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

(11) Publication number: **0 235 194**
B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **22.08.90**

(51) Int. Cl.[5]: **F 16 B 19/10,** B 21 J 15/02

(21) Application number: **86905069.0**

(22) Date of filing: **28.07.86**

(86) International application number:
PCT/US86/01598

(87) International publication number:
WO 87/01418 12.03.87 Gazette 87/06

(54) **AN INTERFERENCE FIT BLIND FASTENER SYSTEM.**

(30) Priority: **27.08.85 US 770160**

(43) Date of publication of application:
09.09.87 Bulletin 87/37

(45) Publication of the grant of the patent:
22.08.90 Bulletin 90/34

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

(56) References cited:
US-A-2 756 624
US-A-3 820 297

(73) Proprietor: **HUCK MANUFACTURING COMPANY**
6 Thomas P.O. Box 19590
Irvine, CA 92713 (US)

(72) Inventor: **KENDALL, James, W.**
6031 Cornell Drive
Huntington Beach, CA 92646 (US)

(74) Representative: **Baillie, Iain Cameron**
c/o Ladas & Parry Isartorplatz 5
D-8000 München 2 (DE)

Courier Press, Leamington Spa, England.

EP 0 235 194 B1

Description

The present invention relates to a blind fastener fastening system and more particularly to blind fasteners adapted to be received in aligned bores in workpieces to be joined together and for providing a preselected installed interference with such bores and the method of manufacturing such fastener.

The present invention is related to and is an improvement on the invention and type fastener disclosed in the United States Patent No. 3,820,297 of June 28, 1974. As such, the fastener of the present invention is directed to providing a preselected interference fit with the holes of workpieces being joined. With the desired interference, improvement in fatigue and other characteristics in the fastened joint can be realized. However, the magnitude of the interference can be relatively critical and will be affected by the materials of the fastener and of the workpieces. In the past, such fasteners, because of the tight tolerances required, have been subject to painstaking manufacturing procedures resulting in a relatively costly construction. In addition the cost for workpiece hold preparation prior to installation has been considerable. The present invention addresses these problems and provides a fastener construction and method by which the fastener can be manufactured relatively inexpensively to close tolerances. At the same time, it is believed that because of the improved reliability in fastener tolerances, the tolerances required for the preparation of the workpiece holes can be relaxed sufficiently to provide significant cost savings in installation.

It is an object of the present invention to provide an improved fastening system including an improved interference fit blind fastener and method of manufacturing such fastener.

The present invention therefore provides a fastener including a blind fastener adapted to be received in aligned bores in workpieces to be secured together and, after installation, to provide a preselected interference with the aligned bores, the fastener including a pin having an enlarged pin head and an elongated pin shank, a tubular sleeve having an enlarged sleeve head and an elongated sleeve shank and adapted to be located on said pin shank whereby the fastener can be installed by the application of a relative axial force between said pin and said sleeve, said pin shank comprising a generally straight expansion portion adjacent said pin head, an intermediate portion separated from said expansion portion by a breakneck groove, and a pull portion adapted to be gripped by an installation tool for setting the fastener by the application of said relative axial force, said expansion portion having an expansion diameter De which is greater than the diameter Ds of said intermediate portion, said sleeve having a generally uniform through bore with a relaxed first inside diameter Di, said sleeve shank having an outer surface with a relaxed first outside diameter Do, the diameter Ds of said intermediate portion being greater than said first inside diameter Di such that said sleeve may be pre-asembled on said intermediate pin portion with a press fit, said pin head being operative relative to the end of said sleeve shank opposite from said sleeve head and in response to said relative axial force to form an enlarged blind head engageable with one side of said workpieces, the axial movement of said pin being arrested upon formation of said blind head and said pin fracturing at said breakneck groove in response to said relative axial force attaining a preselected maximum magnitude, characterized in that to provide a preselected interference of desired magnitude the intermediate portion of said pin shank comprises a generally straight sizing portion which is substantially equal to the length of said sleeve bore, said sleeve shank before pre-assembly with the pin having an outer surface that has a generally uniform first outside diameter Do, such that upon pre-assembly of pin and sleeve the sleeve shank is radially expanded by said sizing portion to an increased second outside diameter Do′ that is greater than that needed to provide the desired magnitude of interference, the outer surface of said expanded sleeve shank being adapted to be subsequently reduced to a predetermined decreased third outside diameter Do′′ which is selected relative to the diameter Dw of said workpiece aligned bores so that the pre-assembled pin and sleeve can be received within said aligned bores with a preselected fit and provide the preselected interference of desired magnitude with said aligned bores upon application of said axial force to the fastener.

The present invention is further directed to a method of providing a fastened joint in a fastener system having a blind fastener adapted to be received in aligned bores of workpieces to be secured together and to provide a preselected interference after installation with the bores, the method including the steps of providing a pin having an enlarged pin head and an elongated pin shank, providing a tubular sleeve having an enlarged sleeve head and an elongated sleeve shank and adapted to be located on said pin shank whereby the fastener can be installed by the application of a relative axial force between said pin and said sleeve, providing said pin shank with a generally straight expansion portion adjacent said pin head, an intermediate portion separated from said expansion portion by a breakneck groove, and a pull portion adapted to be gripped by an installation tool for setting the fastener by the application of said relative axial force, said expansion portion having an expansion diameter De, which is greater than the diameter Ds of the intermediate portion, providing said sleeve with a generally uniform through bore having a relaxed diameter Di, providing the intermediate portion of said sleeve shank with a relaxed first outside diameter Do which is greater than the relaxed first inside diameter Di of said sleeve portion, assembling said sleeve onto said intermediate portion of said pin with a press fit, applying the relative axial force to the fastener to cause said expansion portion to move into said sleeve shank and to radially expand said sleeve shank to provide said preselected interference magnitude with said aligned bores, the axial force on said pin head contacting the end of said sleeve shank opposite from said sleeve head, forming an enlarged blind head engageable with one side of said workpieces, the axial movement of said pin being arrested upon formation of said blind head and said pin fracturing at said breakneck groove in response to said relative axial force attaining a preselected maximum magnitude, characterized by the steps of forming the intermediate portion of said pin shank as a generally straight sizing portion with a length substantially equal to the length of the sleeve bore and providing said sleeve with an outer surface having a generaly uniform first outside diameter Do, pre-assembling the pin sizing portion and sleeve to radially expand the sleeve shank to provide the outer surface thereof with an increased second outside diameter Do' while also expanding the sleeve to a second increased inside diameter Di' which is equal to the diameter Ds of said sizing portion, reducing the second outside diameter Do' of said outer surface of said sleeve shank to a predetermined third decreased outside diameter Do'' such that on installation of the fastener in said aligned workpiece bores said outer surface will provide the preselected interference of a desired magnitude with the bore diameter Dw of said aligned bores, the third decreased outside diameter Do'' being provided relative to said bore diameter Dw of said aligned bores whereby said pin and sleeve as pre-assembled can be received within said aligned bores with a preselected fit.

Other features and advantages of the present invention will become apparent from the subsequent description of a preferred embodiment of the invention taken in conjunction with the accompanying drawings wherein:

Figure 1 is an elevational view with some parts shown in section depicting an interference fit blind fastener including a pin and a sleeve and embodying features of the present invention with the sleeve shown in a position for processing;

Figure 2 is a similar view of the fastener of Figure 1 with the pin and sleeve shown in a final assembled position after processing and with the fastener located in workpiece openings;

Figure 3 is a fragmentary view of the pin of the fastener of Figure 1;

Figure 4 is a fragmentary sectional view of the sleeve of the fastener of Figure 1; and

Figure 5 is a fragmentary, sectional view of the fastener of Figure 1 as installed in the workpieces.

A blind fastener assembly 10 is shown in Figure 1 and includes a pin 12 (Figure 3) and a sleeve 14 (Figure 4). The pin 12 has an enlarged head 16 connected to a smooth expansion shank portion 20 via a tapered portion 18. A breakneck groove 22 is connected to the shank portion 20 via a tapered portion 21 and to a reduced diameter intermediate or sizing shank portion 25. A gripping portion 24 is further reduced in diameter and is connected to the intermediate shank portion 25 via a tapered portion 26. The gripping portion 24 comprises a plurality of annular pull grooves 28 which facilitates gripping of the pin 12 whereby the fastener 10 can be set by a tool of known construction.

Cooperating with the pin 12 is the sleeve 14 which is hollow, having a generally uniform through bore 30 of a relaxed diameter Di (Figure 4). The sleeve 14 has an enlarged, frusto conically shaped head portion 32 connected to a smooth shank 34 of a uniform outside relaxed diameter Do. The diameter Di of bore 30 of sleeve 14 is larger in diameter than the maximum diameter Dp of pull portion 24 of pin 12 and hence the sleeve 14 slips readily over that portion; however, the sizing shank portion 25 has a diameter Ds which is slightly larger in diameter than the bore 30 and hence when the sleeve 14 is assembled to the pin 12 the shank 34 will be slightly radially expanded as it is press fitted onto the shank portion 25; in this manner the two pieces are held together and in addition a sizing function is performed which facilitates the construction of the fastener 10 having the advantages noted.

The fastener 10 can be used to secure a pair of workpieces 38 and 40 which are provided with aligned bores 42 and 44, respectively (Figure 2). Bore 44 is uniform while bore 42 terminates in a frusto conically shaped portion 46. In operation the fastener 10, assembled as shown in Figure 1 (but modified in a manner to be described), is located in the bores 42 and 44 with the enlarged head portion 32 of sleeve 14 matingly located in the conical bore portion 46. The shank 34 of the sleeve 14 is located in bores 42 and 44 with a close tolerance but clearance fit and extends partially beyond the end wall of the workpiece 40. Next a relative axial force is applied between the pin 12 and sleeve 14; this can be done by a known tool which grips the pull grooves 28 of the pin 12 and pulls the pin 12 while applying a reaction force to the sleeve head portion 32. As the pin 12 is pulled, the shank portion 20 of the pin 12 is moved into the bore 30 of the sleeve 14. While the intermediate shank portion 25 provides a slight, press fit with bore 30, the expansion shank portion 20 is of a diameter De, which is greater than diameter Ds of shank portion 25; the diameter De is predetermined to provide a desired interference with the sleeve bore 30; this desired interference is selected to cause expansion of the sleeve shank 34 whereby it will expand in the workpiece bores 42, 44 to provide the necessary magnitude of interference with the bores 42, 44 to stress the bores 42, 44 to the desired amount.

As the head 16 is pulled into the sleeve bore 30 the tapered portion 18 expands the free end of the sleeve shank 34 to form an enlarged, tulip head 48 (Figure 5). When the tapered portion 18 moves to a position in line with the rear surface of workpieces 40 the motion of the pin 12 is effectively stopped and the pulling force of the tool increases until a preselected magnitude is reached at which the pin 12 will break at the breakneck 22, leaving the installed fastener as shown in Figure 5. The remainder of pin 12 will be frictionally held to the expanded sleeve 14.

Fasteners similar in general physical appearance to that shown in the drawings have been provided for expansion of a sleeve to fill the holes in the workpieces; however, such fasteners have utilized a pin member designed to wire draw after the initial sleeve expansion provides hole fill; this results in little effective stressing of the workpiece holes or bores. With the present construction (as with that shown in the aforesaid U. S. Patent 3,820,297), the desired interference is not provided merely by preventing wire drawing through an increase in the strength of the pin since ancillary problems such as sleeve extrusion, excessive installation loads, etc., can occur. Here the interference fit blind fastener is provided by a careful balancing of the strengths of the pin 12 and sleeve 14 considering the characteristics of the material of the workpieces 38, 40.

The magnitude of the final, desired interference between the set fastener and the workpiece bores will vary as a function of the area or of the diameter of the bores. This interference in terrms of expansion in bore diameter can be expressed as a percentage, i.e., interference to bore diameter. It is desirable that this percentage interference be between around 0.5 percent and 1 percent with the preferred interference being around 0.75% over the maximum workpiece hole diameter.

As noted in order to obtain the desired interference, the strengths of the pin 12 and sleeve 14 of the fastener 10 must be carefully balanced with the strength of the workpieces 38, 40. Thus the pin 12 must be of sufficient strength to withstand the frictional forces encountered during setting without significant yielding or wire drawing. The sleeve 14 should be of a strength whereby it will elastically expand sufficiently to fill the holes or bores 42, 44 and to radially expand the holes 42, 44 to the desired magnitude of interference fit. The sleeve 14, however, should be of a sufficient strength such that it will not yield excessively and extrude. The workpieces 38, 40 also must be of sufficient strength such that the material around the bores 42, 44 will expand but will not yield appreciably and hence will not extrude; thus the strength of the workpieces 38, 40 should be sufficient relative to the desired interference to avoid appreciable yielding and/or extrusion. In one construction satisfactory results were obtained utilizing (a high hardness pin 12 made of alloy steel AISI 8740 and having a hardness of around 49—52 Rc, (b) a sleeve 14 made of Monel-QQ-0-281 and having a hardness of around 65 R15N to around 70 R15N, and (c) workpieces 38, 40 made of aluminum 2024 T3 or 7075 T6 having a Brinell hardness of around 150. It is desirable to provide the tensile strength characteristics of the sleeve 14 to be close to or greater than that of the workpiece 38, 40. Note that the pin 12 is of a higher hardness than the sleeve 14. With the construction as described above it was found advantageous to utilize an extreme pressure lubricant between the pin 12 and sleeve 14 to minimize the frictional forces. One such lubricant found to be satisfactory was a commercially available molybdenumdisulphide lubricant.

As noted the objective is to provide a preselected magnitude of interference between the outside surface 50 of the sleeve 14 and the workpiece bores or openings 42, 44 by virtue of the radial expansion of the sleeve 14 caused by the expansion shank portion 20 of the pin 12. In the past, this has been accomplished by monitoring and matching sleeves and pins and by a series of carefully controlled manufacturing procedures. Thus, with prior constructions, the sleeve bore 30 would be drilled, reamed and honed to very tight tolerances. In a similar manner the outside surface 50 of the sleeve 14 was precision ground to tight tolerances. The expansion shank portion 20 of the pin 12 was also precision ground to tight tolerances. However, even here the stack up of tolerances on the sleeve 14 and pin 12 required that the workpiece openings 42, 44 be carefully prepared to a preselected close tolerance. For example, the total tolerance on the workpiece openings or bores 42, 44 would be held to 0.0014" (.036 mm) regardless of diameter.

In the present invention a simpler and less expensive manufacturing procedure is utilized to provide the fastener 10 having the desired interference fit advantages. To accomplish this objective, the pin 12 is constructed to have a shank portion which provides for an initial, known sizing function relative to the sleeve 14. This is accomplished by the intermediate sizing shank portion 25 which has an axial length generally the same as the sleeve bore 30. The sizing shank portion 25 while dimensioned to provide an interference or press fit with the sleeve bore 30 is still of a diameter Ds significantly less than the diameter De of the expansion shank portion 20.

In construction, the pin 12 is formed by relatively inexpensive processes such as heading and rolling. The sleeve 14 can also be formed by relatively inexpensive processes such as punching and piercing and/or drilling. The latter manufacturing processes can be readily inexpensively controlled to provide piece to piece consistency within a relatively large tolerance band which large tolerance band can be accommodated by the present invention. The large tolerance band is typically attainable without extraordinary precision or dimensional controls.

As noted the relaxed diameter Di of sleeve bore 30 and the diameter Ds of sizing shank portion 25 are provided, in one form, to have a press fit up to around .003" (.008 mm) (regardless of diameter). This initial radial expansion is generally of a low magnitude and is within the elastic limit of the sleeve material. Now with the sleeve 14 initially pre-assembled onto the sizing shank portion 25, through bore 30 will be expanded to a diameter Di' which will be equal to diameter Ds of the sizing shank portion 25. The relaxed outside diameter Do will now be expanded to a larger diameter Do' (see Figure 1). The sleeve 14, prior to the sizing or initial expansion, was constructed with a relaxed inside diameter Di and relaxed outside diameter Do such that the final expansion by the expansion shank portion 20 within openings 42, 44 would result in excessive interference; in other words, the sleeve shank portion 20 is deliberately, initially provided to be oversize to accommodate subsequent machining operations. However, with the sleeve 14 initially expanded on the sizing shank portion 25, the sleeve 14 can now be ground at its outer surface 50 to provide the required outside diameter Do'' (Figure 2) which will give the desired final interference fit with openings 42, 44. The latter can be accomplished knowing the relaxed diameters Di and Do of the sleeve 14 and knowing the sizing and expansion diameters Ds and De, respectively, of the pin 12. The diameters of the sizing shank portion 25 (Ds) and expansion shank portion 20 (De) can be readily determined on a batch basis after completion of the pin 12. For example, in processing, the pins are headed; the pull grooves are rolled; the breakneck groove is rolled or cut; the pin is heat treated, cleaned, and then both diameters Ds and De are measured without further machining of the two associates surfaces. The diameter Dw of workpiece bores 42 and 44 is also known or predictably known and hence the desired bore expansion diameter Dw' is known. Having the preceding information, the desired cross-sectional area of the wall of sleeve 14 can be determined. The relaxed inside diameter Di, of the sleeve 14, when pre-assembled and sized on shank portion 25 to a diameter Di', will be equal to the sizing diameter Ds of portion 25; both De and Ds are known. It is now a simple matter to determine the diameter Do'' to which the outside surface 50 of the sleeve shank 34 need be ground to attain a diameter Dw' which is greater than relaxed bore diameter Dw to provide the desired interference. This can be determined by the relationship:

$$Do'' = \sqrt{(Dw')^2 - ((De)^2 - (Ds)^2)}$$

As noted, the diameter Do'' to which the sleeve 14 is ground will be such as to provide clearance with the bores 42, 44. The final radial expansion of the sleeve 14 in installation is such as to be within the elastic limit or only slightly into yield of the sleeve material.

Thus a simple and direct method is provided by which the fastener 10 can be constructed in an economical manner. At the same time, since the final outside sleeve diameter Do'' is now more reliably controlled, the tolerances on the workpiece bores 42 and 44 need not be so closely controlled resulting in a further economy in installation.

An example of the differences in required total tolerances between the prior art system and that of the present invention can be seen from the following comparison table:

Prior Art System	Dimension	New System
.0014" (.036 mm)	Workpiece Bore Diameter (Dw)	.003" (.008 mm)
.0004" (.010 mm)	Expansion Pin Shank Diameter (De)	.0015" (.038 mm)
————	Sizing Pin Shank Diameter (Ds)	.0015" (.038 mm)
.0004" (.010 mm)	Relaxed Sleeve Bore Diameter (Di)	.0015" (.038 mm)
.0005" (.013 mm)	Final Outer Sleeve Diameter (Do'')	.0005" (.013 mm)

The above table is generally applicable for fasteners over a wide range of diameters. Note that the prior art system has no pin portion such as the sizing shank portion 25.

Thus it can be seen that the present method and fastener construction can result in significant economies in fastener manufacture and in the workpiece preparation for installation.

When the fastener 10 is provided for use with workpieces 38, 40 of the aluminum alloys noted, the pin head 16 is provided to be of a slightly smaller diameter Dh than the initially expanded outside diameter Do' of the sleeve shank portion 20. At the same time, it has been found advantageous to provide the tapered pin portion 18 to have an included angle X of around 60°. The latter angle facilitates bulbing of the blind end of sleeve shank portion 20 while still facilitating sufficent movement of the pin 12 within sleeve 14 without excessive axial loads whereby premature pin break at the breakneck groove 22 is inhibited.

Thus it can be seen that, with the features of the present invention, the advantages of an interference fit type fastener can be secured in an economical manner.

Claims

1. A fastener including a blind fastener adapted to be received in aligned bores in workpieces to be secured together and, after installation, to provide a preselected interference with the aligned bores, the fastener including a pin (12) having an enlarged pin head (16) and an elongated pin shank (20, 25), a tubular sleeve (14) having an enlarged sleeve head (32) and an elongated sleeve shank (34) and adapted to be located on said pin shank (20, 25) whereby the fastener can be installed by the application of a relative axial force between said pin (12) and said sleeve (14), said pin shank comprising a generally straight expansion portion (20) adjacent said pin head, an intermediate portion (25) separated from said expansion portion (20) by a breakneck groove (22), and a pull portion (24, 28) adapted to be gripped by an installation

tool for setting the fastener by the application of said relative axial force, said expansion portion (20) having an expansion diameter De which is greater than the diameter Ds of said intermediate portion (25), said sleeve (14) having a generally uniform through bore (30) with a relaxed first inside diameter Di, said sleeve shank (34) having an outer surface (50) with a relaxed first outside diameter Do, the diameter Ds of said intermediate portion (25) being greater than said first inside diameter Di such that said sleeve (14) may be pre-assembled on said intermediate pin portion (25) with a press fit, said pin head (16) being operative relative to the end of said sleeve shank (34) opposite from said sleeve head (32) and in response to said relative axial force to form an enlarged blind head (48) engageable with one side of said workpieces, the axial movement of said pin (12) being arrested upon formation of said blind head and said pin (12) fracturing at said breakneck groove (22) in response to said relative axial force attaining a preselected maximum magnitude, characterized in that to provide a preselected interference of desired magnitude the intermediate portion of said pin shank comprises a generally straight sizing portion (25) which is substantially equal to the length of said sleeve bore (30), said sleeve shank (34) before pre-assembly with the pin (12) having an outer surface (50) that has a generally uniform first outside diameter Do, such that upon pre-assembly of pin (12) and sleeve (14) the sleeve shank (34) is radially expanded by said sizing portion (25) to an increased second outside diameter Do' that is greater than that needed to provide the desired magnitude of interference, the outer surface (50) of said expanded sleeve shank (34) being adapted to be subsequently reduced to a predetermined decreased third outside diameter Do'' which is selected relative to the diameter Dw of said workpiece aligned bores so that the pre-assembled pin (12) and sleeve (14) can be received within said aligned bores with a preselected fit and provide the preselected interference of desired magnitude with said aligned bores upon application of said axial force to the fastener (10).

2. The fastener of claim 1, characterized in that the hardness of said pin (12), sleeve (14) and the workpieces are selected to provide the desired magnitude of said preselected interference between pin (12) and sleeve (14) and the workpiece bores substantially within the elastic limit of said pin (12), sleeve (14) and workpieces without significant wire drawing of said pin (12).

3. The fastener of claim 1 or 2, characterized in that said pull portion (24, 28) has a maximum diameter Dp which is less than the diameter Ds of said sizing portion (25), the diameter Dp of said pull portion (24, 28) also being less than said relaxed first inside diameter Di of said sleeve through bore (30).

4. The fastener of claim 1, 2 or 3, characterized in that the decreased third outside diameter Do'' of said sleeve shank is determined by the following relationship:

$$Do'' = \sqrt{(Dw')^2 - (De)^2 - (Ds)^2}$$

where Dw' is the desired expanded diameter of said aligned bores.

5. The fastener of any of claims 1—4, characterized in that said pin (12) is made of material having a hardness of from around 49 Rc to around 52 Rc, said sleeve (14) being constructed of a material having a hardness of from around 60 R15N to around 70 R15N and with said workpieces being constructed of aluminum having a strength proximate to that of said sleeve (14).

6. The fastener of any of claims 1 to 5, characterized in that said pin head (16) has a diameter less than said predetermined decreased third outside diameter Do'' of said sleeve shank (34) and has a tapered portion (18) connecting said pin head (16) to said expansion portion (20) with said tapered portion (18) defining an included angle of around 60°.

7. The fastener of any of the preceding claims, characterized in that said press fit used for pre-assembly of pin and sleeve is an interference of up to around .003" (.008 mm).

8. A method of providing a fastened joint in a fastener system having a blind fastener adapted to be received in aligned bores of workpieces to be secured together and to provide a preselected interference after installation with the bores, the method including the steps of providing a pin (12) having an enlarged pin head (16) and an elongated pin shank (20, 25) providing a tubular sleeve (14) having an enlarged sleeve head (32) and an elongated sleeve shank (34) and adapted to be located on said pin shank whereby the fastener can be installed by the application of a relative axial force between said pin (12) and said sleeve (14), providing said pin shank (34) with a generally straight expansion portion (20) adjacent said pin head (16), an intermediate portion (25) separated from said expansion portion (20) by a breakneck groove (22), and a pull portion (24, 28) adapted to be gripped by an installation tool for setting the fastener by the application of said relative axial force, said expansion portion (20) having an expansion diameter De, which is greater than the diameter Ds of the intermediate portion (25), providing said sleeve with a generally uniform through bore (30) having a relaxed diameter Di, providing the intermediate portion (25) of said sleeve shank (34) with a relaxed first outside diameter Do which is greater than the relaxed first inside diameter Di of said sleeve portion (34), assembling said sleeve (14) onto said intermediate portion (25) of said pin (12) with a press fit, applying the relative axial force to the fastener to cause said expansion portion (20) to move into said sleeve shank (34) and to radially expand said sleeve shank (34) to provide said preselected interference magnitude with said aligned bores, the axial force on said pin head (16) contacting the end of said sleeve shank (34) opposite from said sleeve head (32), forming an enlarged blind head (48) engageable with one side of said workpieces, the axial movement of said pin (12) being arrested upon

formation of said blind head (48) and said pin (12) fracturing at said breakneck groove in response to said relative axial force attaining a preselected maximum magnitude, characterized by the steps of forming the intermediate portion of said pin shank (20) as a generally straight sizing portion (25) with a length substantially equal to the length of the sleeve bore (30) and providing said sleeve (14) with an outer surface (50) having a generally uniform first outside diameter Do, pre-assembling the pin sizing portion (25) and sleeve (14) to radially expand the sleeve shank (34) to provide the outer surface (50) thereof with an increased second outside diameter Do' while also expanding the sleeve to a second increased inside diameter Di' which is equal to the diameter Ds of said sizing portion (25), reducing the second outside diameter Do' of said outer surface (50) of said sleeve shank (34) to a predetermined third decreased outside diameter Do'' such that on installation of the fastener in said aligned workpiece bores said outer surface (50) will provide the preselected interference of a desired magnitude with the bore diameter Dw of said aligned bores, the third decreased outside diameter Do'' being provided relative to said bore diameter Dw of said aligned bores whereby said pin (12) and sleeve (14) as pre-assembled can be received within said aligned bores with a preselected fit.

9. The method of claim 8, further characterized by the step of providing the pull portion (24, 28) of the pin (12) with a maximum diameter Dp which is less than the diameter Ds of said sizing portion (25) of said pin (12), the diameter Dp of said pull portion (24, 28) also being less than the relaxed inside diameter Di of the sleeve (14) and the diameter Ds of said sizing portion (25) being greater than the relaxed inside sleeve diameter Di, to provide for a press fit therebetween.

10. The method of claim 9, further characterized by the step of determining the magnitudes of said sizing portion diameter Ds and of said expanding diameter De of said expansion portion (20) and forming the third decreased outside diameter Do'' of said sleeve shank (34) to have a magnitude in accordance with the following relationship:

$$Do'' = \sqrt{(Dw')^2 - ((De)^2 - (Ds)^2)}$$

where Dw' is the desired expanded diameter of said aligned bores.

Patentansprüche

1. Befestigungselement mit einem Blindbefestigungselement, das geeignet ist, in miteinander fluchtenden Bohrungen von aneinander zu befestigenden Werkstücken aufgenommen zu werden und nach dem Einbau mit den miteinander fluchtenden Bohrungen eine vorgewählte Preßpassung zu bilden, wobei das Befestigungselement einen Zapfen (12) besitzt, der einen verbreiterten Zapfenkopf (16) und einen langgestreckten Zapfenschaft (20, 25) aufweist, ferner eine rohrförmige Hülse (14), die einen verbreiterten Hülsenkopf (32) und einen langgestreckten Hülsenschaft (34) besitzt und die auf dem Zapfenschaft (20, 25) positionierbr ist, so daß das Befestigungselement durch Ausübung einer relativen Axialkraft zwischen dem Zapfen (12) und der Hülse (14) eingebaut werden kann, wobei der Zapfenschaft einen dem Zapfenkopf benachbarten, allgemein geradlinigen Aufweitteil (20), einen von dem Aufweitteil (20) durch eine Sollbruchnut (22) getrennten Zwischenteil (25) und einen Ziehteil (24, 28) aufweist, der in einem Einbauwerkzeug einspannbar ist, das zum Setzen des Befestigungselements durch Ausübung der genannten relativen Axialkraft dient, wobei der Aufweitteil (20) einen Aufweitdurchmesser De hat, der größer ist als der Durchmesser Ds des Zwischenteils (25), die Hülse (14) von einer allgemein einheitlichen Bohrung (30) durchsetzt ist, die im entspannten Zustand einen ersten Innendurchmesser Di hat, der Hülsenschaft (34) eine Außenfläche (50) besitzt, die im entspannten Zustand einen ersten Außendurchmesser Do hat, der Durchmesser Ds des Zwischenteils (25) größer ist als der erste Innendurchmesser Di, so daß die Hülse (14) auf dem Zwischenteil (25) des Zapfens mit einer Preßpassung vormontierbar ist, der Zapfenkopf (16) durch die Einwirkung de relativen Axialkraft relativ zu dem dem Hülsenkopf (32) entgegengesetzten Ende des Hülsenschaftes (34) derart betätigbar ist, daß ein verbreiterter Blindkopf (48) ausgebildet wird, der an eine Seite der Werkstücke anstellbar ist, die Axialbewegung des Zapfens (12) nach der Ausbildung des Blindkopfes angehalten wird und der Zapfen (12) an der Sollbruchnut (22) bricht, wenn die relative Axialkraft eine vorgewählte maximale Stärke ereicht, dadurch gekenneichnet, daß zum Herstellen einer vorgewählten Preßpassung mit einem gewünschten Übermaß der Zwischenteil des Zapfenschaftes einen allgemein geradlinigen Kalibrierteil (25) besitzt, der allgemein ebensolang ist wie die Bohrung (30) der Hülse, daß der Hülsenschaft (34) vor seinem Vormontieren auf dem Zapfen (12) eine Außenfläche (50) mit einem allgemein einheitlichen ersten Außendurchmesser Do besitzt, so daß beim Vormontieren des Zapfens (12) und der Hülse (14) der Kalibrierteil (25) den Hülsenschaft (34) auf einen größeren zweiten Außendurchmeser Do' aufweitet, der größer ist als zum Herstellen des gewünschten Übermaßes erforderlich ist, wobei die Außenfläche (50) des aufgeweiteten Hülsenschaftes (34) geeignet ist, danach auf einen vorherbestimmten, kleineren dritten Außendurchmesser Do'' reduziert zu werden, der relativ zu dem Durchmesser Dw der miteinander fluchtenden Bohrungen der Werkstücke so gewählt ist, daß der Zapfen (12) und die Hülse (14) im vormontierten Zustand von den miteinander fluchtenden Bohrungen mit einer vorgewählten Passung aufgenommen werden und nach dem Ausüben der genannten Axialkraft auf das Befestigungselement (10)

die vorgewählte Preßpassung mit dem gewünschten Übermaß gegenüber den miteinander fluchtenden Bohrungen erhalten wird.

2. Befestigungselement nach Anspruch 1, dadurch gekennzeichnet, daß die Härten des Zapfens (12), der Hülse (14) und der Werkstücke so gewählt sind, daß das gewünschte Übermaß der vorgewählte Preßpassung zwischen dem Zapfen (12) und der Hülse (14) und den Werkstückbohrungen im wesentlichen innerhalb der Elastizitätsgrenze des Zapfens (12), der Hülse (14) und der Werkstücke liegt und im wesentlichen kein Drahtzug des Zapfens (12) auftritt.

3. Befestigungselement nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Ziehteil (24, 28) einen maximalen Durchmesser Dp hat, der kleiner ist als der Durchmesser Ds des Kalibrierteils (25), und daß der Durchmesser Dp des Ziehteils (24, 28) auch kleiner ist als der im entspannten Zustand erhaltene Innendurchmesser Di der Bohrung (30) der Hülse.

4. Befestigungselement nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß der verringerte dritte Außendurchmesser Do'' des Hülsenschaftes durch folgende Beziehung bestimmt ist:

$$D'' = \sqrt{(Dw')^2 - ((De)^2 - (Ds)^2)}$$

in der Dw' der geünschte Durchmesser der miteinander fluchtenden Bohrungen nach deren Aufweiten ist.

5. Befestigungselement nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß der Zapfen (12) aus einem Werkstoff mit einer Härte von etwa RHC 49 bis etwa RHC 52 besteht, daß die Hülse (14) aus einem Werkstoff mit einer Härte von etwa 60 R15N bis etwa 70 R15N besteht und daß die Werkstücke aus Aluminium bestehen, das ungefähr dieselbe Festigkeit hat wie der Werkstoff der Hülse (14).

6. Befestigungselement nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß der Zapfenkopf (16) einen durchmesser hat, der kleiner ist als der vorherbestimmte verringerte dritte Außendurchmesser Do'' des Hülsenschaftes (34) und daß der Zapfenkopf einen verjüngten Teil (18) besitzt, der den Zapfenkopf (16) mit dem Aufweitteil verbindet und der einen Winkel von etwa 60° einschließt.

7. Befestigungselement nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die zum Vormontieren des Zapfens und der Hülse vewendete Passung ein Übermaß von bis zu etwa 0,008 mm hat.

8. Verfahren zum Herstellen einer Festverbindung in einem Befestigungssystem, das ein Blindbefestigungselement aufweist, das geeignet ist, in miteinander fluchtenden Bohrungen von aneinander zu befestigenden Werkstücken auf genommen zu werden und nach dem Einbau mit den Bohrungen eine vorgewählte Preßpassung zu bilden, wobei das Verfahren folgende Schritte aufweist: es wird ein Zapfen (12) verwendet, der einen verbreiterten Zapfenkopf (16) und einen langgestreckten Zapfenschaft (20, 25) besitzt; es wird eine rohrförmige Hülse (14) verwendet, die einen verbreiterten Hülsenkopf (32) und einen langgestreckten Hülsenschaft (34) besitzt und die auf dem Zapfenschaft positionierbar ist, so daß das Befestigungselement durch Ausübung einer relativen Axialkraft zwischen dem Zapfen (12) und der Hülse (14) eingebaut werden kann, der Zapfenschaft (34) wird mit einem dem Zapfenkopf (16) benachbartern, allgemein geradlinigen Aufweitteil (20), mit einem von dem Aufweitteil (20) durch eine Sollbruchnut (22) getrennten Zwischenteil (25) und mit einem Ziehteil (24, 28) ausgebildet, der in einem Einbauwerkzeug einspannbar ist, das dazu dient, das Befestigungselement durch Ausübung der genannten relativen Axialkraft zu setzen, wobei der Aufweitteil (20) einen Aufweitdurchmesser De hat, der größer ist als der Durchmesser Ds des Zwischenteils (25), die Hülse wird mit einer allgemein gleichmäßigen, die Hülse durchsetzenden Bohrung (30) ausgebildet, die im entspannten Zustand einen Durchmesser Di hat, der Zwischenteil (25) des Hülsenschafts (34) wird so ausgebildet, daß er im entspannten Zustand einen ersten Außendurchmesser Do hat, der größer ist als der erste Innendurchmesser Di des genannten Hülsenschaftes (34) im entspannten Zustand desselben; die Hülse (14) wird mit einer Preßpassung auf dem Zwischenteil (25) des zapfens (12) montiert; durch Ausüben der relativen Axialkraft auf das Befestigungselement wird der Aufweitteil (20) in den Hülsenschaft (34) hineinbewegt und veranlaßt, den Hülsenschaft (34) derart aufzuweiten, daß mit den miteinander fluchtenden Bohrungen die vorgewählte Preßpassung erhalten wird, wobei die Axialkraft, die auf den Zapfenkopf (16) ausgeübt wird, der den Hülsenschaft (34) an seinem dem Hülsenkopf (32) entgegengesetzten Ende berührt, zur Ausbilding eines verbreiterten Blindkopfes (48) führt, der an eine Seite der Werkstücke anstellbar ist, die Axialbewegung des Zapfens (12) nach der Ausbildung des Blindkopfes (48) angehalten wird und der Zapfen (12) an der Sollbruchnut bricht, wenn die relative Axialkraft eine vorgewählte maximale Stärke erreicht, gekennzeichnet durch folgende Schritte: der Zwischenteil des Zapfenschaftes (20) wird als allgemein geradliniger Kalibrierteil (25) ausgebildet, der im wesentlichen ebensolang ist wie die Bohrung (30) der Hülse, die Hülse (14) wird mit einer Außenfläche (50) ausgebildet, die einen allgemein einheitlichen ersten Außendurchmesser Do besitzt; der Kalibrierteil (25) des Zapfens und die Hülse (14) werden derart vormontiert, daß der Hülsenschaft (34) radial aufgeweitet wird und dadurch die Außenfläche (50) des Hülsenschaftes den größeren zweiten Außendurchmesser Do' annimmt, wobei die Hülse auch auf einen zweiten vergrößerten Innendurchmesser Di' aufgeweitet wird, der gleich dem Durchmesser Ds des Kalibrierteils (25) ist; der zweite Außendurchmesser Do' der Außenfläche (50) des Hülsenschaftes (34) wird auf einen solchen vorherbestimmten dritten verringerten Außendurchmesser Do'' reduziert, daß beim Einbau des Befestigungselements in die miteinander fluchtenden Bohrungen der Werkstücke zwischen der Außenfläche (50) und dem Durchmesser Dw der

miteinander fluchtenden Bohrungen eine vorgewählte Preßpassung mit einem gewünschten Übermaß erhalten wird, wobei der dritte verringerte Außendurchmesser Do'' relativ su dem Bohrungsdurchmesser Dw der miteinander fluchtenden Bohrungen so hergestellt wird, daß der Zapfen (12) und die Hülse (14) im vormontierten Zustand von den miteinander fluchtenden Bohrungen mit einer vorgewählten Passung aufgenommen werden können.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß der Ziehteil (24, 28) des Zapfens mit einem maximalen Durchmesser Dp ausgebildet wird, der kleiner ist als der Durchmesser Ds des Kalibrierteils (25) des Zapfens (12), wobei der Durchmesser Dp des Ziehteils (24, 28) auch kleiner ist als der im entspannten Zustand erhaltene Innendurchmesser Di der Bohrung (20) und der Durchmesser Ds des Kalibrierteils (25) größer ist als der im entspannten Zustand erhaltene Innendurchmesser Di der Hülse, so daß zwischen ihnen eine Preßpassung erhalten wird.

10. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß der Durchmesser Ds des Kalibrierteils und der Aufweitdurchmesser De des Aufweitteils (20) so bestimmt werden und der Hülsenschaft (34) mit einem solchen verringerten Außendurchmesser Do'' ausgebildet wird, daß dessen Betrag der folgenden Beziehung entspricht:

$$Do'' = \sqrt{(Dw')^2 - ((De)^2 - (Ds)^2)}$$

in der Dw' der gewünschte Durchmesser der miteinander fluchtenden Bohrungen im aufgeweiteten Zustand ist.

Revendications

1. Un système de fixation comportant un organe de fixation aveugle adapté pour être reçu dans des trous alignés dans des pièces à fixer ensemble et, après installation, de façon à établir un ajustement serré présélectionné avec les trous alignés, l'organe de fixation comprenant une broche (12) pourvue d'une tête élargie (16) et d'une tige de broche allongée (20, 25), un manchon tubulaire (14) comportant une tête élargie (32) et une tige allongée (34) et adapté pour être placé sur ladite tige de broche (20, 25), de façon que l'organe de fixation puisse être installé par application d'une force axiale relative entre ladite broche (12) et ledit manchon (14), ladite tige de broche comprenant une partie d'expansion (20) généralement droite et adjacente à ladite tête de broche, une partie intermédiaire (25) séparée de ladite partie d'expansion (20) par une rainure (22) formant col de rupture, et une partie de traction (24, 28) adaptée pour être saisie par un outil d'installation pour la mise en place de l'organe de fixation par application de ladite force axiale relative, ladite partie d'expansion (20) ayant un diamètre d'expansion De qui est supérieur au diamètre Ds de ladite partie intermédiaire (25), ledit manchon (145) comportant un trou traversant (30) généralement uniforme ayant un premier diamètre intérieur Di en l'état relaxé, ladite tige de manchon (34) comportant une surface extérieure (50) ayant un premier diamètre extérieur Do en l'état relaxé, le diamètre Ds de ladite partie intermédiaire (25) étant supérieur audit premier diamètre intérieur Di de telle sorte que ledit manchon (14) puisse être préassemblé sur ladite partie intermédiaire de broche (25) avec ajustement serré, ladite tête de broche (16) étant opérationnelle en relation avec l'extrémité de ladite tige de manchon (34) qui est opposée à ladite tête de manchon (32) et en réponse à ladite force axiale relative pour former une tête aveugle élargie (48) pouvant être engagée dans un côté desdites pièces, le mouvement axial de ladite broche (12) étant arrêté lors de la formation de ladite tête aveugle et ladite broche (12) se rompant dans ladite rainure (22) formant col de rupture, en réponse à l'atteinte d'une grandeur maximale présélectionnée par ladite force axiale relative, caractérisé en ce que, pour obtenir un ajustement serré présélectionné de grandeur désirée, la partie intermédiaire de ladite tige de broche comprend une portion de calibrage (25) généralement droite, qui est sensiblement égale à la longueur dudit trou de manchon (30), ladite tige de manchon (34) comportant, avant préassemblage avec la broche (14), une surface extérieure (50) qui a un premier diamètre extérieur Do généralement uniforme, de telle sorte que, lors d'un préassemblage de la broche (12) et du manchon (14), la tige de manchon (34) soit radialement expansée par ladite partie de calibrage (25) jusqu'à un second diamètre extérieur accru Do' qui est supérieur à ce qui est nécessaire pour obtenir la grandeur désirée d'ajustement serré, la surface extérieure (50) de ladite tige de manchon expansé (34) étant adaptée pour être ensuite réduite à un troisième diamètre extérieur réduit prédéterminé Do'', et qui est choisi par rapport au diamètre Dw desdits trous alignés desdites pièces de telle sorte que la broche (12) et le manchon (14) préassemblés puissent être reçus dans lesdits trous alignés avec un serrage présélectionné et établissent l'ajustement serré présélectionné de grandeur désirée avec lesdits trous alignés lors de l'application de ladite force axiale au système de fixation (10).

2. Le système de fixation selon la revendication 1, caractérisé en ce que les duretés de ladite broche (12), dudit manchon (14) et desdites pièces sont choisies de manière là obtenir la grandeur désirée dudit ajustement serré présélectionné entre la broche (12) et le manchon (14) et les trous des pièces en restant sensiblement dans la limite élastique de ladite broche (12), dudit manchon (14) et desdites pièces sans étirage sensible de ladite broche (12).

3. Le système de fixation selon une des revendications 1 ou 2, caractérisé en ce que ladite partie de traction (24, 28) a un diamètre maximal Dp qui est inférieur au diamètre Ds de ladite partie de calibrage (25), le diamètre Dp de ladite partie de traction (24, 28) étant aussi inférieur audit premier diamètre intérieur Di en l'état relaxé dudit trou traversanat (30) du manchon.

4. Le système de fixation selon une des revendications 1, 2 ou 3, caractérisé en ce que le troisième diamètre extérieur réduit Do'' de ladite tige de manchon est déterminé par la relation suivante:

$$D'' = \sqrt{(Dw')^2 - ((De)^2 - (Ds)^2)}$$

où Dw' désigne le diamètre d'expansion désiré desdits trous alignés.

5. Le système de fixation selon une quelconque des revendications 1 à 4, caractérisé en ce que ladite broche (12) est formée d'un matériau ayant une dureté comprise entre environ 49 Rc et environ 52 Rc, ledit manchon (14) étant constitué d'un matériau ayant une dureté comprise entre environ 60 R15N et environ 70 R15N et lesdites pièces étant formées d'aluminium ayant une résistance proche de cellel dudit manchon (14).

6. Le système de fixation selon une quelconque des revendications 1 à 5, caractérisé en ce que ladite tête de broche (16) a un diamètre inférieur audit troisième diamètre extérieur réduit prédéterminé Do'', de ladite tige de manchon (34) et comporte une partie effilée (18) reliant ladite tête de broche (16) avec ladite partie d'expansion (20), ladite partie effilée (18) définissant un angle inclus d'environ 60°.

7. Le système de fixation selon une quelconque des revendications précédentes, caractérisé en ce que ledit ajustement serré utilisé pour un préassemblage de la broche et du manchon correspond à une différence négative de cotes pouvant atteindre environ 0,003" (0,008 mm).

8. Un procédé de formation d'un joint fixé dans un système de fixation comportant un organe de fixation aveugle adapté pour être reçu dans des trous alignés de pièces à fixer ensemble et pour établir un ajustement serré présélectionné après mise en place dans les trous, le procédé comprenant les étapes consistant à disposer d'une broche (12) comportant une tête élargie (16) et une tige allongée (20, 25), à disposer d'un manchon tubulaire (14) comportant une tête élargie (32) et une tige allongée (34) et adapté pour être placé sur ladite tige de broche afin que l'organe de fixation puisse être installé par application d'une force axiale relative entre ladite broche (12) et ledit manchon (14), à pourvoir ladite tige de broche (34) d'une partie d'expansion (20) généralement droite et adjacente à ladite tête de broche (16), d'une partie intermédiaire (25) séparée de ladite partie d'expansion (20) par une rainure (22) formant col de rupture, et d'une partie de traction (24, 28) adaptée pour être saisie par un outil d'installation en vue de la mise en place de l'organe de fixation par l'application de ladite force axiale relative, ladite partie d'expansion (20) ayant un diamètre d'expansion De qui est supérieur au diamètre Ds de la partie intermédiare (25), à pouvoir ledit manchon d'un trou traversant (30) dans l'ensemble uniforme et comportant un diamètre Di à l'état relaxé, à pourvoir la partie intermédiaire (25) de ladite tige de manchon (34) d'un premier diamètre extérieur Do à l'état relaxé qui est supérieur au premier diamètre intérieur Di à l'étant relaxé de ladite partie de manchon (34), à assembler ledit manchon (14) sur ladite partie intermédiaire (25) de ladite broche (12) avec ajustement serré, à appliquer la force axiale relative à l'organe de fixation pour faire en sorte que ladite partie d'expansion (20) pénètre dans ladite tige de manchon (34) et produise une expansion radiale de ladite tige de manchon (34) pour établir ladite grandeur présélectionnée d'ajustement serré avec lesdits trous alignés, la force axiale s'exerçant sur ladite tête de broche (16) établissant un contact avec l'extrémité de ladite tige de manchon (34) qui est opposée à ladite tête de manchon (32), à former une tête aveugle élargie (48) pouvant s'appliquer contre un côté desdites pièces, le mouvement axial de ladite broche (12) étant arrêté lors de la formation de ladite tête aveugle (48) et ladite broche (12) se rompant dans ladite rainure formant col de rupture en réponse à l'atteinte d'une grandeur maximale présélectionnée par ladite force axiale relative, caractérisé par les étapes consistant à former la partie intermédiaire de ladite tige de broche (20) comme une partie de calibrage généralement droite (25), ayant une longueur sensiblement égale à la longueur du trou de manchon (30), et à pourvoir ledit manchon (14) d'une surface extérieure (50) ayant un premier diamètre extérieur Do généralement uniforme, à préassembler la partie de calibrage (25) de la broche et le manchon (14) pour produire une expansion radiale de la tige de manchon (34) de façon à pourvoir sa surface extérieure (50) d'un second diamètre extérieur accru Do' tout en assurant également une expansion du manchon jusqu'à un second diamètre intérieur accru Di' qui est égal au diamètre Ds de ladite partie de calibrage (25), à réduire le second diamètre extérieur Do' de ladite surface extérieure (50) de ladite tige de manchon (34) jusqu'à un troisième diamètre extérieur réduit prédéterminé Do'' de telle sorte que, lors de l'installation de l'organe de fixation dans lesdits trous alignés des pièces, ladite surface extérieure (50) établisse l'ajustement serré présélectionné d'une grandeur désirée avec le diamètre Dw desdits trous alignés, le troisième diamètre extérieur réduit Do'' étant établi par rapport audit diamètre Dw desdits trous alignés de telle sorte que ladite broche (12) et ledit manchon (14) puissent, dans la condition de préassemblage, être reçus dans lesdits trous algnés avec un ajustement serré présélectionné.

9. Le procédé selon la revendication 8, caractérisé en outre par l'étape consistant à pourvoir la partie de traction (24, 28) de la broche (12) d'un diamètre maximal D qui et inférieur au diamètre Ds de ladite partie de calibrage (25) de ladite broche (12), le diamètre Dp de ladite partie de traction (24, 28) étant aussi inférieur au diamètre intérieur Di en l'état relaxé du manchon (14) et le diamètre Ds de ladite partie de calibrage (25) étant supérieur au diamètre intérieur Di du manchon en l'état relaxé de façon à créer entre eux un ajustement serré.

10. Le procédé selon la revendication 9, caractérisé en outre par l'étape consistant à déterminer les grandeurs dudit diamètre Ds de la partie de calibrage et dudit diamètre d'expansion De de ladite partie d'expansion (20) et à former le troisième diamètre extérieur réduit Do'' de ladite tige de manchon (34) de

telle sorte qu'il ait une grandeur conforme à la relation suivante:

$$Do'' = \sqrt{(Dw')^2 - ((De)^2 - (Ds)^2)}$$

où Dw' désigne le diamètre d'expansion désiré desdits trous alignés.

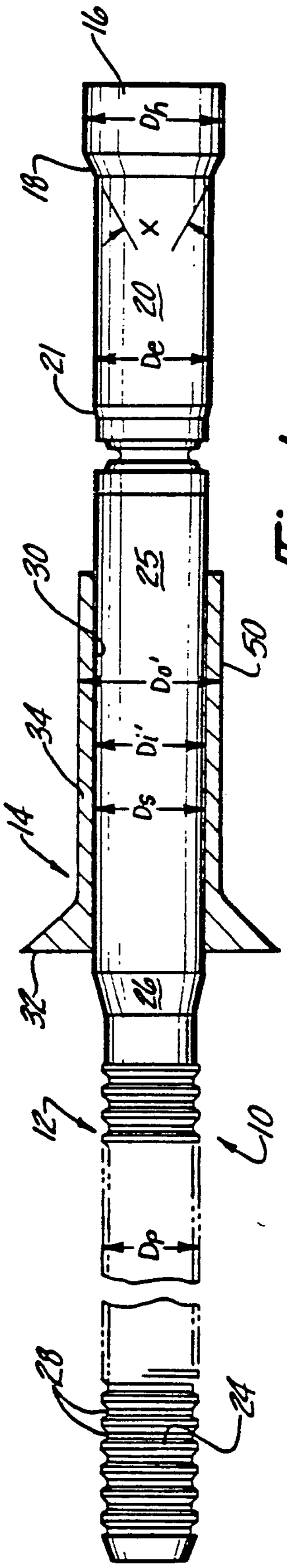
16
Dh
18
X
20
De
21
25
30
50
Do'
34
Di'
Ds
14
32
26
12
10
Dp
28
24

Fig-1

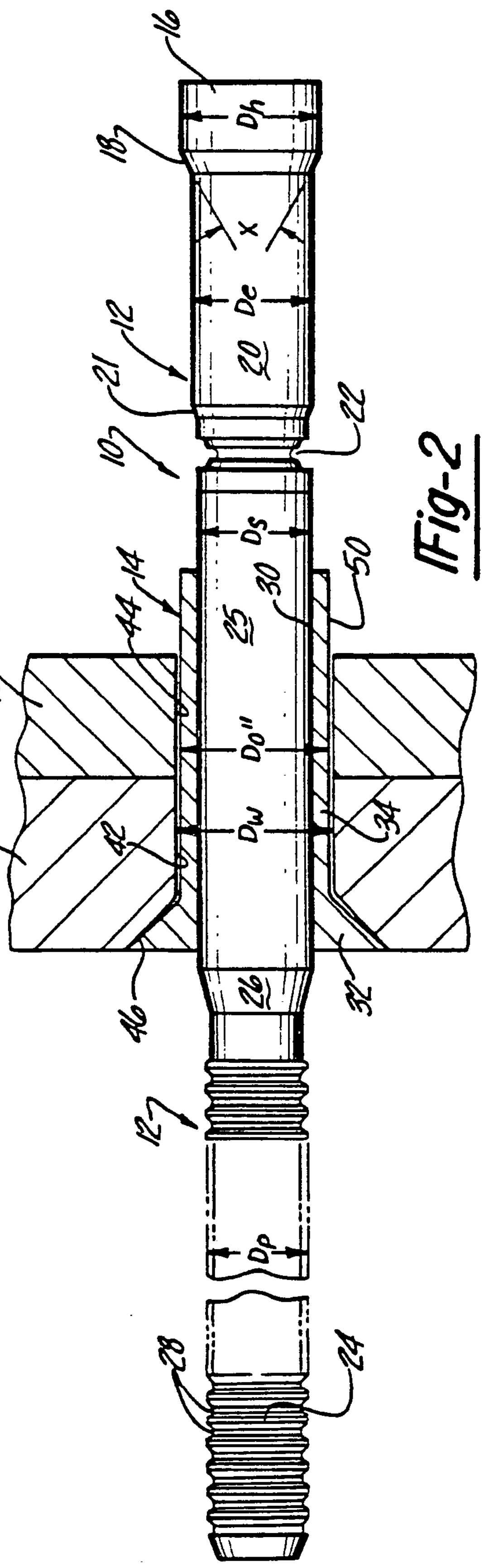
16
Dh
18
X
De
12
20
21
22
10
Ds
14
44
25
30
50
40
Do''
38
Dw
42
34
46
26
32
12
Dp
28
24

Fig-2

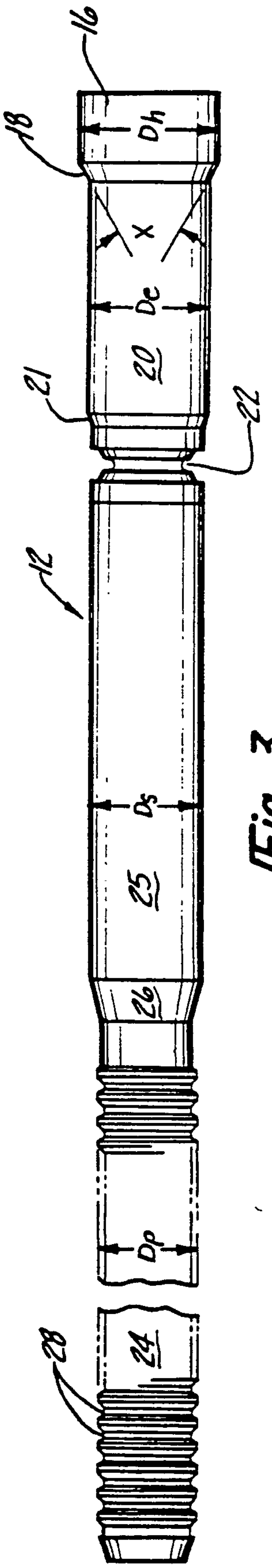

Fig-3

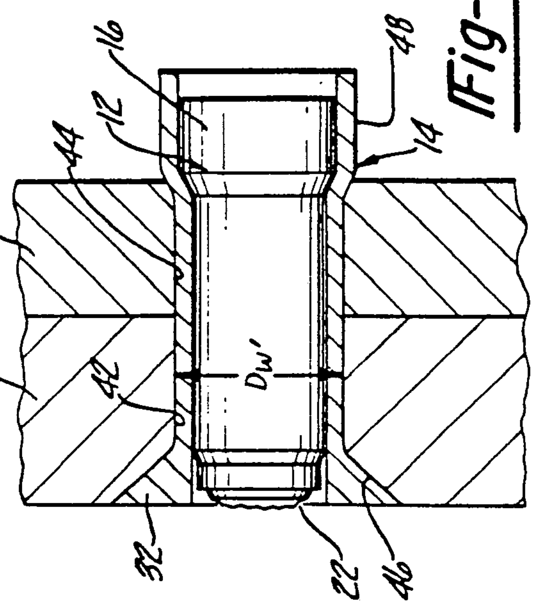

Fig-5

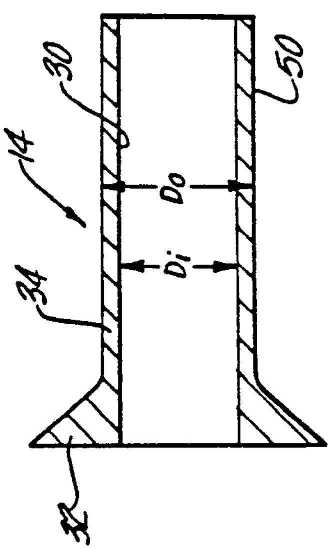

Fig-4