicinity of the joint portion thereof so that it is plastically deformed into an indented portion of that part, so that said first and second members are connected together by the binding force generated in that the section of said one of said members surrounding said indented portion.

According to this embodiment, the end portion of a first

cylindrical part 1 can be easily fitted perpendicularly into a recess 2A in a second part 2 without the use of a special support block. This connecting structure is especially useful for connecting members that do not pass through each other, and enables a highly-accurate hermetic connection of such members. In this structure the joint portion of the softer member flows into spaces between projections provided on the harder member, and is deformed plastically and locally thereby. Consequently, elastic stresses are generated in the deformed softer member, so that the softer member is connected with the harder member with a large binding force, and the connected product thus obtained has an extremely good resistance to rotary torque and pull-out forces. Since this structure is obtained at room temperature from beginning to end, the members being connected are not influenced thermally unlike welded or soldered members. This means that the connected members can remain in a stably-connected state semipermanently.

In the above embodiment, an iron material is quoted as an example of a harder material, and aluminum or copper as an example of a softer material, but the material of the member which is most pressed can be any softer material. When both the first and second members being connected are made of iron, for example, the first member could be hardened in advance. As previously mentioned, the first member could be formed as a cylinder by the cold pressing. In such a case,

the material is hardened naturally, so that that member need not be specially hardened.

Fig. 3 is a partially-sectioned view of a principal portion of a cylindrical member which is to be connected by another embodiment of the method accorcing to the present invention. The cylindrical member is substantially in the shape of a cup in the same way as the cylindrical member of the previous embodiment, but of a plurality of annular grooves 11B are provided in the portion of the outer circumferential surface thereof which corresponds to the depth of a bottom 11A thereof. The connection structure applied to this member does not differ in any way from that applied to the cylindrical member of the previous embodiment, but it is effective when applied to a member which requires a higher resistance to pull-out forces, this member is connected to another in the rotational direction by only a frictional engagement.

Fig. 4 is a partially-sectioned view of members connected by a third embodiment of the structure according to the present invention. The characteristics of this embodiment reside in that a collar 12B is formed around the outer circumferential surface of the bottom of a cylindrical member, and an indented portion 32C is formed in an inner circumferential surface 32B of a recess 32A in a second member 32 which faces the collar 12B. The collar 12B is fitted into the recess 32A in the second member 32 and is then pressed axially by a metal mold,

so that the material of the collar flows plastically and locally into the indented portion 32C, connecting the two member together firmly. Accordingly, the joint portion of the first member 12 must be made of a material that is softer than the material of the joint portion of the second member 32, but the binding force of this material is in no way less than that of the softer members used in the previous embodiments.

Fig. 5 illustrates the structure according to the present invention when applied to a crankshaft of an internal-combustion engine, such as the engine of a motorcycle. Referring to the drawing, a solid shaft 15 provided with straight splines 15A and an end thread 15B is attached to one surface of an iron flange 34 so that the shaft 15 extends at right angles to the surface of the flange 34. Another solid shaft 16 is attached to the other surface of the flange 34 in a stageered manner with respect to the shaft 15. The connection structure applied to these members is exactly the same as that used in the previous embodiments, but the solid shafts 15, 16 attached to the iron flange 34 are of hardened steel.

According to the embodiment, complexed parts such as crack shaft are separated into a plurality of simple member and then each member is plastically deformed each other with a butt joint, whereby productivity is improved.

Patent Claims

1. A connecting structure for two members comprising a first member (1) and a second member (2) placed opposite one end of said first member, said first member being fitted into a recess (2A) formed in a surface of said second member (2), at least one annular groove (1B) is formed on a surface of either of said first member (1) or said second member (2), and a portion of said first member (1) or said second member (2) is plastically deformed into said at least one annular groove (1B), whereby said first and second members are connected together by the binding force generated in the section of said one of said members surrounding said grooved portion.

2. The connecting structure for two members according to claim 1, wherein said first member (1) is a bottomed (1A) cylindrical part provided with annular grooves (1B) around the outer circumferential surface of an end portion thereof, said grooved end portion thereof is fitted into said recess (2A) in said second member (2), said second member is pressed locally in the axial direction along the outer circumferential surface of said first member (1) so that it is deformed plastically into the grooved portion of said outer circumferential surface of said first member, whereby said second member is connected with said first member.

3. The connecting structure for two members according to claim 1, wherein said first member comprising a bottom and a collar (12B) is fitted into said recess (32A) formed in said second member (32), said collar (12B) is pressed locally in the axial direction so that it is plastically deformed into said groove[illegible] formed in the

inner circumferential surface of said recess (32A) in said second member (32), whereby said first member is connected to said second member.

4. The connecting structure for two members according to any one of claims 1-3, wherein said grooved portion is provided with indented portion (1C, 32C) at the bottom thereof.

FIG. 1

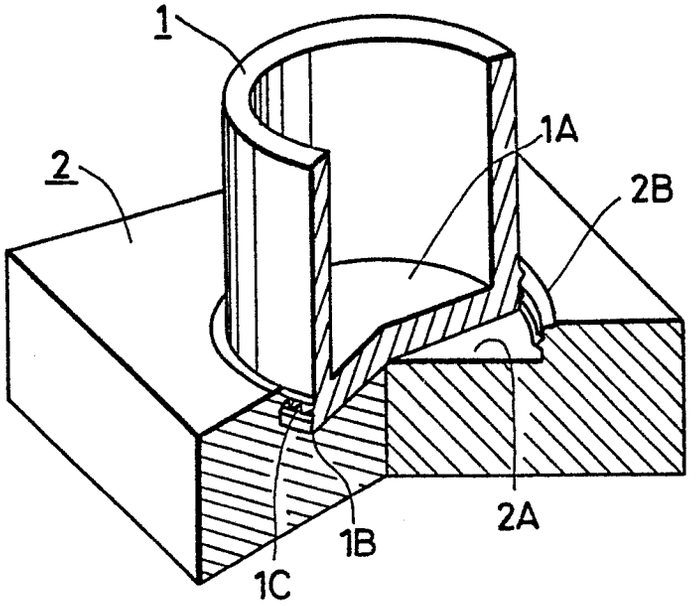

FIG. 2A

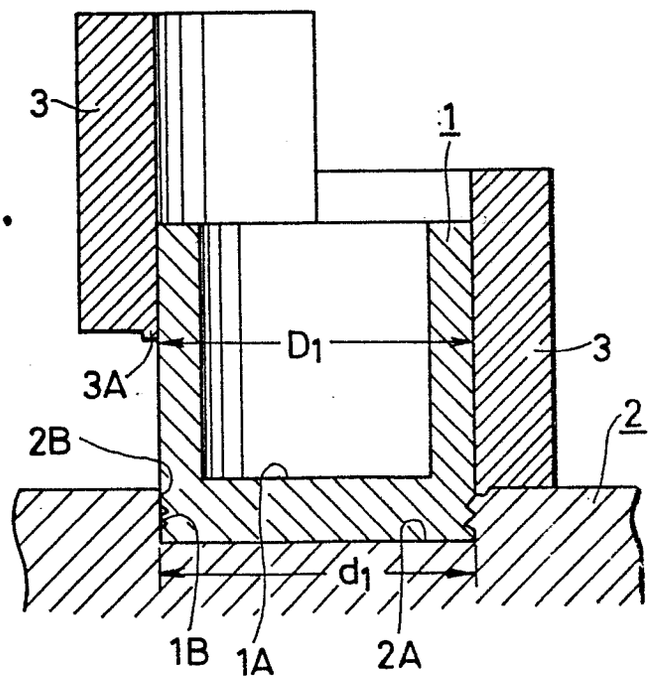

FIG. 2B

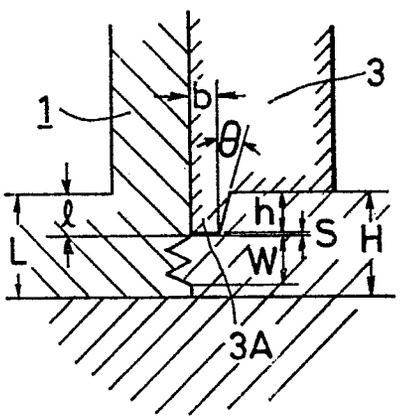

FIG. 3

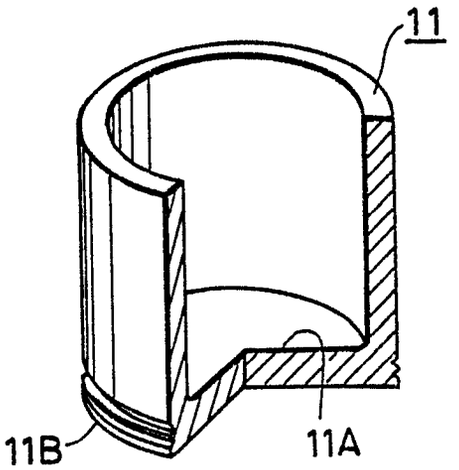

FIG. 4

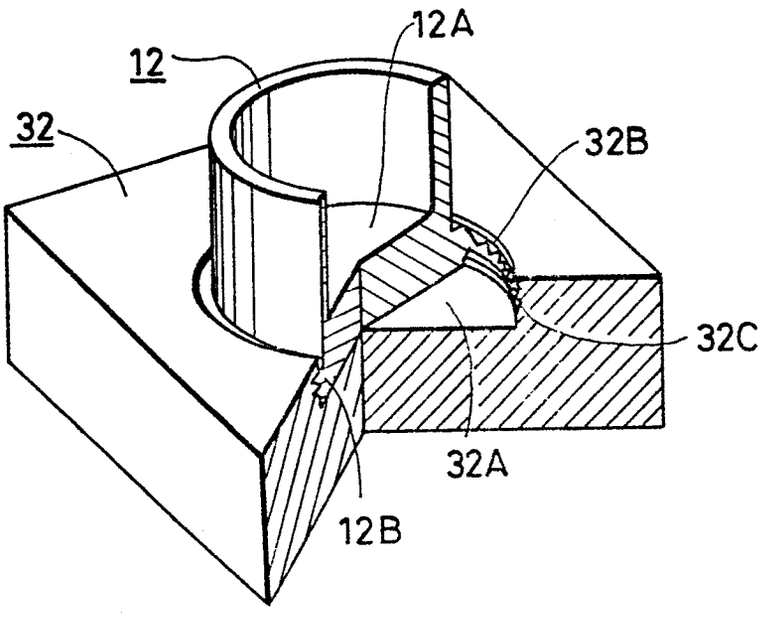

FIG. 5