

(19)



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Office européen des brevets



(11)

**EP 0 527 581 B1**

(12)

## EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention  
of the grant of the patent:  
**05.06.1996 Bulletin 1996/23**

(51) Int Cl.<sup>6</sup>: **F16B 19/10**

(21) Application number: **92307037.9**

(22) Date of filing: **03.08.1992**

(54) **High strength blind bolt with uniform high clamp over an extended grip range**

Hochleistungs-Blindboltzen mit gleicher Greifkraft über einen erweiterten Greifbereich

Rivet aveugle à haute resistance avec serrage constant sur un domaine etendu

(84) Designated Contracting States:  
**DE ES FR GB IT SE**

(30) Priority: **09.08.1991 US 742866**  
**27.05.1992 US 888795**

(43) Date of publication of application:  
**17.02.1993 Bulletin 1993/07**

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**EP 0 527 581 B1**

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## Description

The present invention relates to multi-piece fasteners and more particularly to a high strength blind bolt using a lockbolt like swaged construction and providing a high final clamp load of workpieces secured together and further relates to such blind fasteners particularly adapted for constructions utilizing box beams or columns, bridges and the like.

The fastener of the present invention relates generally to multi-piece blind bolt fasteners which include a main sleeve, an expandable sleeve and a pin wherein the expandable sleeve is moved axially relative to the main sleeve and is expanded radially thereover to form a blind head in response to a relative axial force applied via the pin. In this regard the blind bolt of the present invention bears a general resemblance to a threaded blind fastener of the type shown in U.S. Patent No. 3,643,544 issued February 22, 1972 to Joseph H. Massa; fasteners of this type have been sold under the trade name Visu-Lok and/or Jo-Bolt by the Monogram Aerospace Fastener Company and Voi-Shan Manufacturing Company of the United States. See also U.S. Patent No. 3,262,353 issued July 26, 1966 to R. Waeltz et al, U.S. Patent No. 2,765,699 issued 9 October 1956 to J LaTorre, US Patent No. 2,887,003 issued 19 May 1959 to Brilmeyer and US Patent No. 3,107,572 issued 22 October 1963 to Orloff. The prior blind bolt fasteners, however, have certain problems since the main sleeve absorbs a significant portion of the clamp load developed and the clamp load, tensile strength and blind side protrusion can vary with grip range.

The blind bolt disclosed in US Patent No. 2,765,699 uses a main sleeve with a tapered nose and an expandable sleeve. In this bolt the main sleeve stays fixed and in constant contact with the expandable sleeve even after the blind head is formed.

According to one aspect of the present invention there is provided a blind bolt for securing a plurality of workpieces at a desired clamp load with the workpieces having aligned openings therein and having an accessible surface and a blind side surface and adapted to be installed by a relative axial force applied by an installation tool from the accessible surface side of the workpieces, said blind bolt comprising:

a pin member having an elongated pin shank terminating at one end in an enlarged pin head;  
said pin shank having a securing portion comprising a plurality of securing grooves;  
sleeve means adapted to receive said pin shank and comprising a main sleeve structure having an elongated sleeve shank portion, said sleeve shank portion adapted to be located in the aligned openings in the workpieces;  
said sleeve means further comprising an expandable sleeve structure being located on said pin shank between said pin head and said main sleeve struc-

ture;

an engaging member located on said pin shank at the accessible surface side of the workpieces and adapted to be engaged by the installation tool whereby a relative axial force of a first magnitude can be applied by the installation tool between said pin member and said engaging member to clamp the workpieces together at a relative axial force of a first magnitude;

said expandable sleeve structure being radially deformable in response to a relative axial force of a second magnitude less than said first magnitude to form an enlarged blind head for reacting against the blind side surface;

said blind bolt characterised by:

said sleeve means including an enlarged counter-bored structure operatively connected with said main sleeve shank portion, said counterbored structure including a frangible portion adapted to fracture at a third magnitude of relative axial force less than said first magnitude and greater than said second magnitude and to receive a portion of said main sleeve structure thereby moving said main sleeve structure out of axial load bearing engagement with said blind head, whereby said first magnitude of relative axial force and the final clamp load applied to the workpieces will be substantially unaffected by said main sleeve structure.

According to a further aspect of the present invention there is provided a blind bolt for securing a plurality of workpieces at a desired clamp load with the workpieces having aligned openings therein and having an accessible surface and a blind side surface and adapted to be installed by a relative axial force applied by an installation tool from the accessible surface side of the workpieces, said blind bolt comprising:

a pin member having an elongated pin shank terminating at one end in an enlarged pin head;  
said pin shank having a securing portion;  
sleeve means including a main sleeve structure having an elongated sleeve shank portion, said sleeve shank portion adapted to be located in the aligned openings in the workpieces, said main sleeve structure adapted to receive said pin shank;  
said sleeve means further comprising an expandable sleeve structure adapted to receive said pin shank and being located on said pin shank between said pin head and said main sleeve structure;  
engaging means operatively connected with said sleeve means and including an engaging structure adapted to be engaged by the installation tool whereby a relative axial force of a first magnitude can be applied by the installation tool between said pin member and said engaging means to clamp the workpieces together at a relative axial force of a first magnitude;

said expandable sleeve structure being radially deformable in response to the relative axial force of a second magnitude less than said first magnitude to form an enlarged blind head for reacting against the blind side surface;

said blind bolt characterised by:

said sleeve means including a collapsible structure adapted to collapse at a third magnitude of relative axial force less than said first magnitude and greater than said second magnitude with said main sleeve structure thereby moving out of an axial load bearing connection whereby said blind head will engage the blind side surface such that said first magnitude of relative axial force and the final clamp load applied to the workpieces will be substantially between said pin member, said blind head and said engaging means.

The hereinafter described and illustrated constructions of blind bolts in accordance with the present invention have a wide grip range capability and a high strength blind head of a uniform structure is formed over this wide grip range. Thus the blind head of uniform structure will have the same blind side protrusion over the grip range.

Different forms of blind bolts in accordance with the present invention will now be briefly discussed.

In one form of the invention, the high strength blind fastener includes a pin, an expandable or primary sleeve, a main or secondary sleeve, and a collar adapted to be swaged into lock grooves in the pin in response to a preselected relative axial force applied between the pin and collar. In the present invention the collar initially transmits an axial force from the swage anvil of the setting tool to the main sleeve. The pin has an enlarged head which transmits an opposite axial force against the expandable sleeve by virtue of a pulling force exerted by the tool. As the axial force increases, the expandable sleeve is moved axially relative to a tapered nose portion at the blind side of the main sleeve and is radially expanded to overengage that end of the main sleeve. In prior constructions, the amount of radial expansion of the blind head was determined by the angle of the tapered nose and its distance from the blind side of the workpieces being joined. Thus the shape and hence strength of the blind head could vary depending upon the nose angle and spacing of the expandable sleeve from the blind side surface. The pin head, of course, would not engage the tapered nose portion. Unlike prior constructions, however, the pin head is adapted to engage the nose portion of the main sleeve at which time the blind head is fully defined; the expandable sleeve and tapered nose portion, however, are provided to be of limited lengths such that the blind head is substantially fully formed when the pin head engages the nose portion and before the blind head engages the blind side of the workpieces. At this stage of the installation the workpieces have not been subjected to any clamp loads

between the collar and the blind head via the pin. In order to bring the blind head into engagement with the blind side surface, the main sleeve is provided with a frangible portion which will fracture at a preselected magnitude of relative axial force whereby the tapered nose portion and the fully formed blind head can freely move axially; the fully formed blind head will then be brought into contact with the blind side surface of the workpieces with no axial restraint from the now severed, freely collapsible main sleeve. Now the workpieces are pulled together by the further application and increase in the relative axial pulling force substantially solely between the blind head and the collar via the action on the pin. The force clamping the workpieces together continues to increase until the collar is swaged into the lock grooves on the pin. The final clamp load on the workpieces can be determined first by an initial magnitude of relative axial force attained just before the collar starts to be swaged onto the pin and thereafter by elongation of the collar in response to swage. The initial axial clamp force on the workpieces is sometimes referred to as "pre-load" while the final clamping force after full swage is referred to as "final clamp load". The beginning of swaging at this pre-load is sometimes referred to as "primary clinch".

As noted with the fastener of the present invention, a unique construction is provided in which the "final clamp load" is maximized; at the same time the fastener can be provided with a wide grip range and the maximized "final clamp load" will be generally uniformly available over this wide grip range. One of the limitations with prior blind fasteners formed as noted is that a part of the relative axial force applied between the pin and collar is expended on the main sleeve. This is avoided in the present invention since the main sleeve is formed such that after the expandable sleeve has been expanded to form the blind head the main sleeve collapses or is axially deformed such that the relative axial force thereafter is applied substantially solely between the blind head and the collar via the pin. Thus, high clamp loads can be attained similar to that attainable by two piece lock-bolt constructions such as that shown in U.S. Patent No. 4,921,384 for Swage Fasteners With A High Stand-Off Collar by Keith Nordyke and issued May 1, 1990. As will be seen the collar design of the '384 patent can also be advantageously utilized with the present invention.

In another form of the invention, a controlled tension type threaded nut and bolt construction is used. As will be seen, in this embodiment a nut member is threadably engaged on a threaded portion of the shank of the pin. A splined portion is located at the terminal end of the pin shank. An installation tool has a central socket member adapted to engage the splined portion and an outer wrench member adapted to grip the nut whereby torque can be applied between the two to provide relative rotation by which the nut is threaded onto the pin to attain the desired clamp up.

Thus the high strength blind bolt of the present in-

vention is readily adapted for use in applications in which high strength bolts, such as SAE Grade 5 (ASTM A325) or higher, are frequently used. It is also desirable for use where blind welding, nut plates and other complex construction fastening systems are used. In this regard, the blind fastener of the present invention, because of its high clamp load, is especially suited for construction of buildings, bridges, and the like where high strength and durability are of considerable importance along with the capability of providing high clamp loads of the assembled parts. Thus the blind bolt of the present invention has a high tensile strength such as SAE Grade 5 or greater and/or the tensile strength of the Japanese Grade F8T bolt or greater. In addition the unique blind bolt construction, particularly in the pull-type swage version, will have the capability of providing a final clamp load of between around 70% to around 80% of the minimum ultimate tensile load of the fastener. This is accomplished, in part, by the use of high strength ferrous materials having a high hardness.

In another form of the invention the main sleeve is of a generally straight tubular construction, i.e. without a tapered nose portion, and the blind head is formed by bulging, through column loading, the end of the expandable sleeve which is located beyond the blind side of the workpieces. In this regard, this latter form of the invention is generally of the type shown in U.S. Patents No. 2,061,628 and 2,026,629 issued November 24, 1936 to Huck, U.S. Patent No. 2,114,493 issued April 19, 1938 to Huck and U.S. Patent No. 2,527,307 issued October 24, 1950 to Huck. As with the prior embodiments, however, the blind head is first formed away from the blind side surface and the main sleeve will fracture or collapse at a higher relative axial force bringing the blind head into engagement with the blind side surface with no axial restraint from the collapsed main sleeve. Formation of the blind head at a preselected location can be facilitated by band annealing the expandable sleeve at a selected location. See in this regard U.S. Patent No. 3,253,495 issued to Orloff on May 31, 1966. As will be seen the bulbed blind head can provide an enlarged bearing surface and hence be especially useful in applications in which the workpiece openings are substantially larger than the effective diameter of the fastener.

Thus it is a general object of the present invention to provide a unique high strength blind bolt of a construction that forms a high strength blind head having a uniform, desired configuration over a wide grip range.

It is another general object of the present invention to provide a unique high strength blind bolt having a swage type construction and providing a generally uniform final clamp load over a wide grip range.

Thus it is another general object of the present invention to provide a unique high strength blind bolt utilizing a tension control type threaded construction and providing a generally uniform final clamp load over a wide grip range.

It is still another object of the present invention to

provide a unique blind bolt construction for forming high strength blind fasteners having a high strength head and including a swage type construction utilizing a collar having a high stand-off capability.

It is a general object of the present invention to provide a unique high strength blind bolt which provides a high final clamp load.

Other objects, features and advantages of the present invention will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, in which:

Figure 1 is a longitudinal view with some portions shown in section of a blind fastener of the present invention including a pin, a collar, a primary or expandable sleeve, a secondary or main sleeve having a tapered nose portion and hold-off washer in assembly relationship with workpieces to be secured together;

Figure 1A is a fragmentary view to increased scale of a portion of the pin of Figure 1 taken generally in the area of the circle 1A in Figure 1;

Figure 2 is a view similar to Figure 1 showing the blind fastener after the expandable sleeve has been axially moved over the tapered nose portion and has been radially expanded to define a blind head; Figure 3 is a view similar to Figures 1 and 2 showing the blind fastener after the blind head has been formed and the frangible portion of the main sleeve has been fractured permitting the nose portion to move axially relative to the remainder of the expansion sleeve;

Figure 4 is a view similar to Figures 1-3 showing the blind fastener after it has been finally set;

Figure 5 is a sectional fragmentary view to increased scale of the main sleeve of the fastener of Figure 1;

Figure 6 is a view similar to Figure 5 depicting a modified form of the main sleeve with a separate nose section and frangible section;

Figure 7 is a pictorial view with some parts shown broken away and others in section depicting the blind fastener of the present invention adapted for use in a box beam/column application for securing a plurality of I-beams with one I-beam shown pre-assembled;

Figure 8 is a sectional view of the structure of Figure 7 taken generally in the direction of the arrows 8-8 in Figure 7 but showing the one I-beam in place for assembly with some blind fasteners shown set and others shown prior to setting;

Figure 9 is a side elevational view with some parts shown broken away and others shown in section of the present invention adapted for use in a bridge structure application;

Figure 10 is a pictorial view depicting the use of the high strength blind fastener of the present invention adapted for use in securing a pair of box beams

together;

Figure 11 is a longitudinal view similar to Figure 1 depicting a modified form of the invention, prior to installation and in which the blind head is to be formed by bulbing through column loading;

Figure 12 is a longitudinal view of the fastener of Figure 11 in which the blind head has been formed by bulbing away from the blind side surface of the workpieces being secured;

Figure 13 is a longitudinal view of the fastener of Figure 11 depicting the fastener after it has been set;

Figure 14 is a longitudinal view to enlarged scale of the blind fastener of Figure 11;

Figure 15 is a longitudinal view similar to Figure 1 depicting a modified form of the invention utilizing a threaded nut and bolt type construction by which the fastener is installed through applied torque;

Figure 16 is a view similar to Figure 15 showing the blind fastener after the expandable sleeve has been axially moved over the tapered nose portion and has been radially expanded to define a blind head;

Figure 17 is a view similar to Figures 15 and 16 showing the fastener after it has been finally set;

Figure 18 is a fragmentary, sectional view to enlarged scale taken generally in the area of the circle 18A in Figure 15;

Figure 19 is a fragmentary, sectional longitudinal view to enlarged scale of the primary or expandable sleeve of the embodiment of Figures 15-17;

Figure 20 is an end view of the fastener of Figure 15 taken generally in the direction of the arrow 20A in Figure 15; and

Figure 21 is an end view of the set fastener of Figure 17 taken generally in the direction of the arrow 21A in Figure 17.

Looking now to Figure 1, a blind fastener 10 includes a central, core pin 12, a tubular collar 14, a primary or expandable sleeve 16, a secondary or main sleeve 18 and a hold-off washer 20. The collar 14, as shown, is of the high stand-off type shown in the '384 patent to Nordyke and hence the specific details thereof will be omitted for purposes of simplicity. The collar 14 is adapted to be swaged into lock grooves 22 in a lock groove portion 19 on an elongated shank 23 of pin 12. In the form of the invention shown in Figure 1, the lock grooves 22 are in the form of a continuous helical thread.

In some constructions the hold-off washer 20 may be eliminated and in others the collar 14 may be formed with an enlarged flange in place of such hold-off washer. As will be seen one advantage of using a separate hold-off washer 20 is that the washer 20 can be selected to be of one material and hardness to facilitate hold-off and to resist bearing loads and deformation while the collar 14 can be selected of a different material and hardness to facilitate swaging in lock grooves 22.

The collar 14 has a through bore 24 for receiving

the shank 23 of pin 12. The outer surface 32 of collar 14 is generally straight at its inner end and is generally frusto-conically shaped over its radially inclined intermediate portion to define an enlarged diameter outer end. The collar 14, however, has a generally uniform wall thickness throughout its length.

The outer tapered surface of collar 14 continues its inclination generally at the same angle over the majority of the surface towards the opposite, outer end portion of collar 14. The outer surface of the outer end portion terminates in a stand-off chamfer 34. The magnitude of radially compressive force applied by a swage anvil of an installation tool in swaging the collar 14 onto pin 12 is determined in part by the angle of the stand-off chamfer 34, which transfers load axially and radially for a given applied force via the anvil. The installation tool and swage anvil can be of a construction generally known in the art and hence the details thereof have been omitted for purposes of simplicity.

As noted in the '384 patent to Nordyke the collar 14 because of the radially outwardly tapered or conical shape of its shank will provide the desired stand-off but in addition, because of its generally uniform wall thickness, will provide a generally uniform fill of the lock grooves 22 of pin 12 without excessive necking of the pin 12 and hence with minimal distortion of the lock grooves 22.

The collar 14 is provided with a limited female thread 36 located in a straight portion of the bore 24 at the inner end of collar 14. The limited female thread 36 is adapted to threadably engage the threaded lock groove portion 19 of pin 12 to hold the components of fastener 10 together in the assembled relationship as shown in Figure 1. In this regard a construction could be utilized such as that shown in U.S. Patent No. 4,867,625 by Richard Dixon for Variable Clamp Fastener and Method issued September 19, 1989. Similarly, a construction could be used such as that shown in the U. S. Patent to Walter Smith No. 4,813,834, issued March 21, 1989. Both of the latter patents can be considered as prior art to the present invention.

The pin member 12 has an enlarged head 37 at one end of pin shank 23. The pin shank 23 has a relatively smooth portion 38 leading to the threaded lock groove portion 19; a reduced diameter pintail portion 40 is formed with a plurality of pull grooves 44 and is connected to lock groove portion 19 via an annular breakneck groove 42. The breakneck groove 42 is of a reduced cross-sectional area which is designed to fracture at a predetermined axial load.

The expandable, primary sleeve 16 is of a generally tubular shape having a generally uniform inside and outside diameter.

The secondary or main sleeve 18 has a shank portion 46 with an outer surface of generally constant maximum outside diameter D (see Figure 5); a tapered nose portion 48 is located at the inner end of shank portion 46. The tapered nose portion 48 is formed with an angle

A with a line parallel with the axis X of the fastener 10. As will be seen, the unique construction of the fastener 10 permits the selection of a wide range of angles A from between around 12° to around 20°. The main sleeve 18 has a generally uniform diameter through bore 55 terminating at its outer end in an enlarged diameter counterbore 57 defining a frangible portion 51.

The shank portion 46 of secondary sleeve 18 extends through aligned openings 50 and 52 in a pair of workpieces 54 and 56, respectively, with the outer surface 49 of workpiece 56 engaged by the hold-off washer 20. The outside diameter D of shank portion 46 of secondary sleeve 18 is selected to fit through the aligned openings 50 and 52 with a clearance fit. In this regard the diameter of pin head 37 and the outside diameter of the expandable primary sleeve 16 are generally the same, i.e. diameter D, such that each can also be accepted through the openings 50 and 52 in a clearance relationship.

The shank portion 46 of main sleeve 18 has an annular groove 53 formed in its outer surface adjacent to the frangible portion 51 which defines a reduced diameter portion 63. The outside diameter of groove 53 should be less than or equal to the inside diameter D1 of counterbore 57. An annular, frangible rib or web 61 connects the frangible portion 51 in an axially in-line and radially offset position with the groove 53. As will be seen the frangible rib 61 is selected to be of sufficient strength to accept the magnitude of relative axial force required to move the expandable sleeve 16 over the tapered nose portion 48 until the pin head 37 engages the nose portion 48 and to thereafter sever permitting the reduced diameter portion 63 to move within the frangible portion 51, i.e. the frangible portion 51 can move axially into the space defined by the groove 53. In this regard, it should be noted that the compression of the nose portion 48 against the smooth shank portion 38 of the pin 12 could be such that fracture of the rib 61 could occur with the pin head 37 slightly spaced from the nose portion 48. The length of this space is minimal being around the wall thickness of the expandable sleeve 16.

Thus to set the fastener 10, a relative axial force is exerted by an installation tool (not shown) between the pin member 12 and relative to the collar 14, secondary sleeve 18 and expandable sleeve 16.

The free end 58 of expandable sleeve 16 engages the tapered nose portion 48 on secondary sleeve 18. The inside diameter of sleeve 16 has a chamfer 59 at free end 58 at an angle substantially the same as that of nose portion 48. The chamfer 59 is slight, however, reducing the wall thickness at free end 58 by no more than around 25%. In this regard chamfer 59 is provided at both ends of the sleeve 16 whereby either end can serve as the free end 58 thereby simplifying assembly. Thus as expandable sleeve 16 is moved axially it over-engages the surface of the tapered nose portion 48 and is radially expanded. At the same time, as the pin 12 begins to move axially through the collar 14, the limited

collar thread 36 will shear or deform sufficiently to permit the pin 12 to move freely through the collar 14. As the relative axial force is thus applied, the expandable sleeve 16 will be moved axially relative to the secondary sleeve 18 over the tapered nose portion 48 until the pin head 37 engages the nose portion 48. In this position the expandable sleeve 16 will have been radially expanded to fully define the blind head 62, at a point spaced from the blind side surface 60. This is shown in Figure 2. As the relative axial force increases the frangible rib 61 fractures permitting the nose portion 48 to move generally freely axially relative to the frangible portion 51 of the sleeve 18. The axial width W of groove 53 is selected to be at least equal to the distance L from the free end 58 of expandable sleeve 16 to the blind side surface 60 of workpiece 54 after the blind head 62 is fully formed as shown in Figure 2. Thus the blind head 62 is moved into engagement with the blind side surface 60 of workpiece 54 as shown in Figure 3. Now the relative axial load is applied substantially solely between the collar 14 and the pin 12 via the pin head 37 and the blind head 62.

In this condition however, the swaging or deformation of the material of the collar 14 into the pin lock grooves 22 has not yet started and, hence, the pin 12 and collar 14 can now respond as a typical pull type swage type fastener. The relative axial load increases pulling the workpieces 54 and 56 together and swaging the material of collar 16 into the lock grooves 22. Upon completion of swage, the axial load is increased until fracture of the breakneck groove 42 whereby the pintail portion 40 is severed and the installation is completed as shown in Figure 4.

In prior constructions the angle A of nose portion 48 has been significant with regard to the strength of the resultant blind head and with regard to the grip range of the particular fastener. In addition the taper angle A has been significant both with regard to blind side clearance both in a preset condition and in the final installed condition.

It is desirable that the blind head 62 be finally formed with the free end 58 extending generally parallel to the axis X of the fastener 10. A large bell shaped or conical configuration would locate the free end 58 in an orientation which is non-parallel to the axis X; thus such a blind head would have less resistance to column loading and hence its load capacity would be reduced. To a great extent in the past the formation of the blind head 62 to the desired parallel construction was dictated by the magnitude of the angle A of nose portion 48. The larger the angle A the more the outer end 58 will be flared radially outwardly as it moves over the nose portion 48. This could require a greater blind side distance from blind side surface 60 before the outer end 58 could move sufficiently radially inwardly to assume the desired generally parallel orientation with axis X. This was a factor in order to permit such fasteners to be used over a reasonable grip range. With such prior constructions the

expandable sleeve by necessity would move past the tapered nose portion in grip conditions from maximum to minimum. But with the present invention the length LS of the expandable sleeve 16, generally, need be no longer than the tapered length LA of tapered nose portion 48 since the tapered nose portion 48 will in a sense be moved out of the way after it has accomplished its purpose of forming the blind head.

The width W of the groove 53 can be selected to define the grip range of the fastener 10. In this regard, the fastener 10 is constructed such that in the maximum grip condition the free end 58 of the fully formed blind head 62 will be spaced from the blind side surface 60 of workpiece 54 a slight distance L (see Figure 2). This is to provide sufficient spacing to ensure fracturing of the rib 61 and movement of the nose portion 48 into the frangible portion 51. With this relationship set, the width W can be selected to define the minimum grip and hence grip range of the fastener 10. Thus the width W of the groove 53 should be at least slightly greater than the grip range of the fastener 10 in order to assure complete travel of the nose portion 48 into the frangible portion 51 in the minimum grip condition. At the same time, the axial length  $L_x$  of counterbore 57 must also be sufficient such that in the minimum grip condition it will fully receive the reduced diameter portion 63 without engagement of its end 69 with the washer 20. In all cases throughout the grip range, then, the main sleeve 18 will have collapsed or deformed via fracturing of the rib 61 whereby the main sleeve 18 will no longer be in a load bearing relationship with the blind head 62 and/or the pin head 37; thus in this collapsed condition the main sleeve 18 will have no effect on the magnitude of the final clamp load attainable. With no loss of clamp load through the main sleeve 18, the final clamp load will be generally uniform throughout the grip range. Thus the construction of the present invention permits the selection of a large grip range with a resultant uniform clamp load merely by selection of the width W and length  $L_x$ . In this regard the "grip range" of a fastener is defined by the difference between the minimum and maximum total thickness of workpieces that a single fastener can secure together. It can be seen that the fastener of the present invention will be capable of generally uniformly delivering rated values, i.e. tensile, clamp load, etc., within a large grip range.

As previously noted a principal objective of the present invention is to provide a blind fastener having very high strength characteristics not present in any other blind fastener to be used in applications in which conventional high strength bolts have been used. In addition to providing a blind head 62 which geometrically has a high resistance to column buckling, the materials of the fastener 10 are selected to be of high strength and hence high hardness. Thus in one form of the invention the expandable, primary sleeve 16 can be made of a relatively high strength, ductile material such as a 4130 steel of aircraft quality having a Rockwell hardness of

between around 28Rc to around 32Rc. In addition it has been found advantageous to utilize 4130 aircraft quality steel having a nickel content greater than around .17% by weight; the related specification for the 4130 aircraft quality steel provides for a maximum nickel content of .25% by weight. It appears that the additional nickel sufficiently improves the ductility of the expandable sleeve 16 such that axial splitting of the sleeve wall from radial expansion and from high hoop stresses in installation is inhibited. In this regard with a fastener 10 with expandable sleeve 16 constructed of the materials noted and having a sleeve diameter D of around 17.4 mm (.685 inches), the wall thickness was around 2.6 mm (.102 inches) to assure that the blind head 62 was of adequate strength; in the metric system the noted dimensions would generally apply to a 16 mm fastener.

It should also be noted that the expandable sleeve 16, which is constructed of a high strength material can be provided to be of a minimum length LS which is slightly longer than the length LA of the tapered nose portion 48, i.e. by around the thickness of the expandable sleeve 16. The slight extra length of LS is provided to compensate for the possible slight spacing between the pin head 37 and the nose portion 48 at fracture of rib 61 and hence to provide that the free end 58 of the expandable sleeve 16 will terminate at the end or slightly beyond the end of the tapered portion 48. This is to assure that the blind head 62 is formed generally uniformly to the desired final diameter. This expandable sleeve 16 of minimum length can accommodate the entire grip range which as noted can be selected to be large. With the length LS of sleeve 16 at a minimum the resistance to columnar buckling is increased thereby providing a blind head with a high strength capability.

The strength of the pin member 12 is very significant and hence the pin member 12 can be constructed of a ferrous or other material having a Rockwell hardness of between around 38Rc to around 42Rc or higher such as a 4130 steel of aircraft quality. At the same time the collar 14 can be constructed of a ferrous or other material such as a 1008, 1010, or 1018 low carbon steel having a Rockwell hardness of between around 68Rb to around 78Rb. The secondary or main sleeve 18 can be constructed of a ferrous or other material such as a 4130 steel having a Rockwell hardness of between around 43Rc to around 47Rc.

The hold-off washer 20 can be constructed of a ferrous or other material such as a high carbon steel having a Rockwell hardness of between around 40 Rc to around 45 Rc. The washer 20 is thus harder than the collar 14 and generally of equal hardness to the secondary sleeve 18 and hence can effectively resist the extrusion of one into the other. In one form of the invention the washer 20 had a thickness of around 2.5 mm (0.100 inches) where the secondary sleeve 18 had an outside diameter D of around 17.4 mm (.685 inches) with the expandable sleeve 16 having the dimensions previously noted. At the same time a dry film lubricant such as mo-

lydisulphide is used to reduce friction between the moving parts. A molydisulphide such as Ecoa Lub 642 by Everlube has been found satisfactory.

One of the advantages of the use of a minimum length LS of the expandable sleeve 16 is a significant reduction in blind side clearance B (see Figure 1) resulting in part from a reduction in the blindside protrusion of the end of the nose portion 48 of main sleeve 18 from blind side surface 60 which is required to form the blind head 62. Also the final installed blind side clearance B' can be minimized (see Figure 4). In addition with the present invention the grip range of the fastener will be greater than prior constructions having the same nose angle A. All of the above can be accomplished while still meeting the desired strength characteristics for the fastener 10.

With the use of high strength, high hardness materials stress concentrations can be a factor in the load capability and overall performance of the fastener. Thus it is desirable to minimize stress concentrations at high load areas.

As noted, it is desirable to reduce the stress concentrations such as that at the juncture between the inner surface 65 of the pin head 37 and smooth shank portion 38. This is accomplished by providing a generally streamlined shape to the fillet 71 located at that juncture. Such a streamlined shape is approximated by utilizing a double radius of R1 and R2 (see Figure 1A). The larger radius R1 is generally tangent to the shank portion 38 and is around twice the radius R2 which is generally tangent to the inner surface 65 of pin head 37. For a pin 12 having a pin shank portion 38 with a diameter of around 11.4 mm (.450 inches) and a pin head 37 having an outside diameter of around 17.4 mm (.685 inches) a radius R1 of 2.6 mm (.102 inches) and a radius R2 of 1.27 mm (.050 inches) was found satisfactory in reducing the stress concentration ratio at fillet 71. In this context the fillet 71 extended for an axial distance d of around 2 mm (.080 inches).

It should also be noted that the slight chamfers 59 on the inside diameter at the opposite ends of expandable sleeve 16 plus its inner radial clearance with the smooth pin shank portion 38 assures that the confronting end of expandable sleeve 16 will not engage the fillet 71.

In addition to the reduction of the stress concentration at fillet 71, as noted, the lock grooves 22 are formed to be generally shallow in depth and to have roots of the generally streamlined contour. Thus the lock grooves 22 could utilize the groove shape and concepts of U.S. Patent No. 5,090,852 by Richard D. Dixon for High Strength Fastener and Method filed on April 20, 1988 and issued on February 25, 1992. With this root construction, the stress concentration at the lock grooves 22 is also reduced.

As noted, the enlarged diameter outer portion of tapered collar 14 will provide stand-off resistance to initial swage, i.e. primary clinch. The interaction of the swage

surface of the swage anvil and the angle of the stand-off chamfer 34 are such as to assist in providing a preselected stand-off whereby initiation of swaging of the collar 14 into the lock grooves 22 will not begin until that lower magnitude of relative axial force has been attained which is sufficient to form the blind head 62.

As noted in the '852 Dixon patent, the pin grooves 22 can be of a shallow helical construction with a generally streamlined shape whereby a high strength construction can be achieved having a desirable high clamp load. With the noted shallow groove structure, the volume of the collar 14 was selected to generally provide 'overpacking', i.e., a volume of material to provide substantially more volume of collar material for filling pin grooves 22 than is available within the swage envelope defined by the cavity of the swage anvil and the confronting lock grooves 22. In that construction, it has been found desirable to provide a volume of collar material which has an excess of at least around 14% to around 16%.

To enhance the strength of fastener 10 the pin grooves 22 and adjacent pin shoulders and the complementary grooves and shoulders of the swaged collar 14 can be proportioned in width relative to the respective shear strengths of the materials of pin 12 and collar 14, such that both the shoulders defined by pin grooves 22 of the pin 12 and the shoulders defined by interlock grooves of the swaged collar 14 are in incipient or simultaneous failure in shear at or above the preselected minimum ultimate design tensile load on associated workpieces 54 and 56. It is preferred that the design provide for the shoulders defined by the grooves of collar 14 to fail prior to the shoulders defined by pin lock grooves 22, i.e. the shoulders of pin lock grooves 22 would fail in shear at approximately 110% of the tensile load at which the shoulders of collar 14 would fail. By proportioning the grooves as noted, the engaged length of pin and collar can be minimized for a given tensile load. Of course, by providing sufficient collar length, the above shear strength relationship can be maintained while providing for a tensile failure diametrically across the pin lock groove portion 19.

As noted it is desirable that the high strength fastener of the present invention provide a high final clamp load to the fastened joint. To achieve this result high installation loads including final pin break load at breakneck groove 42 are required from the installation tool. These loads, however, are generally absorbed by the tool and are thus not fully transmitted to the operator handling the installation tool. Thus the high load occurring at pin break at breakneck groove 42 is substantially absorbed by the tool by virtue of the fact that the swaged collar is tightly located within the swage anvil of the tool.

Thus it is important that the breakneck groove 42 not fail prematurely since this could result in undesirable shock loads being transmitted to the operator.

In order to assure complete swage of the collar 14 without premature pin break at breakneck groove 42, it

is desirable that the difference Df in magnitude between the magnitude of relative axial force Ds to swage the collar 14 and relative axial force Db to cause pin break at breakneck groove 42 be large in order to avoid premature pin break and the undesired shock load to the operator. In one example the difference Df was around 40 percent of the pin break load Db with the swage load Ds being around 60 percent of the pin break load Db. Also in order to avoid a tensile failure in the pull grooves 44 at the high relative axial setting loads encountered it was found desirable to have the root diameter of the breakneck groove 42 relative to the root diameter of the pull grooves to be in the ratio of around .82:1.

With the fastener 10 installed, the swaged collar 14 will have a complementary female thread formed in its through bore 24.

The embodiment of Figures 1 and 2 shows the main sleeve 18 to be of a one piece construction. However, a main sleeve of a multiple pieced construction could be used advantageously and such is shown in Figure 6. Thus in Figure 6 components similar to like components in the embodiment of Figures 1, 2 and 5 are given the same numeral designation with the addition of the subscript "e".

Thus in Figure 6, the main sleeve 18e is shown to be substantially identical to sleeve 18 of Figure 1 but of a two piece structure. The nose portion 48e is part of a nose shank section 73 while the frangible portion 51e is part of a separate stepped shank section 75. The shank section 75 is of a stepped construction with a reduced diameter portion 53e of an outside diameter D1e performing the function of the groove 53 of Figure 1. At the same time the counterbore 57e is also formed to be of the diameter D1e. The functioning of the two piece main sleeve 18e would then be essentially the same as that of sleeve 18. However, the use of a separate nose shank section 73 and stepped shank section 75 could facilitate and simplify manufacturing procedures. In addition a common nose shank section 73 could be used with different lengths of stepped shank section 75 to accommodate different fastener lengths. This could not only further simplify manufacture but also reduce the inventory of the noted components.

Looking now to Figures 7 and 8, a box beam/column construction 70 is shown and comprises a vertically mounted box beam/column 72 utilized to secure horizontally extending I-beams 74 via pairs of flanged attachment brackets 76 adapted to be secured to the box beam/column 72 by fasteners of the present invention.

With prior constructions, joints such as that shown in Figures 7 and 8 have required relative complex procedures and/or fastening structures such as blind welding, nut plates, and the like. With the present invention a simpler yet effective attachment structure can be used.

Thus each of the flanged attachment brackets 76 is generally T-shaped and has a base portion 78 and a central leg portion 80 extending transversely therefrom.

The base portion 78 can be provided with a plurality of bores 82 adapted to match a similar plurality of bores 84 in the adjacent wall portion 87 of the box beam/column 72. The I-beam 74 is located between the central leg portions 80 of a cooperating pair of brackets 76 and secured thereto by a plurality of fasteners 86 which can be threaded fasteners or other type of non-blind fastener. Now the blind fastener 10 of Figure 1 is applied between the base portion 78 of bracket 76 and the wall portion 87 to secure the two elements together.

It should be noted that the box beam/column 72 can be of a standard construction having standard dimensions such that the internal distance N between walls 87 will be around 150 mm (5.9 inches). At the same time the distance G between the center lines of the receiving holes or bores 84 will be around 80 mm (3.15 inches). This will then provide a limit on the blind side clearance between fasteners 10 where two or more I-beams 74 or other structures are to be attached to the box beam/column 72 at the different side walls 87 via brackets 76. Figure 8 is a sectional view showing four I-beams 74 with brackets 76 mounted to each. In the preset condition the blind side of the fastener 10 will extend the greatest distance into the open section inside the box beam/column 72. It is desirable in such applications that the set fastener have a minimal blind side protrusion. This is shown in Figure 8 with the set fasteners indicated as 10' and the preset fasteners indicated as 10. Thus in the present invention it is important that the blind side clearance required for the preset fastener 10 and set fastener 10' be limited and/or minimized. This is accomplished by the use of nose portion 48 and hence expandable sleeve 16 of a minimum length.

Thus in Figure 8 with the blind side protrusion of the set fastener 10' being reduced as noted the center line distance G can be maximized such that the adjacent preset fastener 10 can be inserted proximate to but in clearance relationship with the blind side of set fastener 10'. For a secondary or main sleeve 18 of diameter D of around 17.4 mm (.685 inches), the primary or expandable sleeve 16 can have a length LS of from around 10.6 mm (.420 inches) to around 11.7 mm (.460 inches) and the blind side protrusion B would be between around 33 mm (1.30 inches) and 34.5 mm (1.36 inches) over the grip range of the fastener. Another advantage of the fastener 10 of the present invention in the application such as Figure 8, is its ease of removability. Thus the set collar need only be cut-off and the remainder of the fastener pushed through and later replaced with a new fastener.

Frequently bridges and roadways, either being newly constructed or repaired, require the attachment of beams, support brackets and the like in areas which are either generally inaccessible from one side or accessible only through relatively complex procedures. Figure 9 illustrates a typical construction in which accessibility to one side of a structure is generally blocked. In the description of the embodiment of Figure 9 components similar to like components in the embodiment of

Figures 1-2 have been given the same number designation with the addition of the letter postscript "a".

Thus a concrete (or other type) road surface 81 is supported on a structure including a generally horizontal support plate 83. The support plate 83 is in turn supported by a generally T shaped vertical structure 91 defined by vertical plates 85, 85' and L-shaped brackets 89. The T-shaped structure 91 is secured to the support plate 83 by a plurality of fasteners 10a and 10a' constructed in the manner of fastener 10. The fastener 10a is shown in its pre-set condition while fasteners 10a' are shown in the set condition. Thus the fastener 10a (10a') includes a pin 12a having an enlarged pin head 37a and an expandable sleeve 16a, a main sleeve 18a, a hold-off washer 20a and a swageable collar 14a. Note that the blind side of the joint must be provided with cavities 90 which are formed by a special drilling technique with the support plate 83 in place. Here it is desirable that the depth M of the cavity 90 be maintained at a minimum. Thus the fastener 10a having a minimized blind side clearance requirement is well suited for such applications and hence the cavities 90 need be of a depth M only slightly greater than the blind side clearance B. This can be seen from the preset fastener 10a which can be configured to have the minimum blind side clearance for the maximum grip condition. While conventional bolts can be used in such applications it is only by way of complex procedures by which openings are formed in the support plate 83 to permit access to the concrete or blind side of the support plate 83.

Figure 10 depicts another box beam type construction in which the fastener of the present invention can be advantageously utilized. In the description of the embodiment of Figure 10 components similar to like components in the embodiment of Figures 1-2 and 4 have been given the same number designation with the addition of the letter postscript "b".

Thus in Figure 10 a pair of box beams 72b (similar to box beam 72 of Figure 4) are to be secured together end-to-end by way of generally flat brackets 92. Here rows of blind fasteners 10b can be used through aligned openings 94 and 96 in the beams 72b and brackets 92 respectively to secure the beams 72b together in the end-to-end orientation shown. Other constructions would require weld nuts, nut plates, welding or other relatively complex structures and/or procedures.

Looking now to Figures 11-14 a modified form of the blind fastener is shown in which components similar to like components in the embodiment of Figures 1-5 have been given similar numeral designations with the addition of the letter postscript "c".

Looking now to Figures 11 and 14, a blind fastener 10c includes a central, core pin 12c, a tubular collar 14c, a primary or expandable sleeve 16c, a secondary or main sleeve 18c and a hold-off washer 20c. The pin 12c, collar 14c and hold-off washer 20c can be of a construction and material the same as pin 12, collar 14 and washer 20 of Figures 1-3 and hence the specific details there-

of will be omitted for purposes of simplicity. Thus the collar 14c is adapted to be swaged into lock grooves 22c in a threaded lock groove portion 19c on an elongated shank 23c of pin 12c. The collar 14c has a through bore 24c for receiving the shank 23c of pin 12c.

The collar 14c is provided with a limited female thread 36c located in a straight portion of the bore 24c at the inner end of collar 14c. The limited female thread 36c is adapted to threadably engage the threaded lock groove portion 19c of pin 12c to hold the components of fastener 10c together in the assembled relationship as shown in Figure 11.

The pin member 12c has an enlarged head 37c at one end of pin shank 23c. The pin shank 23c has a relatively smooth portion 38c leading to the threaded lock groove portion 19c; a reduced diameter pintail portion 40c is formed with a plurality of pull grooves 44c and is connected to lock groove portion 19c via an annular breakneck groove 42c. The breakneck groove 42c is of a reduced cross-sectional area which is designed to fracture at a predetermined axial load.

The expandable, primary sleeve 16c is of a generally tubular shape having a generally uniform outside diameter Dc and a generally uniform inside diameter D1c.

The secondary or main sleeve 18c has a main shank portion 46c with an outer surface also of a generally constant outside diameter Dc and a bore 55c with an inside diameter D1c, the same as expandable sleeve 16c. The main shank portion 46c terminates in an end shank portion 100 of a reduced outside diameter of a diameter D1c' for a purpose to be seen. The end shank portion 100 of main sleeve 18c has a generally uniform reduced diameter bore D2 which extends partially into bore 55c thereby defining an annular frangible rib or web 61c.

The main shank portion 46c and end shank portion 100 of secondary sleeve 18c extend through aligned openings 50c and 52c in a pair of workpieces 54c and 56c, respectively, with the outer surface 49c of workpiece 56c engaged by the hold-off washer 20c. The outside diameter Dc of main shank portion 46c of secondary sleeve 18c is selected to fit through the aligned openings 50c and 52c with a clearance fit. In this regard the diameter of pin head 37c and the outside diameter Dc of the expandable primary sleeve 16c are generally the same, i.e. diameter Dc.

The outside diameter D1c' of end shank portion 100 should be less than or equal to the inside diameter D1c of main shank portion 46c. The frangible rib 61c is selected to be of sufficient shear strength to accept the magnitude of relative axial force required to bulb the expandable sleeve 16c to form a blind head 62c and to thereafter sever permitting the reduced diameter end shank portion 100 to move within the main shank portion 46c, i.e. the end shank portion 100 can move axially into the bore 55c of main shank portion 46c.

The main sleeve 18c can be constructed of the same materials as main sleeve 18. The expandable

sleeve 16c can be constructed of a hardenable material such as a low to medium carbon steel. The expandable sleeve 16c is through hardened to a Rockwell hardness of around Rb95. In order to facilitate the formation of blind head 62c at a desired location, the expandable sleeve 16c is band annealed over a section 102. The band annealed section 102 is preferably located midway along the length of the expandable sleeve 16c in order to provide the formation of the bulbed blind head 62c at this mid location. In one form of the invention the annealed section 102 was annealed to a Rockwell hardness of around Rb70.

Thus to set the fastener 10c, a relative axial force is exerted by an installation tool (not shown) between the pin member 12c and relative to the collar 14c, secondary sleeve 18c and expandable sleeve 16c.

The free end 48c of expandable sleeve 16c engages the confronting end 58c of secondary sleeve 18c. As the relative axial force is thus applied, the expandable sleeve 16c will collapse at the band annealed section 102 folding radially outwardly to form the blind head 62c. At the same time, as the pin 12c moves axially through the collar 14c, the limited collar thread 36c will shear or deform sufficiently to permit the pin 12c to move freely through the collar 14c. In this position the expandable sleeve 16c will have been collapsed to fully define the blind head 62c, at a point spaced a distance  $L_c$  from the blind side surface 60c. This is shown in Figure 12. As the relative axial force increases the frangible rib 61c fractures permitting the main shank portion 46c to move generally freely axially relative to the end shank portion 100 of the sleeve 18c. The axial width  $W_c$  of end shank portion 100 is selected to be at least equal to the distance  $L_c$  from the blind head surface 104 of blind head 62c to the blind side surface 60c of workpiece 54c after the blind head 62c is fully formed as shown in Figure 12. Thus the blind head 62c is moved into engagement with the blind side surface 60c of workpiece 54c as shown in Figure 13. Now the relative axial load is applied substantially solely between the collar 14c and the pin 12c via the pin head 37c and the blind head 62c.

Upon completion of swage, the axial load is increased until fracture of the breakneck groove 42c whereby the pintail portion 40c is severed and the installation is completed as shown in Figure 13.

The width  $W_c$  of the end shank portion 100 can be selected to define the grip range of the fastener 10c. In this regard, the fastener 10c is constructed such that in the maximum grip condition the spacing  $L_c$  of the blind head engaging surface 104 of the fully formed blind head 62c from the blind side surface 60c of workpiece 54c is a slight distance. This is to provide sufficient spacing to ensure fracturing of the rib 61c and movement of the main shank portion 46c over the end shank portion 100. With this relationship set, the width  $W_c$  can be selected to define the minimum grip condition and hence grip range of the fastener 10c.

It should be noted that the expandable sleeve 16c,

can be provided to be of a minimum length  $L_S$  sufficient to assure that the blind head 62c is formed generally uniformly to the desired final diameter. This expandable sleeve 16c of minimum length can accommodate the entire grip range which as noted can be selected to be large. At the same time the bulbed blind head 62c will be of a relatively large diameter thereby providing for a large bearing area against the blind side surface 60c. The large diameter blind head 62c also permits use of the fastener 10c in applications where there is relatively large clearance between the workpiece openings 50c and 52c and the main sleeve 18c.

Note that with the construction as shown in Figures 11-13 a single expandable sleeve 16c could be used with a number of different lengths of fasteners such as fastener 10c, i.e. longer or shorter pins 12c and main sleeves 18c. At the same time it should be noted that, in some applications, the expandable sleeve 16c and main sleeve 18c could be made of a one piece construction. Likewise the collar 14c could be made integrally with the main sleeve 18c and also in a unitary construction with the expandable sleeve 16c. In this regard means other than the collar 14c could be utilized for locking together the pin 12c and expandable sleeve 16c with blind head 62c.

In another form of the present invention a tension control threaded type system is utilized and thus a threaded nut and bolt type construction is provided. Such a system is shown in Figures 15-21 where components similar to like components in the embodiment of Figures 1-5 have been given the same numeral designation with the addition of the letter postscript "f". Unless otherwise stated, the description of such similar components which was given in the discussion of Figures 1-5 shall be considered to apply to the same numbered components with the postscript "f" in Figures 15-21.

Looking now to Figures 15-17, a blind fastener 10f includes a central, core bolt or pin 12f, a threaded nut 14f, a primary or expandable sleeve 16f, a secondary or main sleeve 18f and a hold-off washer 20f.

The pin 12f has an enlarged head 37f at one end of pin shank 23f. The pin shank 23f has a relatively smooth portion 38f leading to a threaded shank portion 19f; a reduced diameter splined, pintail portion 40f is formed with a plurality of circumferentially disposed, axially extending splines 44f (see Figure 20) and is connected to the threaded portion 19f via an annular breakneck groove 42f. The breakneck groove 42f is of a reduced cross-sectional area which is designed to fracture at a predetermined torsional load. As can be seen in Figure 15, the nut 14f is adapted to be threadably engaged with the threaded shank portion 19f.

The expandable, primary sleeve 16f and the secondary or main sleeve 18f are generally identical with primary sleeve 16 and main sleeve 18 of Figures 1-5 and hence the specific details thereof shall not be repeated here.

In contrast to the pull and swage type fastener 10 of Figures 1-5, the threaded or torque type fastener 10f is adapted to be set by torque applied between the pin 12f and nut 14f via the threaded engagement of nut 14f on the threaded shank portion 19f. The installation can be accomplished by a tool 101 of a construction generally known in the art and hence only a portion of the tool 101 is shown and the details thereof have been omitted for purposes of simplicity. The nut 14f has a conventional hexagonal outer surface 103 which is adapted to be drivingly engaged by a tubular socket like outer wrench member 105 having a hexagonally shaped inner surface 106 at its outer end configured to matingly receive the hexagonal outer nut surface 103. The tool 101 has a central socket member 108 which has an inner surface 110 at its outer end which is splined to matingly receive the splined pintail portion 40f of the pin member 12f. In one form of tool 101, the central member 108 is resiliently axially biased forwardly to provide sufficient engagement with the splined pintail portion 40f as shown in Figure 15 to accept the initial torque loads. The outer wrench member 105 and central member 108 are adapted to be rotated relative to each other. Thus to install the fastener 10f the tool 101 is applied to the outer end of the fastener 10f with the wrench member 105 in engagement with the hexagonal nut surface 103 and with the central member 108 in engagement with the splined pintail portion 40f. When the tool 101 is actuated the wrench member 105 is rotated relative to the central member 108 whereby the nut 14f is threaded onto the threaded shank portion 19f. Note that as this occurs the pin member 12f moves axially relative to the nut 14f until there is full engagement between splined portion 40f and inner socket surface 110. After such full engagement the resilient bias on the central member 108 permits it to be moved axially rearwardly to thus accommodate the additional axial movement of the pin member 12f relative to the tool 101.

Thus in this way a relative axial force is developed between the pin member 12f and the secondary sleeve 18f and expandable sleeve 16f by virtue of the torque applied by the tool 101 between the pin 12f and nut 14f.

The free end 58f of expandable sleeve 16f engages the tapered nose portion 48f on secondary sleeve 18f. The inside diameter of sleeve 16f has a chamfer 59f at free end 58f at an angle substantially the same as that of nose portion 48f (see Figure 19). Chamfer 59f is provided at both ends of the sleeve 16f whereby either end can serve as the free end 58f thereby simplifying assembly. Thus as expandable sleeve 16f is moved axially it overengages the surface of the tapered nose portion 48f and is radially expanded. At the same time, as the pin 12f begins to move axially via the relative rotation with the nut 14f, the relative axial force is thus applied and the expandable sleeve 16f will be moved axially relative to the secondary sleeve 18f over the tapered nose portion 48f until the pin head 37f engages the nose portion 48f. In this position the expandable sleeve 16f will have

been radially expanded to fully define the blind head 62f, at a point spaced from the blind side surface 60f. This is shown in Figure 16. As the relative axial force increases the frangible rib 61f fractures permitting the nose portion 48f to move generally freely axially relative to the frangible portion 51f of the sleeve 18f. The axial width Wf of groove 53f is selected to be greater than the distance Lf from the free end 58f of expandable sleeve 16f to the blind side surface 60f of workpiece 54f after the blind head 62f is fully formed as shown in Figure 16. In a minimum grip condition, i.e. workpieces 54f and 56f of minimum total thickness, the width Wf should be at least slightly greater than the distance Lf to assure that the fractured nose portion 48f is removed from load bearing engagement with the expanded sleeve 16f. Thus the blind head 62f is moved into engagement with the blind side surface 60f of workpiece 54f as shown in Figure 17. As noted, with the fractured nose portion 48f out of load bearing engagement, the resultant relative axial load resulting from the torque between the nut 14f and pin 12f is applied substantially solely between the nut 14f and the pin 12f via the pin head 37f and the blind head 62f.

In this condition the applied torque and resultant axial load is increased until fracture of the breakneck groove 42f whereby the pintail portion 40f is severed and the installation is completed as shown in Figure 17. The remaining fractured portion 42f' of breakneck groove 42f is indicated in Figures 17 and 21. Thus the final clamp load attained and applied by the set fastener 10f of Figure 17 will not be affected by the fractured nose portion 48f.

The torque applied fastener 10f will have the same minimum blind side clearance Bf in its preset condition (Figure 15) and the same minimum blind side clearance in its set condition (Figure 17) as the pull type fastener 10 of Figures 1-5. In order to minimize the length of the pintail portion 40f and the protruding length P of the threaded pin shank portion 19f after installation, the lengths of both the pintail portion 40f and of the threaded pin shank portion 19f have been minimized. In order to start formation of the blind head 62f by expanding the expandable sleeve 16f, threaded engagement between all of the threads of the nut 14f and threads of the threaded pin shank portion 19f is not required. Thus the number of threads initially engaged is selected to be around 25% greater than that required to withstand the applied torque to start the formation of the blind head 62f without thread damage. It is believed preferable that at least three full threads be initially engaged. Similarly full engagement of the splined inner surface 110 of central socket member 108 with the splined pintail portion 40f is not initially necessary. As can be seen in Figure 16, with the blind head 62f fully formed there is now greater engagement of the threads of the nut 14f with the threads of the threaded pin shank portion 19f. At the same time there is also greater engagement of the splined inner surface 110 and the splined pintail portion 40f. In this way the overall length of the fastener 10f can

be limited and perhaps more importantly the extent of final pin protrusion P can be limited over the grip range of the fastener 10f. In this regard the final pin protrusion P in the maximum grip condition, by the proper selection of the amount of required thread engagement at different stages of installation, can be substantially zero or set to be no greater than the minimum blind side clearance Lf (see Figure 16).

As previously noted with the pull type fastener 10 of Figures 1-5, a principal objective of the present invention is to provide a blind fastener having very high strength characteristics not present in other blind fasteners whereby such blind fastener can be used in applications in which conventional high strength bolts have been used. In addition to providing a blind head 62f which geometrically has a high resistance to column buckling, the materials of the fastener 10f are selected to be of high strength and hence high hardness and are generally the same as that described for the fastener 10. In addition, however, the nut 14f can be made of a high strength material such as a 4130 alloy steel of aircraft quality having a Rockwell hardness of between around 28Rc to around 32Rc or of the same Rockwell hardness as pin member 12f, i.e. between around 38Rc to around 42Rc.

It should be noted that the number of threads of nut 14f engaged with the threaded pin shank portion 19f in full, final engagement is selected to be sufficient to provide the desired high level of clamp up of the workpieces 54f and 56f and to resist the maximum design tensile load on the resultant joint. Thus the nut height or width H of nut 14f is selected to be sufficient to provide the necessary number of threads to withstand these loads on full engagement. At the same time the length of the threaded pin shank portion 19f is selected to provide full thread engagement with the threads of nut 14f over the entire grip range of the fastener 10f while providing the minimum protruding length P. In this way the overall length of the fastener 10f can be minimized in both the installed and uninstalled conditions.

As noted with fastener 10 of Figures 1-5, by being able to utilize an expandable sleeve 16f of a minimum length, excessive flaring of the free end 58f is avoided; this factor plus the shorter overall length provides excellent resistance to buckling under column loading. As with the pull type fastener 10, with fastener 10f a dry film lubricant such as molydisulphide can be used to reduce friction between the moving parts. A molydisulphide such as Ecoa Lub 642 by Everlube is believed to be satisfactory.

It is important that the axis of expandable sleeve 16f be maintained in coaxial alignment with the axis of the pin 12f during the installation cycle including formation of the blind head 62f and its engagement with the blind side surface 60f. In order to avoid high frictional forces caused by engagement between the nose portion 48f and the smooth pin shank portion 38f as the sleeve 16f is radially expanded, the inside diameter of the nose por-

tion 48f and sleeve 16f are provided to have a preselected desired radial clearance with the confronting surface of the pin shank portion 38f. Note, however, that when the frangible rib 61f fractures the severed nose portion 48f is free to move axially away from the sleeve 16f which has now been expanded. As a result of the radial clearance, the sleeve 16f could, in some applications, move or shift radially relative to the pin shank portion 38f and hence shift radially relative to the axis of the pin 12f such that the axis of the sleeve 16f is no longer in coaxial alignment with the axis of the pin 12f; this could place the sleeve 16f in a position eccentric to the workpiece opening 50f. In this condition one side of the sleeve 16f could initially move partially into the workpiece opening 50f whereby the bearing engagement would be irregular circumferentially causing an off-center or circumferentially irregular engagement with the underside of the pin head 37f. This could result in loss of strength and/or premature failure of the installed fastener. To maintain the desired concentricity and to avoid tilting or loss of coaxial alignment a tapered surface 112 of enlarged and increasing diameter is provided on the pin shank portion 114 immediately adjacent to and connected with the underside surface 116 of the pin head 37f (see Figure 18). The tapered surface 112 on the pin shank portion 114 is provided with the same angle of taper as the tapered end 59f of expandable sleeve 16f. Now when the expandable sleeve 16f is located on the pin shank 23f the mating tapered surfaces 59f and 112 will guide the associated end of sleeve 16f towards the pin head 37f and aid in capturing and holding it in the desired coaxial position whereby a uniform, concentric engagement with the underside surface 116 will be assured; this in turn will assure the proper formation of the blind head 62f and uniform engagement with the blind side surface 60f around the workpiece opening 50f. The pin shank portion 114 is smoothly connected to the pin head underside surface 116 by a radiused fillet 118. The radius Rf of fillet 118 is selected to minimize any stress concentration at that point. However, the stresses at the fillet 118 are generally reduced, in any event, because it is radially closer to the outer end of the pin head 37f by virtue of the connecting shank portion 114. In one form of the fastener 10f the tapered surfaces 59f and 112 were inclined at an angle Af of 20° relative to the longitudinal axis of the pin 12f. Also the radius Rf of fillet 118 for a pin 12f having a shank diameter Df of 15.5 mm (.609 inches) was 0.76 mm (.03 inches) and had the center C of radius Rf located generally a distance DR of 2.26 mm (.089 inches) from the radially outer surface 120 of pin head 37f (see Figures 15 and 18).

The underside surface 116 of pin head 37f is inclined from fillet 118 radially outwardly and axially forwardly relative to a plane transverse to the longitudinal axis of the pin 12f generally at an angle Af' of 15°. This is to ensure that the associated engaging end of the expandable sleeve 16f would not engage the fillet 118 but rather would engage the underside surface 116 at a

point radially outwardly from the fillet 118. The construction of the underside surface 116 including angle Af' is selected to cooperate and to assist in capturing and holding the sleeve 16f in the desired coaxial position as discussed above.

It should be noted that the above described construction for capturing and holding the sleeve 16f in the desired coaxial position could be employed with the pull type fastener 10 of Figures 1-4.

In addition to the reduction of the stress concentrations, as noted, the threads 22f of the threaded shank portion 19f are formed to be generally shallow in depth and to have roots of a generally streamlined contour. Thus, in one embodiment, the threads 22f could utilize the groove shape and concepts of '852 Dixon patent previously noted. With this root construction, the stress concentration at the threads 22f is also reduced.

As noted in the '852 Dixon patent, the threads 22f can be of a shallow helical construction with a generally streamlined shape whereby a high strength joint construction can be achieved having a desirable high clamp load. With the noted shallow thread structure, a close tolerance fit with the threads of the nut 14f is desirable. In one form of the invention a Class 3 thread fit was utilized. Thus with a major diameter of 12.7 mm (.500 inches) on the threads 22f of the pin shank portion 19f, a minor diameter of 12.6 mm (.495 inches) was used on the mating threads of the nut 14f.

As noted it is desirable that the high strength fastener of the present invention provide a high final clamp load to the fastened joint. To achieve this result high installation loads including final pin break load at breakneck groove 42f are required from the installation tool 101. These loads, however, are applied by torque and hence are generally absorbed by the tool 101 and are essentially not transmitted to the operator handling the installation tool 101. Thus the high load occurring at pin break at breakneck groove 42f is substantially absorbed by the tool 101 by virtue of the torque application of the fastener 10f.

As with the fastener 10 of the embodiment of Figures 1 and 2, a main sleeve (such as 18f) of a multiple pieced construction could be used advantageously with the fastener 10f such as sleeve 18e with sections 73 and 75 as shown in Figure 6.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope of the claims.

## Claims

1. A blind bolt (10, 10c, 10f) for securing a plurality of workpieces at a desired clamp load with the workpieces (54, 54c, 54f, 56, 56c, 56f) having aligned

openings (50, 52, 50c, 52f) therein and having an accessible surface (49, 49c, 49f) and a blind side surface (60, 60c, 60f) and adapted to be installed by a relative axial force applied by an installation tool from the accessible surface (49, 49c and 49f) side of the workpieces (54, 54c, 54f, 56, 56c, 56f), said blind bolt (10, 10c, 10f) comprising:

a pin member (12, 12c, 12f) having an elongated pin shank (23, 23c, 23f) terminating at one end in an enlarged pin head (37, 37c, 37f); said pin shank (23, 23c, 23f) having a securing portion comprising a plurality of securing grooves (22, 22c, 22f),

sleeve means adapted to receive said pin shank (23, 23c, 23f) and comprising a main sleeve structure (18, 18c, 18e, 18f) having an elongated sleeve shank portion (46, 46c, 46f, 73, 75), said sleeve shank portion (46, 46c, 46f, 73, 75) adapted to be located in the aligned openings (50, 50c, 50f, 52, 52c, 52f) in the workpieces (54, 54c, 54f, 56, 56c, 56f),

said sleeve means further comprising an expandable sleeve structure (16, 16c, 16f) being located on said pin shank (23, 23c, 23f) between said pin head (37, 37c, 37f) and said main sleeve structure (18, 18c, 18e, 18f),

an engaging member (14, 14c, 14f) located on said pin shank (23, 23c, 23f) at the accessible surface (49, 49c, 49f) side of the workpieces (54, 54c, 54f, 56, 56c, 56f) and adapted to be engaged by the installation tool whereby a relative axial force of a first magnitude can be applied by the installation tool between said pin member (12, 12c, 12f) and said engaging member (14, 14c, 14f) to clamp the workpieces (54, 54c, 54f, 56, 56c, 56f) together at a relative axial force of a first magnitude,

said expandable sleeve structure (16, 16c, 16f) being radially deformable in response to a relative axial force of a second magnitude less than said first magnitude to form an enlarged blind head (62, 62d, 62f) for reacting against the blind side surface (60, 60c, 60f),

said blind bolt characterized by:

said sleeve means including an enlarged counterbored structure (51, 51f, 63, 75) operatively connected with said main sleeve shank portion, said counterbored structure (51, 51f, 63, 75) including a frangible portion (61, 61c, 61f) adapted to fracture at a third magnitude of relative axial force less than said first magnitude and greater than said second magnitude and to receive a portion (53, 53e, 53f) of said main sleeve structure (18, 18c, 18e, 18f) thereby moving said main sleeve structure (18, 18c, 18e, 18f) out of axial load bearing engagement with said blind head (62, 62c, 62f), whereby

said first magnitude of relative axial force and the final clamp load applied to the workpieces (54, 54c, 54f, 56, 56c, 56f) will be substantially unaffected by said main sleeve structure (18, 18c, 18e, 18f).

2. The blind bolt (10f) of claim 1 with said securing grooves (22f) of said pin shank (23f) being defined by a helical thread form (22f), said engaging member (14f) having a mating thread form adapted to be threadably engaged with said securing grooves (22f) whereby the relative axial force between said pin member (12f) and said engaging member (14f) is provided by the relative torque applied between said pin member (12f) and said engaging member (14f).

3. The blind bolt (10, 10c) of claim 1 with said securing grooves (22, 22c) of said pin shank (23, 23c) being defined by lock grooves (22, 22c), said engaging member (14, 14c) being a swageable collar (14, 14c) adapted to be located on said pin shank (23, 23c) and to be swaged into said lock grooves (22, 22c) by the installation tool in response to the relative axial force of said first magnitude as applied by the installation tool.

4. The blind bolt (10, 10c) of claim 1 with:

said securing grooves (22, 22c) comprising a plurality of lock grooves (22, 22c) and with said pin shank (23, 23c) having a pull portion (40, 40c) comprising a plurality of pull grooves (44, 44c),

said engaging member being a tubular collar structure (14, 14c) operatively associated with said main sleeve structure (18, 18c) and located on said pin shank (23, 23c) at the accessible surface (49, 49c) side of the workpieces (54, 54c, 56, 56c) and adapted to be swaged into said lock grooves (22, 22c) in response to the relative axial force of a first magnitude applied by the installation tool between said pull grooves (44, 44c) on said pin shank (23, 23c) and said collar structure (14, 14c).

5. The blind bolt (10, 10c, 10f) of any of claims 1-4 with said main sleeve structure (18, 18c, 18e, 18f) terminating at its end opposite from said expandable sleeve structure (16, 16c, 16f) in an enlarged counterbored portion (51, 51e, 51f, 63, 75), an annular grooved portion (53, 53e, 53f, 100) formed on the outer surface of said sleeve shank portion (46, 46c, 46f, 73, 75) adjacent to said enlarged counterbored portion (51, 51e, 51f, 63, 75) and adapted to move axially within said counterbored portion (51, 51e, 51f, 63, 75), said frangible portion (61, 61c, 61f)

connecting said enlarged counterbored portion (51, 51e, 51f, 63, 75) with said annular grooved portion (53, 53e, 53f, 100), said frangible portion (51, 51e, 51f, 61, 61c, 61f) adapted to fracture at a third magnitude of relative axial force less than said first magnitude and greater than said second magnitude with said grooved portion (53, 53e, 53f, 100) moving axially into said enlarged counterbored portion (51, 51e, 51f, 63, 75) thereby moving said main sleeve structure (18, 18c, 18e, 18f) out of axial load bearing engagement with said blind head (62, 62a, 62f), whereby said first magnitude of relative axial force and the final clamp load applied to the workpieces (54, 54c, 54f, 56, 56c, 56f) will be substantially unaffected by said main sleeve structure (18, 18c, 18e, 18f).

6. The blind bolt (10, 10f) of any of claims 1-5 with said main sleeve structure (18, 18e, 18f) having an elongated sleeve shank portion (46, 46f, 73, 75) terminating at an inner end in a tapered nose portion (48, 48e, 48f), said main sleeve structure (18, 18e, 18f) having a first through bore (55) adapted to receive said pin shank (23, 23f) with said first bore (55) having a central axis (x),

said expandable sleeve structure (16, 16f) being a separate member from said main sleeve structure (18, 18e, 18f) and having a second through bore adapted to receive said pin shank (23, 23f) and being located on said pin shank (23, 23f) between said pin head (37, 37f) and said tapered nose portion (48, 48e, 48f),

said tapered nose portion (48, 48e, 48f) defining a preselected angle (A) with said central axis (x),

said expandable sleeve structure (16, 16f) moving axially relative to and expanding radially over said nose portion (48, 48e, 48f) in response to the relative axial force of said second magnitude to form an enlarged blind head (62, 62f) for reacting against the blind side surface (60, 60f).

7. The blind bolt (10, 10f) of claim 6 with said expandable sleeve structure (16, 16f) having a length (LS) within a range of from generally equal to or slightly greater than the length of said tapered nose portion (48, 48e, 48f).

8. The blind bolt (10) of claim 5 with said main sleeve structure (18) including a separate sleeve member (75), said enlarged counterbored portion (57e) and said grooved portion (53e) being on said separate sleeve member (75).

9. The blind bolt (10) of claim 6 with said main sleeve

structure (18) including a separate sleeve member (75) from said tapered nose portion (73), said enlarged counterbored portion and said grooved portion being on said separate sleeve member (75),

said expandable sleeve structure (16) having an axial length generally equal to the axial length of said tapered nose portion (48), said annular groove (53e) and said enlarged counterbored portion (51e) having axial lengths selected to define the grip range of the fastener (10), where the grip range is defined as the difference between the minimum and maximum total thickness of the workpieces that a single fastener can secure together.

10. The blind bolt (10) of claims 1-7 with said sleeve shank portion and said frangible portion of said main sleeve structure (73, 75) comprising a frangible section (75) and a separate sleeve shank section (73), said sleeve shank section (73) and said frangible section (75) adapted to be located in the aligned openings (50, 52) in the workpieces (54, 56),

said frangible section (75) having a radially stepped construction and terminating at its end opposite from said pin head in said enlarged counterbored portion (57e).

11. The high strength blind bolt (10, 10c, 10f) of claims 5, 8 and 10 with said annular groove (53, 53e, 53f, 100) and said enlarged counterbored portion (55c, 57, 57e, 57f) having axial lengths selected to define the grip range of the fastener (10, 10c, 10f), where the grip range is defined as the difference between the minimum and maximum total thickness of the workpieces that a single fastener can secure together.

12. The blind bolt (10f) of claim 1 with said expandable sleeve structure (16f) being located generally in radial clearance relationship with the confronting surface of said pin shank (23f),

guide means (59f, 112) operatively associated with said expandable sleeve structure (16f) and said pin shank adjacent said pin head for holding said expandable sleeve structure (16f) in a generally coaxial relationship with said pin shank (23f) after said main sleeve structure (18f) has moved out of axial load bearing engagement with said blind head (62f).

13. The blind bolt (10f) of claim 12 with said guide means (59f, 112) comprising an enlarged diameter portion (112) on said pin shank (23f) adjacent to said pin head (37f) adapted to be engageable with

the associated end (59f) of said expandable sleeve structure (16f).

14. The blind bolt (10f) of claim 12 with said guide means (59f, 112) comprising an enlarged diameter tapered portion (112) on said pin shank (23f) adjacent to said pin head (37f) adapted to be engageable with the associated end (59f) of said expandable sleeve structure (16f).

15. The blind bolt (10f) of claim 12 with said guide means (59f, 112) comprising an enlarged diameter tapered portion (112) on said pin shank (23f) adjacent to said pin head (37f) adapted to be engageable with the associated end (59f) of said expandable sleeve structure (16f) said associated end (59f) of said expandable sleeve structure (16f), having a cooperating taper (59f) engageable with said tapered portion (112) on said pin shank (23f).

16. The blind bolt (10, 10c, 10f) of claims 1-15 further comprising an enlarged hold-off washer (20, 20c, 20f) adapted to engage the accessible surface (49, 49c, 49f) of the workpieces (54, 54c, 54f, 56, 56c, 56f) and said engaging member 14, 14c, 14f),

said expandable sleeve structure (16, 16c, 16f) having a Rockwell hardness of between around 28Rc to around 32Rc,

said pin member (12, 12c, 12f) having a Rockwell hardness of between around 38Rc to around 42Rc,

said expandable sleeve structure (16, 16c, 16f) being constructed of a quality steel having a nickel content greater than around .17% by weight,

said main sleeve structure (18, 18c, 18e, 18f) having a Rockwell hardness of between around 43Rc to around 47Rc, and

said hold-off washer (20, 20c, 20f) having a Rockwell hardness of between around 40Rc to around 45Rc, whereby a high strength blind bolt is formed.

17. A blind bolt (10, 10c, 10f) for securing a plurality of workpieces (54, 54c, 54f, 56, 56c, 56f) at a desired clamp load with the workpieces (54, 54c, 54f, 56, 56c, 56f) having aligned openings (50, 50c, 50f, 52, 52c, 52f) therein and having an accessible surface (49, 49c, 49f) and a blind side surface (60, 60c, 60f) and adapted to be installed by a relative axial force applied by an installation tool from the accessible surface (49, 49c, 49f) side of the workpieces (54, 54c, 54f, 56, 56c, 56f), said blind bolt (10, 10c, 10f) comprising:

a pin member (12, 12c, 12f) having an elongated pin shank (23, 23c, 23f) terminating at

one end in an enlarged pin head (37, 37c, 37f); said pin shank (23, 23c, 23f) having a securing portion (22, 22c, 22f),

sleeve means including a main sleeve structure (18, 18c, 18e, 18f) having an elongated sleeve shank portion (46, 46c, 46f, 73, 75), said sleeve shank portion (46, 46c, 46f, 73, 75) adapted to be located in the aligned openings (50, 50c, 50f, 52, 52c, 52f) in the workpieces (54, 54c, 54f, 56, 56c, 56f), said main sleeve structure (18, 18c, 18e, 18f) adapted to receive said pin shank (23, 23c, 23f),

said sleeve means further comprising an expandable sleeve structure (16, 16c, 16f) adapted to receive said pin shank (23, 23c, 23f) and being located on said pin shank (23, 23c, 23f) between said pin head (37, 37c, 37f) and said main sleeve structure (18, 18c, 18e, 18f), engaging means (14, 14c, 14f) operatively connected with said sleeve means and including an engaging structure adapted to be engaged by the installation tool whereby a relative axial force of a first magnitude can be applied by the installation tool between said pin member (12, 12c, 12f) and said engaging means (14, 14c, 14f) to clamp the workpieces (54, 54c, 54f, 56, 56c, 56f) together at a relative axial force of a first magnitude,

said expandable sleeve structure (16, 16c, 16f) being radially deformable in response to the relative axial force of a second magnitude less than said first magnitude to form an enlarged blind head (62, 62c, 62f) for reacting against the blind side surface (60, 60c, 60f),

said blind bolt characterized by:

said sleeve means including a collapsible structure (51, 63, 75, 100) adapted to collapse at a third magnitude of relative axial force less than said first magnitude and greater than said second magnitude with said main sleeve structure (18, 18c, 18e, 18f) thereby moving out of an axial load bearing connection whereby said blind head (62, 62c, 62f) will engage the blind side surface (60, 60c, 60f) such that said first magnitude of relative axial force and the final clamp load applied to the workpieces (54, 54c, 54f, 56, 56c, 56f) will be substantially between said pin member (12, 12c, 12f), said blind head (62, 62c, 62f) and said engaging means (14, 14c, 14f).

- 18.** The blind bolt (10, 10f) of claim 17 with said main sleeve structure (18, 18e, 18f) and said expandable sleeve structure (16, 16e, 16f) being separate members,

said main sleeve structure (18, 18e, 18f) having an elongated sleeve shank portion (46, 46f, 73,

75) terminating at an inner end in a tapered nose portion (48, 48e, 48f), said sleeve shank portion (46, 46f, 73, 75) adapted to be located in the aligned openings (50, 50f, 52, 52f) in the workpieces (54, 54f, 56, 56f), said main sleeve structure (18, 18e, 18f) having a first through bore (55) adapted to receive said pin shank (23, 23f) with said first bore (55) having a central axis (x),

said expandable sleeve structure (16, 16f) having a second through bore adapted to receive said pin shank (23, 23f) and being located on said pin shank (23, 23f) between said pin head (37, 37f) and said tapered nose portion (48, 48e, 48f),

said tapered nose portion (48, 48e, 48f) defining a preselected angle (A) with said central axis (x),

said expandable sleeve (16, 16f) moving axially relative to and expanding radially over said nose portion (48, 48e, 48f) in response to the relative axial force of said second magnitude to form the enlarged blind head (62, 62f) for reacting against the blind side surface (60, 60f).

- 19.** The blind bolt (10f) of claim 17 with said securing portion (22f) being defined by a helical thread form (22f), said engaging means (14f) having a mating thread form adapted to be threadably engaged with said securing portion (22f) whereby the relative axial force between said pin member (12f) and said engaging means (14f) is provided by the relative torque applied between said pin member (12f) and said engaging means (14f).

- 20.** The blind bolt (10, 10c) of claim 17 with said securing portion (22, 22c) of said pin shank (23, 23c) being defined by lock grooves (22, 22c), said engaging means (14, 14c) being a swageable collar (14, 14c) adapted to be located on said pin shank (23, 23c) and to be swaged into said lock grooves (22, 22c) by the installation tool in response to the relative axial force of said first magnitude as applied by the installation tool.

- 21.** The blind bolt (10, 10c, 10f) of claims 17 and 18 with said engaging means (14, 14c, 14f) including lock means (14, 14c, 14f) operatively connected with said sleeve means and including a lock structure adapted to be moved into engagement with said securing portion (22, 22c, 22f) in response to the relative axial force of a first magnitude applied by the installation tool whereby the final clamp load applied to the workpieces (54, 54c, 54f, 56, 56c, 56f) will be substantially between said pin member (12, 12c, 12f), said blind head (62, 62c, 62f) and said lock means of said engaging means (14, 14c, 14f).

22. The blind bolt (10, 10c) of claims 17 and 18 with

said securing portion (22, 22c) of said pin shank (23, 23c) comprising a plurality of lock grooves (22, 22c) and with said pin shank (23, 23c) having a pull portion (40, 40c) comprising a plurality of pull grooves (44, 44c),  
 said engaging means including a collar structure (14, 14c) located on said pin shank (23, 23c) at the accessible surface (49, 49c) side of the workpieces (54, 54c, 56, 56c) and adapted to be swaged into said lock grooves (22, 22c) in response to the relative axial force of a first magnitude applied by the installation tool between said pin member (12, 12c) and said collar structure (14, 14c) whereby the final clamp load applied to the workpieces (54, 54c, 56, 56c) will be substantially between said pin member (12, 12c), said blind head (62, 62c) and said collar structure (14, 14c) of said engaging means.

23. The blind bolt (10c) of claims 17, 21 and 22 with said expandable sleeve structure (10c) having a weakened portion (102) adapted to fold radially outwardly to form said blind head (62c) in a bulb form in response to the relative axial force of said second magnitude.

24. The blind bolt of claims 17, 21 and 22 with said main sleeve structure (18c) and said expandable sleeve structure (16c) being separate members,

said main sleeve structure (18c) having an elongated sleeve shank portion (46c) adapted to be located in the aligned openings (50c, 52c) in the workpieces (54c, 56c), said main sleeve structure (18c) having a first through bore adapted to receive said pin shank (23c), said expandable sleeve structure (16c) having a second through bore adapted to receive said pin shank (23c) and being located on said pin shank (23c) adjacent said pin head (37c), said expandable sleeve structure (16c) having a weakened portion (102) adapted to fold radially outwardly to form said blind head (62c) in a bulb form in response to the relative axial force of said second magnitude.

25. The blind bolt (10, 10c, 10f) of claims 17, 21, 22 and 24 with said main sleeve structure (18, 18c, 18f) being formed as one piece with said collapsible structure (51, 63, 100).

26. The blind bolt (10, 10c, 10f) of claims 17-25 with said collapsible structure (51, 63, 75, 100) of said main sleeve structure (18, 18c, 18e, 18f) including a frangible section (61, 61c, 61f) adapted to fracture

at said third magnitude of relative axial force.

27. The blind bolt of claims 17-25 with said collapsible structure (51, 63, 75, 100) of said main sleeve structure (18, 18c, 18e, 18f) including a radially stepped structure defined by two sleeve portions (46, 46c, 46f, 51, 51e, 51f, 53e, 100) connected by a frangible section (61, 61c, 61f) with said frangible section (61, 61c, 61f) adapted to fracture at said third magnitude of relative axial force to permit said stepped structure to axially move within itself.

28. The blind bolt (10) of claim 18 with said collapsible structure (75) being a member separate from the remainder (73) of said main sleeve structure 18e.

29. The blind bolt (10, 10e, 10f) of claims 18 and 28 with said expandable sleeve structure (16, 16e, 16f) having a length within a range of from generally equal to or slightly greater than the length of said tapered nose portion (48, 48e, 48f) by around the wall thickness of said expandable sleeve structure (16, 16e, 16f).

30. The blind bolt (10, 10c) of claim 22 with

said pin shank (23, 23c) having a breakneck groove (42, 42c) located between said lock grooves (22, 22c) and said pull grooves (44, 44c) and adapted to fracture at a preselected magnitude of relative axial force after said collar structure (14, 14c) has been fully swaged in said lock grooves (22, 22c), the root diameter of said breakneck groove (42, 42c) relative to that of said pull grooves (44, 44c) being in the ratio of around .82:1 to inhibit fracture at one of said pull grooves (44, 44c) at a magnitude of relative axial force less than that of said breakneck groove (42, 42c).

31. The blind bolt (10, 10c, 10f) of claims 17-30 with

said pin shank (23, 23c, 23f) having a generally smooth shank portion (38, 38c, 38f) extending generally from said pin head (37, 37c, 37f) to said securing portion (22, 22c, 22f), said pin head (37, 37c, 37f) connected to said smooth shank (portion (38, 38c, 38f) by a streamlined fillet generally defined by a first radius (R1) which is generally tangent to said smooth shank portion (38, 38c, 38f) and a second radius (R2) which is generally tangent to the inner surface (65) of said pin head (37, 37c, 37f), said first radius (R1) being around twice the magnitude of said second radius (R2).

32. The blind bolt (10, 10c, 10f) of any of claims 17-31

with

said workpieces including a box beam (72) and a structure (74, 76) to be secured to at least two adjacent, transverse sides (87) of said box beam (72),

said adjacent transverse sides (87) defining a corner,

sets of aligned openings (82, 84) having axes in a common plane with at least two of said sets of aligned openings (82, 84) being in each adjacent transverse side at said corner,

one said blind bolt (10, 10c, 10f) located in each of said sets of aligned openings (82, 84) at said corner with an installed one of said blind bolt (10, 10c, 10f) providing clearance within said box beam (72) with a preinstalled one of said blind bolt (10, 10c, 10f) at said corner.

33. The blind bolt (10, 10c, 10f) of any of claims 17-31 with

said workpieces including at least a pair of plate like members (83, 89) with one (83) of said members (83, 89) generally located in engagement with a relatively solid substrate (81),

said aligned openings in said pair of members (83, 89) being in line with a blind cavity (90) in said substrate (81) with said blind cavity (90) being formed while said substrate (81) is adjacent said one (83) of said members (83, 89),

said blind bolt (10, 10c, 10f) in the preset condition having the blind side protrusion of said pin head (37a) and said expandable sleeve (16a) selected to be a minimum with the clearance of said pin head (37a) with said cavity (90) being a minimum.

34. The blind bolt (10, 10c, 10f) of claims 17-26 and 28-33 being a high strength blind bolt with the desired clamp load being between around 70% to around 80% of the minimum ultimate tensile strength of the installed blind bolt and with

said sleeve shank portion (46, 46c, 46f, 73, 75) of said main sleeve structure (18, 18c, 18e, 18f) terminating at its end opposite from said pin head (37, 37c, 37f) in an enlarged counterbored portion (51, 51f, 55c, 63, 75), said collapsible structure (51, 63, 75, 100) including a grooved portion (53e, 53f, 63, 100) and a frangible portion (61, 61c, 61f), said grooved portion (53e, 53f, 63, 100) having an annular groove (53, 53e, 53f, 100) formed on the outer surface of said sleeve shank portion adjacent to said enlarged counterbored portion (51, 51f, 55c, 63, 75) and adapted to move axially within said enlarged counterbored portion (51, 51f, 55c,

63, 75), said frangible portion (61, 61c, 61f) connecting said enlarged counterbored portion (51, 51f, 55c, 63, 75) with said annular grooved portion (53e, 53f, 63, 100), said frangible portion (61, 61c, 61f) adapted to fracture at a third magnitude of relative axial force less than said first magnitude and greater than said second magnitude with said grooved portion (53e, 53f, 63, 100) moving axially into said enlarged counterbored portion (51, 51f, 55c, 63, 75) thereby moving said main sleeve structure (18, 18c, 18e, 18f) out of axial load bearing engagement with said blind head (62, 62c, 62f), whereby the final clamp load applied to the workpieces (54, 54c, 54f, 56, 56c, 56f) will be substantially unaffected by said main sleeve structure (18, 18c, 18e, 18f),

an enlarged hold-off washer (20, 20c, 20f) adapted to engage the accessible surface (49, 49c, 49f) of the workpieces (54, 54c, 54f, 56, 56c, 56f) and said engaging means (14, 14c, 14f),

said expandable sleeve structure (16, 16c, 16f) having a Rockwell hardness of between around 28Rc to around 32Rc,

said pin member (12, 12c, 12f) having a Rockwell hardness of between around 38Rc to around 42Rc,

said expandable sleeve structure (16, 16c, 16f) being constructed of a quality steel having a nickel content greater than around .17% by weight,

said hold-off washer (20, 20c, 20f) having a Rockwell hardness of between around 40Rc to around 45Rc, whereby a high strength blind bolt is formed,

said main sleeve structure (18, 18c, 18e, 18f) having a Rockwell hardness of between around 43Rc to around 47Rc.

## Patentansprüche

1. Blindbolzen (10, 10c, 10f) zum Befestigen einer Vielzahl von Werkstücken mit einer gewünschten Vorspannkraft, wobei die Werkstücke (54, 54c, 54f, 56, 56c, 56f) fluchtende Bohrungen (50, 52, 50c, 52f) darin besitzen und eine zugängliche Fläche (49, 49c, 49f) und eine nicht zugängliche Seitenfläche (60, 60c, 60f) haben, und welcher ausgelegt ist, um mit einer relativen Axialkraft montiert zu werden, die mit einem Montagewerkzeug von der zugänglichen Seite (49, 49c und 49f) der Werkstücke (54, 54c, 54f, 56, 56c, 56f) aufgebracht wird, wobei der Blindbolzen (10, 10c, 10f) aufweist:

ein Stift-Bauteil (12, 12c, 12f), welches einen verlängerten Stiftschaft (23, 23c, 23f) besitzt,

welcher an einem Ende mit einem vergrößerten Stiftkopf (37, 37c, 37f) endet, wobei der Stiftschaft (23, 23c, 23f) einen Sicherungsabschnitt hat, welcher eine Vielzahl von Sicherungsrillen (22, 22c, 22f) aufweist, eine Hülse-Einrichtung, die ausgelegt ist, den Stiftschaft (23, 23c, 23f) aufzunehmen und welche einen Haupthülse-Aufbau (18, 18c, 18e, 18f) aufweist, der einen verlängerten Hülse-Abschnitt (46, 46c, 46f, 73, 75) hat, wobei der Hülse-Abschnitt (46, 46c, 46f, 73, 75) ausgelegt ist, um in die fluchtenden Bohrungen (50, 50c, 50f, 52, 52c, 52f) in den Werkstücken (54, 54c, 54f, 56, 56c, 56f) eingesetzt zu werden, und die Hülse-Einrichtung ferner einen Spreizhülse-Aufbau (16, 16c, 16f) aufweist, welcher auf dem Stiftschaft (23, 23c, 23f) zwischen dem Stiftkopf (37, 37c, 37f) und dem Haupthülse-Aufbau (18, 18c, 18e, 18f) angeordnet ist, ein Eingriffs-Bauteil (14, 14c, 14f), das auf dem Stiftschaft (23, 23c, 23f) an der zugänglichen Seitenfläche (49, 49c, 49f) der Werkstücke (54, 54c, 54f, 56, 56c, 56f) angeordnet ist, und welches ausgelegt ist, um mit dem Montagewerkzeug einzugreifen, wodurch eine relative Axialkraft einer ersten Größenordnung zwischen dem Stift-Bauteil (12, 12c, 12f) und dem Eingriffs-Bauteil (14, 14c, 14f) mit dem Montagewerkzeug aufgebracht werden kann, um die Werkstücke (54, 54c, 54f, 56, 56c, 56f) bei einer relativen Axialkraft einer ersten Größenordnung miteinander festzuklemmen, wobei der Spreizhülse-Aufbau (16, 16c, 16f) infolge einer relativen Axialkraft einer zweiten Größenordnung, welche geringer als die erste Größenordnung ist, radial verformbar ist, um einen vergrößerten Blindkopf (62, 62c, 62f) zu bilden, um auf die nicht zugängliche Seite der Fläche (60, 60c, 60f) zu wirken, und der Blindbolzen dadurch **gekennzeichnet** ist, daß die Hülse-Einrichtung einen erweiterten, ausgesenkten Abschnitt (51, 51f, 63, 75) aufweist, welcher in Wirkverbindung mit dem Haupthülse-Abschnitt ist, daß der ausgesenkte Abschnitt (51, 51f, 63, 75) einen Sollbruch-Bereich (61, 61c, 61f) aufweist, der ausgelegt ist, um bei einer dritten Größenordnung der relativen Axialkraft, welche geringer als die erste Größenordnung und größer als die zweite Größenordnung ist, zu brechen und um einen Abschnitt (53, 53e, 53f) des Haupthülse-Aufbaus (18, 18c, 18e, 18f) aufzunehmen und dadurch den Haupthülse-Aufbau (18, 18c, 18e, 18f) aus einem Axiallast Eingriff mit dem Blindkopf (62, 62c, 62f) zu bewegen, wodurch die erste Größenordnung der relati-

ven Axialkraft und die endgültige Vorspannkraft, die auf die Werkstücke (54, 54c, 54f, 56, 56c, 56f) aufgebracht wird, im wesentlichen von dem Haupthülse-Aufbau (18, 18c, 18e, 18f) unbeeinflusst bleibt.

## 2. Blindbolzen (10f) gemäß Anspruch 1

mit den Sicherungsrillen (22f) des Stiftschaftes (23f), die durch ein schraubenförmiges Gewinde (22f) definiert sind und mit dem Eingriffs-Bauteil (14f) welches ein Gegengewinde besitzt, das ausgelegt ist, um mit den Sicherungsrillen (22f) verschraubbar ineinander zu greifen, wobei die relative Axialkraft zwischen dem Stift-Bauteil (12) und dem Eingriffs-Bauteil (14f) durch das relative Drehmoment geliefert wird, welches zwischen dem Stift-Bauteil (12f) und dem Eingriffs-Bauteil (14f) aufgebracht wird.

## 3. Blindbolzen (10, 10c) gemäß Anspruch 1

mit den Sicherungsrillen (22, 22c) des Stiftschaftes (23, 23c), die durch Versperrillen (22, 22c) definiert sind, und dem Eingriffs-Bauteil (14, 14c), welches eine verpreßbare Buchse (14, 14c) ist, die ausgelegt ist, um auf dem Stiftschaft (23, 23c) angeordnet zu sein und um infolge der mit dem Montagewerkzeug aufbrachten relativen Axialkraft der ersten Größenordnung mit dem Montagewerkzeug in die Versperrillen (22, 22c) gedrückt zu werden.

## 4. Blindbolzen (10, 10c) gemäß Anspruch 1 mit:

den Sicherungsrillen (22, 22c), welche eine Vielzahl von Versperrillen (22, 22c) aufweisen, und mit dem Stiftschaft (23, 23c), welcher einen Zugabschnitt (40, 40c) hat, der eine Vielzahl von Zugrillen (44, 44c) aufweist, dem Eingriffs-Bauteil, welches ein rohrförmiger Buchsen-Aufbau (14, 14c) ist, der mit dem Haupthülse-Aufbau (18, 18c) in Wirkverbindung ist, und auf dem Stiftschaft (23, 23c) an der zugänglichen Fläche (49, 49c) der Werkstücke (54, 54c, 56, 56c) angeordnet ist, und ausgelegt ist, um infolge der mit dem Montagewerkzeug zwischen den Zugrillen (44, 44c) auf dem Stiftschaft (23, 23c) und dem Buchsen-Aufbau (14, 14c) aufbrachten relativen Axialkraft einer ersten Größenordnung in die Versperrillen (22, 22c) gedrückt zu werden.

## 5. Blindbolzen (10, 10c, 10f) gemäß einem der Ansprüche 1 bis 4

mit dem Haupthülsen-Aufbau (18, 18c, 18e, 18f) mit seinem dem Spreizhülsen-Aufbau (16, 16c, 16f) gegenüberliegenden Ende, das mit einem erweiterten ausgesenkten Abschnitt (51, 51e, 51f, 63, 75) endet, einem ringförmig genuteten Abschnitt (53, 53e, 53f, 100), welcher an der Außenfläche des Hülsenschaft-Abschnitts (46, 46c, 46f, 73, 75) angrenzend an den erweiterten ausgesenkten Abschnitt (51, 51e, 51f, 63, 75) geformt ist, und welcher ausgelegt ist, sich axial innerhalb des ausgesenkten Abschnitts (51, 51e, 51f, 63, 75) zu verschieben, dem Sollbruch-Abschnitt (61, 61c, 61f), welcher den erweiterten, ausgesenkten Abschnitt (51, 51c, 51e, 51f, 63, 75) mit dem ringförmig genuteten Abschnitt (53, 53e, 53f, 100) verbindet, wobei der Sollbruch-Abschnitt (61, 61c, 61f) ausgelegt ist, um bei einer dritten Größenordnung einer relativen Axialkraft, welche geringer als die erste Größenordnung und größer als die zweite Größenordnung ist, zu brechen, und der ringförmig genutete Abschnitt (53, 53e, 53f, 100), sich in den erweiterten ausgesenkten Abschnitt (51, 51e, 51f, 63, 75) axial verschiebt, und dadurch den Haupthülsen-Aufbau (18, 18c, 18e, 18f) aus einem Axiallast Eingriff mit dem Blindkopf (62, 62a, 62f) bewegt, wodurch die erste Größenordnung der relativen Axialkraft und die endgültige Vorspannkraft, die auf die Werkstücke (54, 54c, 54f, 56, 56c, 56f) aufgebracht wird, im wesentlichen von dem Haupthülsen-Aufbau (18, 18c, 18e, 18f) unbeeinflusst bleibt.

6. Blindbolzen (10, 10f) gemäß einem der Ansprüche 1 bis 5 mit:

dem Haupthülsen-Aufbau (18, 18e, 18f), der einen verlängerten Hülsenschaft-Abschnitt (46, 46f, 73, 75) hat, der an einem inneren Ende mit einem kegeligen Vorderabschnitt (48, 48g, 48f) endet, wobei der Haupthülsen-Aufbau (18, 18e, 18f) eine erste Durchgangsbohrung (55) hat, die ausgelegt ist, den Stiftschaft (23, 23f) aufzunehmen, und die erste Bohrung (55) eine Zentralachse (x) hat, dem Spreizhülsen-Aufbau (16, 16f), der ein getrenntes Bauteil von dem Haupthülsen-Aufbau (18, 18e, 18f) ist, und welcher eine zweite Durchgangsbohrung hat, welche ausgelegt ist, den Stiftschaft (23, 23f) aufzunehmen, und welche auf dem Stiftschaft (23, 23f) zwischen dem Stiftpkopf (37, 37f) und dem kegeligen Vorderabschnitt (48, 48e, 48f) angeordnet ist, wobei der kegeligen Vorderabschnitt (48, 48e, 48f) einen vorgewählten Winkel (A) mit der Zentral-

achse (x) definiert, und

der Spreizhülsen-Aufbau (16, 16f) sich infolge der relativen Axialkraft der zweiten Größenordnung relativ zu dem Vorderabschnitt (48, 48e, 48f) axial bewegt und radial über diesen spreizt, um einen vergrößerten Blindkopf (62, 62f) zu bilden, um auf die nicht zugängliche Seite der Fläche (60, 60f) zu wirken.

7. Blindbolzen (10, 10f) gemäß Anspruch 6

mit dem Spreizhülsen-Aufbau (16, 16f), der eine Länge (LS) innerhalb eines Bereichs von im allgemeinen gleich bis gering größer als die Länge des kegeligen Vorderabschnitts (48, 48e, 48f) hat.

8. Blindbolzen (10) gemäß Anspruch 5

mit dem Haupthülsen-Aufbau (18), welcher ein getrenntes Hülsen-Bauteil (75) aufweist, wobei der erweiterte, ausgesenkte Abschnitt (57e) und der genutete Abschnitt (53e) auf dem getrennten Hülsen-Bauteil (75) sind.

9. Blindbolzen (10) gemäß Anspruch 6 mit:

dem Haupthülsen-Aufbau (18), welcher ein von dem kegeligen Vorderabschnitt (73) getrenntes Hülsen-Bauteil (75) aufweist, wobei der erweiterte, ausgesenkte Abschnitt und der genutete Abschnitt auf dem getrennten Hülsen-Bauteil (75) sind,

dem Spreizhülsen-Aufbau (16), der eine Axiallänge besitzt, die im allgemeinen gleich der Axiallänge des kegeligen Vorderabschnitts (48) ist, und

mit der Ringnut (53e) und dem erweiterten, ausgesenkten Abschnitt (51e), die Axiallängen besitzen, die ausgewählt sind, um den Klemmbereich des Befestigungsmittels (10) zu definieren, wobei der Klemmbereich als die Differenz zwischen der kleinsten und größten Gesamtdicke der Werkstücke definiert ist, die ein einzelnes Befestigungsmittel zusammen befestigen kann.

10. Blindbolzen (10) gemäß den Ansprüchen 1 bis 7

mit dem Hülsenschaft-Abschnitt und dem Sollbruch-Abschnitt des Haupthülsen-Aufbaus (73, 75), welcher einen Sollbruch-Abschnitt (75) und einen getrennten Hülsenschaft-Abschnitt (73) aufweist, wobei der Hülsenschaft-Abschnitt (73) und der Sollbruch-Abschnitt (75), ausgelegt sind, um in den fluchtenden Bohrungen (50, 52) in den Werkstücken (54, 56) angeordnet zu werden, und

der Sollbruch-Abschnitt (75) eine radial gestufte Konstruktion besitzt und dessen dem Blindkopf gegenüberliegendes Ende mit dem erweiterten, ausgesenktem Abschnitt (57e) endet.

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11. Hochfestigkeits-Blindbolzen (10, 10c, 10f) gemäß den Ansprüchen 5, 8 und 10,

wobei die Ringnut (53, 53e, 53f, 100) und der erweiterte, ausgesenkte Abschnitt (55c, 57, 57e, 57f) axiale Längen haben, die gewählt sind, den Klemmbereich des Befestigungsmittels (10, 10c, 10f) zu definieren, und der Klemmbereich als die Differenz zwischen der kleinsten und der größten Gesamtdicke der Werkstücke definiert ist, die ein einzelnes Befestigungsmittel miteinander befestigen kann.

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12. Blindbolzen (10f) gemäß Anspruch 1,

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mit dem Spreizhülsen-Aufbau (16f), der im allgemeinen mit radialem Spiel in bezug auf die Gegenfläche des Stiftschaftes (23f) angeordnet ist, und

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mit Führungsmitteln (59f, 112), die in Wirkverbindung mit dem Spreizhülsen-Aufbau (16f) und dem angrenzend an den Stiftkopf gelegenen Stiftschaft sind, um den Spreizhülsen-Aufbau (16f) in einer im allgemeinen coaxialen Beziehung zu dem Stiftschaft (23f) zu halten, nachdem sich der Haupthülsen-Aufbau (18f) aus dem Axiallast Eingriff mit dem Blindkopf (62f) bewegt hat.

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13. Blindbolzen (10f) gemäß Anspruch 12

mit den Führungsmitteln (59f, 112), wobei der Stiftschaft (23f) angrenzend an den Blindkopf (37f) einen Abschnitt (112) mit vergrößertem Durchmesser aufweist, welcher ausgelegt ist, um mit dem zugeordneten Ende (59f) des Spreizhülsen-Aufbaus (16f) einzugreifen.

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14. Blindbolzen (10f) gemäß Anspruch 12

mit den Führungsmitteln (59f, 112), wobei der Stiftschaft (23f) angrenzend an den Stiftkopf (37f) einen kegeligen Abschnitt (112) mit vergrößertem Durchmesser aufweist, welcher ausgelegt ist, um mit dem zugeordneten Ende (59f) des Spreizhülsen-Aufbaus (16f) einzugreifen.

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15. Blindbolzen (10f) gemäß Anspruch 12

mit den Führungsmitteln (59f, 112),

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wobei der Stiftschaft (23f) angrenzend an den Blindkopf (37f) einen kegeligen Abschnitt (112) mit vergrößertem Durchmesser aufweist, welcher ausgelegt ist, um mit dem zugeordneten Ende (59f) des Spreizhülsen-Aufbaus (16f) einzugreifen, wobei das zugeordnete Ende (59f) des Spreizhülsen-Aufbaus (16f) einen Gegenkegel (29f) besitzt, welcher mit dem kegeligen Abschnitt (112) auf dem Stiftschaft (23f) eingreifen kann.

16. Blindbolzen (10, 10c, 10f) gemäß den Ansprüchen 1 bis 15,

welcher ferner eine vergrößerte Rückhalte-Unterlegscheibe (20, 20c, 20f) aufweist, welche ausgelegt ist, um mit der zugänglichen Fläche (49, 49c, 49f) der Werkstücke (54, 54c, 54f, 56, 56c, 56f) und dem Eingriffs-Bauteil (14, 14c, 14f) einzugreifen, wobei der Spreizhülsen-Aufbau (16, 16c, 16f) eine Rockwell-Härte von zwischen ca. 28Rc bis ca. 32Rc hat, das Stift-Bauteil (12, 12c, 12f) eine Rockwell-Härte von zwischen ca. 38Rc bis ca. 42Rc hat, der Spreizhülsen-Aufbau (16, 16c, 16f) aus einem Qualitätsstahl mit einem Nickelgehalt höher als ca. 0, 17 % vom Gewicht gebaut ist, der Haupthülsen-Aufbau (18, 18c, 18e, 18f) eine Rockwell-Härte von zwischen ca. 43Rc bis ca. 47Rc hat, und die Rückhalte-Unterlegscheibe (20, 20c, 20f) eine Rockwell-Härte von zwischen ca. 40Rc bis ca. 45Rc hat, wodurch ein hochfester Blindbolzen entsteht.

17. Blindbolzen (10, 10c, 10f) zum Befestigen einer Vielzahl von Werkstücken (54, 54c, 54f, 56, 56c, 56f) mit einer gewünschten Vorspannkraft, wobei die Werkstücke (54, 54c, 54f, 56, 56c, 56f) fluchtende Bohrungen (50, 50c, 50f, 52, 52c, 52f) darin haben und eine zugängliche Fläche (49, 49c, 49f) und eine nicht zugängliche Seitenfläche (60, 60c, 60f) haben, und welcher ausgelegt ist, um mit einer relativen Axialkraft montiert zu werden, die mit einem Montagewerkzeug von der zugänglichen Seitenfläche (49, 49c, 49f) der Werkstücke (54, 54c, 54f, 56, 56c, 56f) aufgebracht wird, wobei der Blindbolzen (10, 10c, 10f) aufweist:

ein Stift-Bauteil (12, 12c, 12f), welches einen verlängerten Stiftschaft (23, 23c, 23f) besitzt, welcher an einem Ende in einem vergrößerten Stiftkopf (37, 37c, 37f) endet, wobei der Stiftschaft (23, 23c, 23f) einen Sicherungs-Abschnitt (22, 22c, 22f) hat, eine Hülsen-Vorrichtung, die einen Haupthülsen-Aufbau (18, 18c, 18e, 18f) aufweist, der einen verlängerten Hülsenschaft-Abschnitt

(46, 46c, 46f, 73, 75) hat, wobei der Hülzenschaft-Abschnitt (46, 46c, 46f, 73, 75) ausgelegt ist, um in die fluchtenden Bohrungen (50, 50c, 50f, 52, 52c, 52f) in den Werkstücken (54, 54c, 54f, 56, 56c, 56f) angeordnet zu werden, und der Haupthülsen-Aufbau (18, 18c, 18e, 18f) ausgelegt ist, um den Stiftschaft (23, 23c, 23f) aufzunehmen, und die Hülsen-Vorrichtung ferner einen Spreizhülsen-Aufbau (16, 16c, 16f) aufweist, der ausgelegt ist, um den Stiftschaft (23, 23c, 23f) aufzunehmen und auf dem Stiftschaft (23, 23c, 23f) zwischen dem Stiftkopf (37, 37c, 37f) und dem Haupthülsen-Aufbau (18, 18c, 18e, 18f) angeordnet ist, eine Eingriffs-Einrichtung (14, 14c, 14f), die in Wirkverbindung mit der Haupthülsen-Vorrichtung ist und eine Eingriffsform aufweist, die ausgelegt ist, um mit dem Montagewerkzeug einzugreifen, wodurch eine relative Axialkraft einer ersten Größenordnung mit dem Montagewerkzeug zwischen dem Stift-Bauteil (12, 12c, 12f) und der Eingriffs-Einrichtung (14, 14c, 14f) aufgebracht wird, um die Werkstücke (54, 54c, 54f, 56, 56c, 56f) mit einer relativen Axialkraft einer ersten Größenordnung zusammen zu befestigen, und der Spreizhülsen-Aufbau (16, 16c, 16f) infolge der relativen Axialkraft einer zweiten Größenordnung, welche geringer als die erste Größenordnung ist, radial verformbar ist, um einen vergrößerten Blindkopf (62, 62c, 62f) zu bilden, um auf die nicht zugänglichen Seitenfläche (60, 60c, 60f) zu wirken, wobei der Blindbolzen dadurch **gekennzeichnet** ist, daß: die Hülsen-Vorrichtung einen zerbrechbaren Abschnitt (51, 63, 75, 100) aufweist, der ausgelegt ist, um bei einer dritten Größenordnung der relativen Axialkraft, welche geringer als die erste Größenordnung und größer als die zweite Größenordnung ist, zu brechen, wobei sich der Haupthülsen-Aufbau (18, 18c, 18e, 18f) dadurch aus einer Axialbelastungs-Verbindung bewegt, wodurch der Blindkopf (62, 62c, 62f) mit der nicht zugänglichen Seitenfläche (60, 60c, 60f) in Berührung kommt, so daß die erste Größenordnung der relativen Axialkraft und die endgültige Vorspannkraft, die auf die Werkstücke (54, 54c, 54f, 56, 56c, 56f) aufgebracht wird, im wesentlichen zwischen dem Stift-Bauteil (12, 12c, 12f), dem Blindkopf (62, 62c, 62f) und der Eingriffs-Einrichtung (14, 14c, 14f) sein werden.

#### 18. Blindbolzen (10, 10f) gemäß Anspruch 17

mit dem Haupthülsen-Aufbau (18, 18e, 18f) und dem Spreizhülsen-Aufbau (16, 16c, 16f), die getrennte Bauteile sind, wobei

der Haupthülsen-Aufbau (18, 18e, 18f) einen verlängerten Hülzenschaft-Abschnitt (46, 46f, 73, 75) hat, der an einem inneren Ende mit einem kegeligen Vorderabschnitt (48, 48e, 48f) endet, der Hülzenschaft-Abschnitt (46, 46f, 73, 75) ausgelegt ist, um in die fluchtenden Bohrungen (50, 50f, 52, 52f) in den Werkstücken (54, 54f, 56, 56f) angeordnet zu werden, der Haupthülsen-Aufbau (18, 18e, 18f) eine erste Durchgangsbohrung (55) besitzt, die ausgelegt ist, um den Stiftschaft (23, 23f) aufzunehmen, und die erste Bohrung (55) eine Zentralachse (x) hat, der Spannhülsen-Aufbau (16, 16f) eine zweite Durchgangsbohrung hat, die ausgelegt ist, um den Stiftschaft (23, 23f) aufzunehmen und welcher auf dem Stiftschaft (23, 23f) zwischen dem Stiftkopf (37, 37f) und dem kegeligen Vorderabschnitt (48, 48e, 48f) angeordnet ist, der kegelige Vorderabschnitt (48, 48e, 48f) einen vorgewählten Winkel (A) mit der Zentralachse (x) definiert, die Spreizhülse (16, 16f) sich infolge der relativen Axialkraft der zweiten Größenordnung relativ zu dem Vorderabschnitt (48, 48e, 48f) axial bewegt und radial über diesen spreizt, um den vergrößerten Blindkopf (62, 62f) zu bilden, um auf die nicht zugängliche Seitenfläche (60, 60f) zu wirken.

#### 19. Blindbolzen (10f) gemäß Anspruch 17

mit dem Sicherungsabschnitt (22f), der von einem schraubenförmigen Gewinde (22f) definiert ist, und mit der Eingriffs-Einrichtung (14f), die eine Gegengewindeform hat, die ausgelegt ist, um mit dem Sicherungs-Abschnitt (22f) verschraubbar einzugreifen, wodurch die relative Axialkraft zwischen dem Stift-Bauteil (12f) und der Eingriffs-Einrichtung (14f) durch das relative Drehmoment geliefert wird, welches zwischen dem Stift-Bauteil (12f) und der Eingriffs-Einrichtung (14f) aufgebracht wird.

#### 20. Blindbolzen (10, 10c) gemäß Anspruch 17

mit dem von Versperrrillen (22, 22c) definierten Sicherungsabschnitt (22, 22c) des Stiftschaftes (23, 23c) und mit der Eingriffs-Einrichtung (14, 14c), die eine verpreßbare Buchse (14, 14c) ist, die ausgelegt ist, um auf dem Stiftschaft (23, 23c) angeordnet zu werden, und um mit dem Montagewerkzeug in die Versperrrillen (22, 22c) gedrückt zu werden, infolge der relativen Axialkraft der ersten Größenordnung, die mit dem Montagewerkzeug aufgebracht wird.

#### 21. Blindbolzen (10, 10c, 10f) gemäß den Ansprüchen

17 und 18

mit der Eingriffs-Einrichtung (14, 14c, 14f), die ein Versperrmittel (14, 14c, 14f) aufweist, das in Wirkverbindung mit der Hülsen-Einrichtung ist und einen Versperr-Bereich aufweist, der ausgelegt ist, um mit dem Sicherungs-Abschnitt (22, 22c, 22f) infolge der relativen Axialkraft einer ersten Größenordnung, die mit dem Montagewerkzeug aufgebracht wird, in Eingriff gebracht zu werden, wodurch die endgültige Vorspannkraft, die auf die Werkstücke (54, 54c, 54f, 56, 56c, 56f) aufgebracht wird, im wesentlichen zwischen dem Stift-Bauteil (12, 12c, 12f), dem Blindkopf (62, 62c, 62f) und dem Versperrmittel der Eingriffs-Einrichtung (14, 14c, 14f) bleibt.

**22.** Blindbolzen (10, 10c) gemäß den Ansprüchen 17 und 18 mit:

dem eine Vielzahl von Versperrillen (22, 22c) aufweisenden Sicherungsabschnitt (22, 22c) des Stiftschaftes (23, 23c), und dem Stiftschaft (23, 23c) der einen Zugabschnitt (40, 40c) hat, welcher eine Vielzahl von Zugrillen (44, 44c) aufweist, der Eingriffs-Einrichtung, welche einen Buchsen-Aufbau (14, 14c) aufweist, welcher auf dem Stiftschaft an der zugänglichen Seitenfläche (49, 49c) der Werkstücke (54, 54c, 56, 56c) angeordnet ist, und ausgelegt ist, um infolge der relativen Axialkraft einer ersten Größenordnung, welche mit dem Montagewerkzeug zwischen dem Stift-Bauteil (12, 12c) und dem Buchsen-Aufbau (14, 14c) aufgebracht wird, in die Versperrillen (22, 22c) gedrückt zu werden, wodurch die endgültige Vorspannkraft, welche auf die Werkstücke (54, 54c, 56, 56c) aufgebracht wird, im wesentlichen zwischen dem Stift-Bauteil (12, 12c), dem Blindkopf (62, 62c) und dem Buchsen-Aufbau (14, 14c) der Eingriffs-Einrichtung sein wird.

**23.** Blindbolzen (10c) gemäß den Ansprüchen 17, 21 und 22,

wobei der Spreizhülsen-Aufbau (10c) einen nachgebenden Abschnitt (102) besitzt, der ausgelegt ist, um infolge der relativen Axialkraft der zweiten Größenordnung sich nach außen zu falten, um den Schließkopf (62c) in Form eines Wulstes zu bilden.

**24.** Blindbolzen gemäß den Ansprüchen 17, 21 und 22

mit dem Haupthülsen-Aufbau (c) und dem Spreizhülsen-Aufbau (16c), die getrennte Bau-

teile sind, wobei

der Haupthülsen-Aufbau (18c) einen verlängerten Hülsenschaft-Abschnitt (46c) besitzt, der ausgelegt ist, um in die fluchtenden Bohrungen (50c, 52) der Werkstücke (54c, 56c) angeordnet zu werden,

der Haupthülsen-Aufbau (18c) eine erste Durchgangsbohrung hat, die ausgelegt ist, den Stiftschaft (23c) aufzunehmen, und

der Spreizhülsen-Aufbau (16c) eine zweite Durchgangsbohrung hat, die ausgelegt ist, den Stiftschaft (23c) aufzunehmen und welche auf dem Stiftschaft (23c) angrenzend an den Stiftkopf (37c) angeordnet ist, und der Spreizhülsen-Aufbau (16c) einen nachgebenden Abschnitt (102) besitzt, welcher ausgelegt ist, um infolge der relativen Axialkraft der zweiten Größenordnung sich radial nach außen zu falten, um einen Schließkopf (62c) in Form eines Wulstes zu bilden.

**25.** Blindbolzen (10, 10c, 10f) gemäß den Ansprüchen 17, 21, 22 und 24,

wobei der Haupthülsen-Aufbau (18, 18c, 18f) mit dem zerbrechbaren Aufbau (51, 63, 100) als ein Teil geformt ist.

**26.** Blindbolzen (10, 10c, 10f) gemäß den Ansprüchen 17 bis 27,

wobei der zerbrechbare Aufbau (51, 63, 75, 100) des Haupthülsen-Aufbaus (18, 18c, 18e, 18f) einen Sollbruch-Abschnitt (61, 61c, 61f) aufweist, der ausgelegt ist, um bei der dritten Größenordnung der relativen Axialkraft zu brechen.

**27.** Blindbolzen gemäß den Ansprüchen 17 bis 25,

wobei der zerbrechbare Aufbau (51, 63, 75, 100) des Haupthülsen-Aufbaus (18, 18c, 18e, 18f) einen radial gestuften Aufbau aufweist, welcher von zwei, mit einem Sollbruch-Abschnitt (61, 61c, 61f) verbundenen Hülsen-Abschnitten (46, 46c, 46f, 51, 51e, 51f, 53e, 100) definiert wird, wobei der Sollbruch-Abschnitt (61, 61c, 61f) ausgelegt ist, um bei der dritten Größenordnung einer relativen Axialkraft zu brechen, um dem gestuften Aufbau zu erlauben, sich axial in sich zu verschieben.

**28.** Blindbolzen (10) gemäß Anspruch 18,

wobei der zerbrechbare Aufbau (75) ein vom übrigen Teil (73) des Haupthülsen-Aufbaus (18e) getrenntes Bauteil ist.

29. Blindbolzen (10, 10e, 10f) gemäß den Ansprüchen 18 und 28,

wobei der Spreizhülsen-Aufbau (16, 16e, 16f) eine Länge innerhalb eines Bereichs von im allgemeinen gleich oder geringfügig um ca. die Wanddicke des Spreizhülsen-Aufbaus (16, 16e, 16f) größer als die Länge des kegeligen Vorderabschnitts (48, 48e, 48f) hat.

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30. Blindbolzen (10, 10c) gemäß Anspruch 22 mit:

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dem Stiftschaft (23, 23c), welcher eine Bruch-Auskehlung (42, 42c) hat, die zwischen den Versperrillen (22, 22c) und den Zugrillen (44, 44c) angeordnet ist, und ausgelegt ist, bei einer vorgewählten Größenordnung einer relativen Axialkraft zu brechen, nachdem der Buchsen-Aufbau (14, 14c) völlig in die Versperrillen (22, 22c) gepreßt wurde, wobei der Fußkreisdurchmesser der Bruch-Auskehlung (42, 42c) in bezug auf jenen der Zugrillen (44, 44c) im Verhältnis von ungefähr 0,82 : 1 kleiner als jener der Bruch-Auskehlung (42, 42c) ist, um einen Bruch an einer der Zugrillen (44, 44c) zu verhindern.

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31. Blindbolzen (10, 10c, 10f) gemäß den Ansprüchen 17 bis 30 mit:

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dem Stiftschaft (23, 23c, 23f), welcher einen im allgemeinen glatten Schaftabschnitt (38, 38c, 38f) hat, welcher sich im allgemeinen von dem Stiftkopf (37, 37c, 37f) zu dem Sicherungs-Abschnitt (22, 22c, 22f) erstreckt, dem Stiftkopf (37, 37c, 37f), welcher mit dem glatten Schaftabschnitt (38, 38c, 38f) mit einem stromlinienförmigen Übergang verbunden ist, der im allgemeinen von einem ersten Radius (R1), welcher im allgemeinen tangent zu dem glatten Schaftabschnitt (38, 38c, 38f) ist, und einem zweiten Radius (R2), welcher im allgemeinen tangent zu der inneren Fläche (65) des Stiftkopfes (37, 37c, 37f) definiert wird, wobei der erste Radius (R1) ungefähr die doppelte Größe des zweiten Radius (R2) hat.

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32. Blindbolzen (10, 10c, 10f) gemäß einem der Ansprüche 17 mit 31 mit:

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den Werkstücken, die einen Kastenträger (72) und einen Aufbau (74, 76) aufweisen, welcher mindestens an zwei angrenzende Querseiten (87) des Kastenträgers (72) befestigt werden soll, den angrenzenden Querseiten (87), welche eine Eckkante definieren,

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Paaren von fluchtenden Bohrungen (82, 84), die Achsen in einer gemeinsamen Ebene haben, wobei mindestens zwei der Paare fluchtender Bohrungen (82, 84) in jeder angrenzenden Querseite der Eckkante sind, wobei ein Blindbolzen (10, 10c, 10f) der in jedem der Paare fluchtender Bohrungen (82, 84) an der Eckkante angeordnet ist, mit einem der montierten Blindbolzen (10, 10c, 10f) eine lichte Weite innerhalb des Kastenträgers mit einem der vormontierten Blindbolzen (10, 10c, 10f) an der Eckkante schafft.

33. Blindbolzen (10, 10c, 10f) gemäß einem der Ansprüche 17 bis 31 mit:

den Werkstücken, welche mindestens ein Paar plattenähnliche Bauteile (83, 89) aufweisen, wobei eines der Bauteile (83, 89) im allgemeinen in Eingriff mit einem relativ festen Baugrund (81) angeordnet ist, den in dem Paar von Bauteilen (83, 89) fluchtenden Bohrungen, welche auf einer Linie mit einem Hohlraum (90) in dem Baugrund (81) sind, und der Hohlraum (90) gebildet wird, wenn der Baugrund (81) angrenzend an einem (83) der Bauteile (83, 89) ist, wobei für den Blindbolzen (10, 10c, 10f) in dem vorausgesetzten Zustand, der Überstand des Stiftkopfes (37a) und der Spreizhülse (16a) an der nicht zugänglichen Seite ist, um ein Minimum zu sein, wobei der lichte Abstand des Stiftkopfes (37a) zum Hohlraum (90) ein Minimum ist.

34. Blindbolzen (10, 10c, 10f) gemäß den Ansprüchen 17 bis 26 und 28 bis 33,

der ein hochfester Blindbolzen mit der gewünschten Vorspannkraft ist, die zwischen ca. 70 % bis ca. 80 % der kleinsten spezifischen Zugfestigkeit des montierten Blindbolzen ist, und mit dem Hülsenschaft-Abschnitt (46, 46c, 46f, 73, 75) des Haupthülsen-Aufbaus (18, 18c, 18e, 18f) mit, seinem dem Stiftkopf (37, 37c, 37f) entgegengesetzten Ende, das mit einem erweiterten, ausgesenkten Abschnitt (51, 51f, 55c, 63, 75) endet, mit dem zerbrechbaren Aufbau (51, 63, 75, 100), welcher einen genuteten Abschnitt (53e, 53f, 63, 100) und einen Sollbruch-Abschnitt (61, 61c, 61f) aufweist, wobei der genutete Abschnitt (53e, 53f, 63, 100) eine Ringnut (53, 53e, 53f, 100) hat, welche an der Außenfläche des Hülsenschaft-Abschnitts angrenzend an den erweiterten, ausgesenkten Abschnitt (51, 51f, 55c, 63, 75)

geformt ist, und der ausgelegt ist, um sich innerhalb des erweiterten, ausgesenkten Abschnitts (51, 51f, 55c, 63, 75) axial in sich zu verschieben, der Sollbruch-Abschnitt (61, 61c, 61f) den erweiterten, ausgesenkten Abschnitt (51, 51f, 55c, 63, 75) mit dem ringförmig genuteten Abschnitt (53e, 53f, 63, 100) verbindet, und

der Sollbruch-Abschnitt (61, 61c, 61f) ausgelegt ist, bei einer dritten Größenordnung einer relativen Axialkraft, die geringer als die erste Größenordnung größer als die zweite Größenordnung ist, zu brechen,

wodurch der genutete Abschnitt (53e, 53f, 63, 100) sich axial in dem erweiterten, ausgesenkten Abschnitt (51, 51f, 55c, 63, 75) verschiebt, und dadurch den Haupthülsen-Aufbau (18, 18c, 18e, 18f) aus einem Axiallast Eingriff mit dem Blindkopf (62, 62c, 62f) bewegt, wodurch die endgültige Vorspannkraft, die auf die Werkstücke (54, 54c, 54f, 56, 56c, 56f) aufgebracht wird, im wesentlichen von dem Haupthülsen-Aufbau (18, 18c, 18e, 18f) unbeeinflusst bleibt, und der Blindbolzen ferner eine Rückhalte-Unterlegscheibe (20, 20c, 20f) aufweist, welche ausgelegt ist, um mit der zugänglichen Fläche (49, 49c, 49f) der Werkstücke (54, 54c, 54f, 56, 56c, 56f) und der Eingriffs-Einrichtung (14, 14c, 14f) einzugreifen, wobei

der Spreizhülsen-Aufbau (16, 16c, 16f) eine Rockwell-Härte von zwischen ca. 28Rc bis ca. 32Rc hat,

das Stift-Bauteil (12, 12c, 12f) eine Rockwell-Härte von zwischen ca. 38Rc bis ca. 42Rc hat, der Spreizhülsen-Aufbau (16, 16c, 16f) aus einem Qualitätsstahl gebaut ist, welcher einen Nickelgehalt größer als ca. 0,17 % vom Gewicht hat,

die Rückhalte-Unterlegscheibe (20, 20c, 20f) eine Rockwell-Härte von zwischen ca. 40Rc bis ca. 45Rc hat, wodurch ein hochfester Blindbolzen entsteht, und der Haupthülsen-Aufbau (18, 18c, 18e, 18f) eine Rockwelle-Härte von zwischen ca. 53Rc bis ca. 47Rc hat.

## Revendications

1. Rivet aveugle (10, 10c, 10f) pour assembler plusieurs pièces, avec la force de serrage voulue, les pièces (54, 54c, 54f, 56, 56c, 56f) comportant des ouvertures alignées (50, 52, 50c, 52f) et ayant une face accessible (49, 49c, 49f) et une face aveugle (60, 60c, 60f), et conçu pour être mis en place en exerçant une force axiale relative au moyen d'un outil de pose, par la face accessible (49, 49c, 49f) des pièces (54, 54c, 54f, 56, 56c, 56f), ledit rivet aveugle (10, 10c, 10f) comprenant :

un élément de tige (12, 12c, 12f) comportant une partie cylindrique de forme allongée (23, 23c, 23f) se terminant à l'une de ses extrémités par une tête de tige plus large (37, 37c, 37f),

ladite partie cylindrique de la tige (23, 23c, 23f) ayant une partie servant à la fixation comprenant un ensemble de rainures de fixation (22, 22c, 22f),

un élément de manchon prévu pour recevoir ladite partie cylindrique de la tige (23, 23c, 23f) et comprenant une structure principale de manchon (18, 18c, 18e, 18f) avec un corps de manchon de forme allongée (46, 46c, 46f, 73, 75), ledit corps de manchon (46, 46c, 46f, 73, 75) étant prévu pour se positionner dans les ouvertures alignées (50, 50c, 50f, 52, 52c, 52f) des pièces (54, 54c, 54f, 56, 56c, 56f),

ledit élément de manchon comprenant en outre une structure de manchon expansible (16, 16c, 16f) positionnée sur ladite partie cylindrique de la tige (23, 23c, 23f) entre ladite tête de tige (37, 37c, 37f) et ladite structure principale de manchon (18, 18c, 18e, 18f),

un élément de mise en contact (14, 14c, 14f) positionné sur ladite partie cylindrique de la tige (23, 23c, 23f) du côté de la face accessible (49, 49c, 49f) des pièces (54, 54c, 54f, 56, 56c, 56f) et adapté pour être mis en contact avec l'outil de pose, une force axiale relative d'une première intensité pouvant ainsi être appliquée par l'outil de pose entre ledit élément de tige (12, 12c, 12f) et ledit élément de mise en contact (14, 14c, 14f) pour serrer les pièces (54, 54c, 54f, 56, 56c, 56f) l'une sur l'autre avec une force axiale relative d'une première intensité,

ladite structure de manchon expansible (16, 16c, 16f) étant radialement déformable en réponse à une force axiale relative d'une deuxième intensité, inférieure à ladite force axiale relative d'une première intensité, pour former une tête aveugle élargie (62, 62d, 62f) prévue pour prendre appui sur la face aveugle (60, 60c, 60f),

ledit rivet aveugle étant caractérisé en ce que :

ledit élément de manchon comporte une structure élargie à chambrage (51, 51f, 63, 75) associée en fonctionnement audit corps de manchon, ladite structure à chambrage (51, 51f, 63, 75) comportant une partie fragile (61, 61c, 61f) prévue pour se rompre sous l'effet d'une force axiale relative d'une troisième intensité, infé-

rieure à ladite force axiale relative d'une première intensité et supérieure à ladite force axiale relative d'une deuxième intensité, et pour recevoir une partie (53, 53e, 53f) de ladite structure principale de manchon (18, 18c, 18e, 18f) en déconnectant ainsi ladite structure principale de manchon (18, 18c, 18e, 18f) de la contrainte axiale exercée par ladite tête aveugle (62, 62d, 62f), ladite force axiale relative d'une première intensité et ladite contrainte finale de serrage appliquée aux pièces (54, 54c, 54f, 56, 56c, 56f) n'étant ainsi pratiquement pas influencées par ladite structure principale de manchon (18, 18c, 18e, 18f).

2. Rivet aveugle (10f) selon la revendication 1, dans lequel lesdites rainures de fixation (22f) de ladite partie cylindrique de la tige (23f) sont définies par un filet de forme hélicoïdale (22f), ledit élément de mise en contact (14f) ayant un filet de forme correspondante prévu pour être engagé par filetage sur lesdites rainures de fixation (22f), la force axiale relative qui s'exerce entre ledit élément de tige (12f) et ledit élément de mise en contact (14f) étant obtenue par le couple de rotation relatif appliqué entre ledit élément de tige (12f) et ledit élément de mise en contact (14f).

3. Rivet aveugle (10, 10c) selon la revendication 1, dans lequel lesdites rainures de fixation (22, 22c) de ladite partie cylindrique de la tige (23, 23c) sont définies par des rainures de blocage (22, 22c), ledit élément de mise en contact (14, 14c) étant une bague à refouler (14, 14c) prévue pour être placée sur ladite partie cylindrique de la tige (23, 23c) et pour être refoulée à l'intérieur desdites rainures de blocage (22, 22c), au moyen de l'outil de pose, sous l'effet de la force axiale relative d'une première intensité appliquée par l'outil de pose.

4. Rivet aveugle (10, 10c) selon la revendication 1, dans lequel :

lesdites rainures de fixation (22, 22c) sont constituées par un ensemble de rainures de blocage (22, 22c), et ladite partie cylindrique de la tige (23, 23c) comporte une zone de traction (40, 40c) constituée par un ensemble de rainures de traction (44, 44c),

ledit élément de mise en contact est une structure de bague tubulaire (14, 14c) associée en fonctionnement avec ladite structure principale de manchon (18, 18c) et placée sur ladite partie cylindrique de la tige (23, 23c) du côté de la face accessible (49, 49c) des pièces (54, 54c, 56, 56c) et prévue pour être refoulée à l'intérieur desdites rainures de blocage (22, 22c),

sous l'effet de la force axiale relative d'une première intensité appliquée par l'outil de pose entre lesdites rainures de traction (44, 44c) de ladite partie cylindrique de la tige (23, 23c) et ladite bague tubulaire (14, 14c).

5. Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 1 à 4, dans lequel ladite structure principale de manchon (18, 18c, 18e, 18f) se termine, à l'extrémité opposée de ladite structure de manchon expansible (16, 16c, 16 f), par une partie élargie à chambrage (51, 51e, 51f, 63, 75), une partie à entaille annulaire (53, 53e, 53f, 100) formée sur la face externe dudit corps de manchon (46, 46c, 46f, 73, 75) contiguë à ladite partie élargie à chambrage (51, 51e, 51f, 63, 75) étant prévue pour se déplacer axialement à l'intérieur de ladite partie élargie à chambrage (51, 51e, 51f, 63, 75), ladite partie fragile (61, 61c, 61f) reliant ladite partie élargie à chambrage (51, 51e, 51f, 63, 75) à ladite partie à entaille annulaire (53, 53e, 53f, 100), ladite partie fragile (51, 51e, 51f, 61, 61c, 61f) étant prévue pour se rompre sous l'effet d'une force axiale relative d'une troisième intensité, inférieure à ladite force axiale relative d'une première intensité et supérieure à ladite force axiale relative d'une deuxième intensité, ladite partie entaillée (53, 53e, 53f, 100) se déplaçant axialement à l'intérieur de ladite partie élargie à chambrage (51, 51e, 51f, 63, 75) en déconnectant ainsi ladite structure principale de manchon (18, 18c, 18e, 18f) de la contrainte axiale exercée par ladite tête aveugle (62, 62a, 62f), ladite force axiale relative d'une première intensité et ladite contrainte finale de serrage appliquée aux pièces (54, 54c, 54f, 56, 56c, 56f) n'étant ainsi pratiquement pas influencées par ladite structure principale de manchon (18, 18c, 18e, 18f).

6. Rivet aveugle (10, 10f) selon l'une quelconque des revendications 1 à 5, dans lequel ladite structure principale de manchon (18, 18e, 18f) comporte un corps de manchon (46, 46f, 73, 75) de forme allongée qui se termine à une extrémité intérieure par une partie avant conique (48, 48e, 48f), ladite structure principale de manchon (18, 18e, 18f) comportant un premier alésage traversant (55) prévu pour recevoir ladite partie cylindrique de la tige (23, 23f), ledit premier alésage traversant (55) ayant un axe central (x),

ladite structure de manchon expansible (16, 16f) étant un élément distinct de ladite structure principale de manchon (18, 18e, 18f) et comportant un second alésage traversant prévu pour recevoir ladite partie cylindrique de la tige (23, 23f) et étant placée sur ladite partie cylindrique de la tige (23, 23f), entre ladite tête de tige (37, 37f) et ladite partie avant conique (48,

48e, 48f),

ladite partie avant conique (48, 48e, 48f) formant avec ledit axe central (x) un angle prédéterminé (A),

ladite structure de manchon expansible (16, 16f) se déplaçant axialement par rapport à ladite partie avant (48, 48e, 48f) tout en se dilatant radialement en passant sur celle-ci, sous l'effet de ladite force axiale relative d'une deuxième intensité, pour former une tête aveugle élargie (62, 62f) prévue pour prendre appui sur la face aveugle (60, 60f).

7. Rivet aveugle (10, 10f) selon la revendication 6, dans lequel ladite structure de manchon expansible (16, 16f) a une longueur (LS) comprise dans une plage pratiquement égale ou légèrement supérieure à la longueur de ladite partie avant conique (48, 48e, 48f).

8. Rivet aveugle (10) selon la revendication 5, dans lequel ladite structure principale de manchon (18) comporte un élément de manchon séparé (75), ladite partie élargie à chambrage (57e) et ladite partie à entaille annulaire (53e) se trouvant sur ledit élément de manchon séparé (75).

9. Rivet aveugle (10) selon la revendication 6, dans lequel ladite structure principale de manchon (18) comporte un élément de manchon (75) séparé de ladite partie avant conique (73), ladite partie élargie à chambrage et ladite partie à entaille annulaire se trouvant sur ledit élément de manchon séparé (75),

ladite structure de manchon expansible (16) ayant une longueur axiale pratiquement égale à la longueur axiale de ladite partie avant conique (48),

ladite partie à entaille annulaire (53e) et ladite partie élargie à chambrage (51e) ayant des longueurs axiales choisies de façon à définir la plage de serrage du moyen d'assemblage (10), cette plage de serrage étant définie comme étant la différence entre les épaisseurs totales minimale et maximale des pièces qu'un même moyen d'assemblage peut assembler.

10. Rivet aveugle (10) selon l'une quelconque des revendications 1 à 7, dans lequel ledit corps de manchon et ladite partie fragile de ladite structure principale de manchon (73, 75) comprennent une partie fragile (75) séparée dudit corps de manchon (73), ledit corps de manchon (73) et ladite partie fragile (75) étant prévus pour être placés dans les ouvertures alignées (50, 52) des pièces (54, 56),

ladite partie fragile (75) ayant une structure étagée dans le sens radial et son extrémité opposée à ladite tête de tige se terminant dans ladite partie élargie à chambrage (57e).

11. Rivet aveugle haute résistance (10, 10c, 10f) selon l'une quelconque des revendications 5, 8 ou 10, dans lequel ladite partie à entaille annulaire (53, 53e, 53f, 100) et ladite partie élargie à chambrage (55c, 57, 57e, 57f) ont des longueurs axiales choisies de façon à définir la plage de serrage du moyen d'assemblage (10, 10c, 10f), cette plage de serrage étant définie comme étant la différence entre les épaisseurs totales minimale et maximale des pièces qu'un même moyen d'assemblage peut assembler.

12. Rivet aveugle (10f) selon la revendication 1, dans lequel ladite structure de manchon expansible (16f) est placée généralement en gardant un jeu radial avec la surface de ladite partie cylindrique de la tige (23f) située en vis-à-vis,

un moyen de guidage (59f, 112) associé en fonctionnement avec ladite structure de manchon expansible (16f) et avec ladite partie cylindrique de la tige contiguë à ladite tête de tige pour maintenir ladite structure de manchon expansible (16f) en liaison essentiellement coaxiale avec ladite partie cylindrique de la tige (23f) après que ladite structure principale de manchon (18f) ait été déconnectée de la contrainte axiale exercée par ladite tête aveugle (62f).

13. Rivet aveugle (10f) selon la revendication 12, dans lequel ledit moyen de guidage (59f, 112) comporte une partie ayant un grand diamètre (112) sur ladite partie cylindrique de la tige (23f) contiguë à ladite tête de tige (37f) prévue pour venir en contact avec l'extrémité correspondante (59f) de ladite structure de manchon expansible (16f).

14. Rivet aveugle (10f) selon la revendication 12, dans lequel ledit moyen de guidage (59f, 112) comporte une partie conique de plus grand diamètre (112) sur ladite partie cylindrique de la tige (23f) contiguë à ladite tête de tige (37f) prévue pour venir en contact avec l'extrémité correspondante (59f) de ladite structure de manchon expansible (16f).

15. Rivet aveugle (10f) selon la revendication 12, dans lequel ledit moyen de guidage (59f, 112) comporte une partie conique de plus grand diamètre (112) sur ladite partie cylindrique de la tige (23f) contiguë à ladite tête de tige (37f) prévue pour venir en contact avec l'extrémité correspondante (59f) de ladite structure de manchon expansible (16f), ladite extré-

mité associée (59f) de ladite structure de manchon expansible (16f) ayant un cône correspondant (59f) pouvant venir en contact avec ladite partie conique (112) de ladite partie cylindrique de la tige (23f).

16. Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 1 à 15, comprenant en outre une rondelle de retenue plus large (20, 20c, 20f) prévue pour venir en contact avec la face accessible (49, 49c, 49f) des pièces (54, 54c, 54f, 56, 56c, 56f) et avec ledit élément de mise en contact (14, 14c, 14f),

ladite structure de manchon expansible (16, 16c, 16f) ayant un indice de dureté Rockwell compris entre 28 Rc environ et 32 Rc environ,

ledit élément de tige (12, 12c, 12f) ayant un indice de dureté Rockwell compris entre 38 Rc environ et 42 Rc environ,

ladite structure de manchon expansible (16, 16c, 16f) étant fabriquée dans un acier de haute qualité ayant une teneur pondérale en nickel supérieure à 0,17 % environ,

ladite structure principale de manchon (18, 18c, 18e, 18f) ayant un indice de dureté Rockwell compris entre 43 Rc environ et 47 Rc environ, et

ladite rondelle de retenue (20, 20c, 20f) ayant un indice de dureté Rockwell compris entre 40 Rc environ et 45 Rc environ, ce qui permet d'obtenir un rivet aveugle haute résistance.

17. Rivet aveugle (10, 10c, 10f) pour assembler plusieurs pièces (54, 54c, 54f, 56, 56c, 56f) avec la force de serrage voulue, les pièces (54, 54c, 54f, 56, 56c, 56f) comportant des ouvertures alignées (50, 50c, 50f, 52, 52c, 52f) et ayant une face accessible (49, 49c, 49f) et une face aveugle (60, 60c, 60f), et conçu pour être mis en place en exerçant une force axiale relative au moyen d'un outil de pose, par la face accessible (49, 49c, 49f) des pièces (54, 54c, 54f, 56, 56c, 56f), ledit rivet aveugle (10, 10c, 10f) comprenant :

un élément de tige (12, 12c, 12f) comportant une partie cylindrique de forme allongée (23, 23c, 23f) se terminant à l'une de ses extrémités par une tête de tige plus large (37, 37c, 37f) ;

ladite partie cylindrique de la tige (23, 23c, 23f) ayant une partie servant à la fixation (22, 22c, 22f),

un élément de manchon comprenant une structure principale de manchon (18, 18c, 18e, 18f)

avec un corps de manchon de forme allongée (46, 46c, 46f, 73, 75), ledit corps de manchon (46, 46c, 46f, 73, 75) étant prévu pour se positionner dans les ouvertures alignées (50, 50c, 50f, 52, 52c, 52f) des pièces (54, 54c, 54f, 56, 56c, 56f), ladite structure principale de manchon (18, 18c, 18e, 18f) étant prévue pour recevoir ladite partie cylindrique de la tige (23, 23c, 23f),

ledit élément de manchon comprenant en outre une structure de manchon expansible (16, 16c, 16f) prévue pour recevoir ladite partie cylindrique de la tige (23, 23c, 23f) et positionnée sur ladite partie cylindrique de la tige (23, 23c, 23f) entre ladite tête de tige (37, 37c, 37f) et ladite structure principale de manchon (18, 18c, 18e, 18f),

un élément de mise en contact (14, 14c, 14f) associé en fonctionnement audit manchon et comportant une structure de mise en contact prévue pour être mise en contact avec l'outil de pose, une force axiale relative d'une première intensité pouvant ainsi être appliquée par l'outil de pose entre ledit élément de tige (12, 12c, 12f) et ledit élément de mise en contact (14, 14c, 14f) pour serrer les pièces (54, 54c, 54f, 56, 56c, 56f) l'une sur l'autre avec une force axiale relative d'une première intensité,

ladite structure de manchon expansible (16, 16c, 16f) étant radialement déformable en réponse à une force axiale relative d'une deuxième intensité, inférieure à ladite force axiale relative d'une première intensité, pour former une tête aveugle élargie (62, 62c, 62f) prévue pour prendre appui sur la face aveugle (60, 60c, 60f),

ledit rivet aveugle étant caractérisé en ce que :

ledit élément de manchon comporte une structure repliable (51, 63, 75, 100) prévue pour se replier lorsqu'elle est soumise à une force axiale relative d'une troisième intensité, inférieure à ladite force axiale relative d'une première intensité et supérieure à ladite force axiale relative d'une deuxième intensité, en déconnectant ainsi ladite structure principale de manchon (18, 18c, 18e, 18f) de toute contrainte axiale, ladite tête aveugle (62, 62c, 62f) venant alors en contact avec la face aveugle (60, 60c, 60f) de telle sorte que ladite force axiale relative d'une première intensité et ladite contrainte finale de serrage appliquée aux pièces (54, 54c, 54f, 56, 56c, 56f) s'exercent essentiellement entre ledit élément de tige (12,

12c, 12f), ladite tête aveugle (62, 62c, 62f) et ledit élément de mise en contact (14, 14c, 14f).

18. Rivet aveugle (10, 10f) selon la revendication 17, dans lequel ladite structure principale de manchon (18, 18e, 18f) et ladite structure de manchon expansible (16, 16e, 16f) sont des éléments séparés,

ladite structure principale de manchon (18, 18e, 18f) ayant un corps de manchon de forme allongée (46, 46f, 73, 75) se terminant à l'une de ses extrémités intérieures par une partie avant conique (48, 48e, 48f), ledit corps de manchon (46, 46f, 73, 75) étant prévu pour se positionner dans les ouvertures alignées (50, 50f, 52, 52f) des pièces (54, 54f, 56, 56f), ladite structure principale de manchon (18, 18e, 18f) comportant un premier alésage traversant (55) prévu pour recevoir ladite partie cylindrique de la tige (23, 23f), ledit premier alésage traversant (55) ayant un axe central (x),

ladite structure de manchon expansible (16, 16f) comportant un second alésage traversant prévu pour recevoir ladite partie cylindrique de la tige (23, 23f) et étant placée sur ladite partie cylindrique de la tige (23, 23f), entre ladite tête de tige (37, 37f) et ladite partie avant conique (48, 48e, 48f),

ladite partie avant conique (48, 48e, 48f) formant avec ledit axe central (x) un angle prédéterminé (A),

ledit manchon expansible (16, 16 f) se déplaçant axialement par rapport à ladite partie avant (48, 48e, 48f) tout en se dilatant radialement en passant sur celle-ci, sous l'effet de ladite force axiale relative d'une deuxième intensité, pour former la tête aveugle élargie (62, 62f) devant prendre appui sur la face aveugle (60, 60f).

19. Rivet aveugle (10f) selon la revendication 17, dans lequel ladite partie de fixation (22f) est définie par un filet de forme hélicoïdale (22f), ledit élément de mise en contact (14f) ayant un filet de forme correspondante prévu pour être engagé par filetage sur ladite partie de fixation (22f), la force axiale relative qui s'exerce entre ledit élément de tige (12f) et ledit élément de mise en contact (14f) étant obtenue par le couple de rotation relatif appliqué entre ledit élément de tige (12f) et ledit élément de mise en contact (14f).

20. Rivet aveugle (10, 10c) selon la revendication 17, dans lequel ladite partie de fixation (22, 22c) de ladite partie cylindrique de la tige (23, 23c) est définie par des rainures de blocage (22, 22c), ledit élé-

ment de mise en contact (14, 14c) étant une bague à refouler (14, 14c) prévue pour être placée sur ladite partie cylindrique de la tige (23, 23c) et pour être refoulée à l'intérieur desdites rainures de blocage (22, 22c), au moyen de l'outil de pose sous l'effet de la force axiale relative d'une première intensité appliquée par l'outil de pose.

21. Rivet aveugle (10, 10c, 10f) selon l'une ou l'autre des revendications 17 et 18, dans lequel :

ledit élément de mise en contact (14, 14c, 14f) comporte un moyen de blocage (14, 14c, 14f) associé en fonctionnement audit manchon et comportant une structure de blocage prévue pour être mise en prise avec ladite zone de fixation (22, 22c, 22f) sous l'effet de la force axiale relative d'une première intensité appliquée par l'outil de pose, ladite contrainte finale de serrage appliquée aux pièces (54, 54c, 54f, 56, 56c, 56f) s'exerçant alors essentiellement entre ledit élément de tige (12, 12c, 12f), ladite tête aveugle (62, 62c, 62f) et ledit moyen de blocage dudit élément de mise en contact (14, 14c, 14f).

22. Rivet aveugle (10, 10c) selon l'une ou l'autre des revendications 17 et 18, dans lequel :

ladite zone de fixation (22, 22c) de ladite partie cylindrique de la tige (23, 23c) comporte un ensemble de rainures de blocage (22, 22c) et ladite partie cylindrique de la tige (23, 23c) comprend une zone de traction (40, 40c) comportant un ensemble de rainures de traction (44, 44c),

ledit élément de mise en contact comporte une structure de bague (14, 14c) positionnée sur ladite partie cylindrique de la tige (23, 23c) du côté de la face accessible (49, 49c) des pièces (54, 54c, 56, 56c) et prévue pour être refoulée à l'intérieur desdites rainures de blocage (22, 22c), sous l'effet de la force axiale relative d'une première intensité appliquée par l'outil de pose entre ledit élément de tige (12, 12c) et ladite structure de bague (14, 14c), ladite contrainte finale de serrage appliquée aux pièces (54, 54c, 56, 56c) s'exerçant alors essentiellement entre ledit élément de tige (12, 12c), ladite tête aveugle (62, 62c) et ladite structure de bague (14, 14c) dudit élément de mise en contact.

23. Rivet aveugle (10c) selon l'une quelconque des revendications 17, 21 ou 22, dans lequel ladite structure de manchon expansible (16c) comporte une zone affaiblie (102) prévue pour se replier radialement vers l'extérieur pour constituer ladite

tête aveugle (62c) sous forme de bourrelet, sous l'effet de la force axiale relative d'une deuxième intensité.

- 24.** Rivet aveugle selon l'une quelconque des revendications 17, 21 ou 22, dans lequel ladite structure principale de manchon (18c) et ladite structure de manchon expansible (16c) sont des éléments séparés,

ladite structure principale de manchon (18c) ayant un corps de manchon de forme allongée (46c) prévu pour se positionner dans les ouvertures alignées (50c, 52c) des pièces (54c, 56c), ladite structure principale de manchon (18c) comportant un premier alésage traversant prévu pour recevoir ladite partie cylindrique de la tige (23c),

ladite structure de manchon expansible (16c) comportant un second alésage traversant prévu pour recevoir ladite partie cylindrique de la tige (23c) et étant placée sur ladite partie cylindrique de la tige (23c), près de ladite tête de tige (37c),

ladite structure de manchon expansible (16c) comportant une zone affaiblie (102) prévue pour se replier radialement vers l'extérieur pour constituer ladite tête aveugle (62c) sous forme de bourrelet, sous l'effet de la force axiale relative d'une deuxième intensité.

- 25.** Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 17, 21, 22 ou 24, dans lequel ladite structure principale de manchon (18, 18c, 18f) ne forme qu'une seule pièce avec ladite structure repliable (51, 63, 100).

- 26.** Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 17 à 25, dans lequel ladite structure repliable (51, 63, 75, 100) de ladite structure principale de manchon (18, 18c, 18e, 18f) comporte une partie fragile (61, 61c, 61f) prévue pour se rompre sous l'effet de ladite force axiale relative d'une troisième intensité.

- 27.** Rivet aveugle selon l'une quelconque des revendications 17 à 25, dans lequel ladite structure repliable (51, 63, 75, 100) de ladite structure principale de manchon (18, 18c, 18e, 18f) a une structure étagée dans le sens radial, définie par deux parties de manchon (46, 46c, 46f, 51, 51e, 51f, 53e, 100) reliées par une partie fragile (61, 61c, 61f) prévue pour se rompre sous l'effet de ladite force axiale relative d'une troisième intensité, afin de permettre à ladite structure étagée de se déplacer axialement à l'intérieur d'elle-même.

- 28.** Rivet aveugle (10) selon la revendication 18, dans lequel ladite structure repliable (75) est un élément séparé du reste (73) de ladite structure principale de manchon (18e).

- 29.** Rivet aveugle (10, 10e, 10f) selon l'une ou l'autre des revendications 18 et 28, dans lequel ladite structure de manchon expansible (16, 16e, 16f) a une longueur comprise dans une plage pratiquement égale ou légèrement supérieure à la longueur de ladite partie avant conique (48, 48e, 48f), la différence de longueur correspondant à peu près à l'épaisseur de ladite structure de manchon expansible (16, 16e, 16f).

- 30.** Rivet aveugle (10, 10c) selon la revendication 22, dans lequel :

ladite partie cylindrique de la tige (23, 23c) comporte une gorge de rupture (42, 42c) prévue entre lesdites rainures de blocage (22, 22c) et lesdites rainures de tractions (44, 44c) et prévue pour se rompre sous l'effet d'une force axiale d'intensité prédéterminée, après que ladite structure de bague (14, 14c) ait été totalement refoulée dans lesdites rainures de blocage (22, 22c),

le rapport entre le diamètre de pied de ladite gorge de rupture (42, 42c) et celui desdites rainures de tractions (44, 44c) étant de 0,82:1 environ, afin d'empêcher que la rupture n'ait lieu au niveau de l'une desdites rainures de tractions (44, 44c) sous l'effet d'une force axiale d'intensité inférieure à celle que nécessite ladite gorge de rupture (42, 42c).

- 31.** Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 17 à 30, dans lequel :

ladite partie cylindrique de la tige (23, 23c, 23f) comporte une partie cylindrique essentiellement lisse (38, 38c, 38f) s'étendant généralement depuis ladite tête de tige (37, 37c, 37f) jusqu'à ladite zone de fixation (22, 22c, 22f),

ladite tête de tige (37, 37c, 37f) se raccorde à ladite partie cylindrique lisse (38, 38c, 38f) par un congé profilé, défini essentiellement par un premier arc de cercle de rayon (R1) qui est pratiquement tangent à ladite partie cylindrique lisse (38, 38c, 38f) et par un second arc de cercle de rayon (R2) qui est pratiquement tangent à la face intérieure (65) de ladite tête de tige (37, 37c, 37f),

ledit premier rayon (R1) étant pratiquement le double dudit second rayon (R2).

**32. Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 17 à 31, dans lequel :**

lesdites pièces sont constituées par une poutre en caisson (72) et une structure (74, 76) qui doit être fixée sur au moins deux faces latérales adjacentes (87) de ladite poutre en caisson (72), 5

lesdites faces latérales adjacentes (87) définissent un angle, 10

des ensembles d'ouvertures alignées (82, 84) ont leurs axes situés dans un même plan, deux au moins desdits ensembles d'ouvertures alignées (82, 84) étant situés dans chacune des faces latérales adjacentes dudit angle, 15

un rivet aveugle susdit (10, 10c, 10f) étant placé dans chacun desdits ensembles d'ouvertures alignées (82, 84) dudit angle, de telle sorte que lorsqu'un rivet aveugle susdit (10, 10c, 10f) est posé, il laisse à l'intérieur de ladite poutre en caisson (72) un dégagement suffisant pour un rivet aveugle susdit (10, 10c, 10f) préinstallé dans ledit angle. 20 25

**33. Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 17 à 31, dans lequel :**

lesdites pièces sont constituées par au moins une paire d'éléments en forme de plaque (83, 89) l'un (83) desdits éléments (83, 89) étant généralement en contact avec un substrat relativement solide (81), 30 35

lesdits ensembles d'ouvertures alignées dans ladite paire d'éléments (83, 89) étant alignés avec une cavité fermée (90) dudit substrat (81), ladite cavité fermée (90) étant formée lorsque ledit substrat (81) est adjacent audit élément (83) desdits éléments (83, 89), 40

ledit rivet aveugle (10, 10c, 10f) dans la position de préassemblage à sa tête de tige (37a) et son manchon expansible (16a) qui dépassent côté aveugle d'une longueur choisie minimale et le jeu entre ladite tête de tige (37a) et ladite cavité (90) est également choisi minimal. 45 50

**34. Rivet aveugle (10, 10c, 10f) selon l'une quelconque des revendications 17 à 26 ou 28 à 33 étant un rivet aveugle haute résistance et permettant d'appliquer une contrainte de serrage voulue comprise entre 70 % environ et 80 % environ de la contrainte finale minimale de serrage du rivet aveugle posé, et dans lequel :**

ledit corps de manchon (46, 46c, 46f, 73, 75) de ladite structure principale de manchon (18, 18c, 18e, 18f) se termine, à l'extrémité opposée de ladite tête de tige (37, 37c, 37f), par une partie élargie à chambrage (51, 51f, 55c, 63, 75), ladite structure repliable (51, 63, 75, 100) comportant une partie à entaille annulaire (53e, 53f, 63, 100) et une partie fragile (61, 61c, 61f), ladite partie à entaille annulaire (53e, 53f, 63, 100) ayant une entaille annulaire (53, 53e, 63, 100) formée sur la surface externe dudit corps de manchon adjacente à ladite partie élargie à chambrage (51, 51f, 55c, 63, 75) et prévue pour se déplacer axialement à l'intérieur de ladite partie élargie à chambrage (51, 51f, 55c, 63, 75), ladite partie fragile (61, 61c, 61f) reliant ladite partie élargie à chambrage (51, 51f, 55c, 63, 75) à ladite partie ayant une entaille annulaire (53e, 53f, 63, 100), ladite partie fragile (61, 61c, 61f) étant prévue pour se rompre sous l'effet d'une force axiale relative d'une troisième intensité, inférieure à la force axiale relative d'une première intensité et supérieure à la force axiale relative d'une deuxième intensité, ladite partie à entaille annulaire (53e, 53f, 63, 100) se déplaçant axialement à l'intérieur de ladite partie élargie à chambrage (51, 51f, 55c, 63, 75), en déconnectant ainsi la structure principale de manchon (18, 18c, 18e, 18f) de la contrainte axiale exercée par ladite tête aveugle (62, 62c, 62f), la contrainte finale de serrage appliquée aux pièces (54, 54c, 54f, 56, 56c, 56f) n'étant ainsi pratiquement pas influencée par ladite structure principale de manchon (18, 18c, 18e, 18f),

une rondelle de retenue plus large (20, 20c, 20f) est prévue pour être mise en contact avec la face accessible (49, 49c, 49f) des pièces (54, 54c, 54f, 56, 56c, 56f) et avec ledit élément de mise en contact (14, 14c, 14f),

ladite structure de manchon expansible (16, 16c, 16f) a un indice de dureté Rockwell compris entre 28 Rc environ et 32 Rc environ,

ledit élément de tige (12, 12c, 12f) a un indice de dureté Rockwell compris entre 38 Rc environ et 42 Rc environ,

ladite structure de manchon expansible (16, 16c, 16f) est fabriquée dans un acier haute qualité ayant une teneur pondérale en nickel supérieure à 0,17 % environ,

ladite rondelle de retenue (20, 20c, 20f) a un indice de dureté Rockwell compris entre 40 Rc environ et 45 Rc environ, ce qui permet d'obte-

nir un rivet aveugle haute résistance,

ladite structure principale de manchon (18, 18c, 18e, 18f) a un indice de dureté Rockwell compris entre 43 Rc environ et 47 Rc environ.

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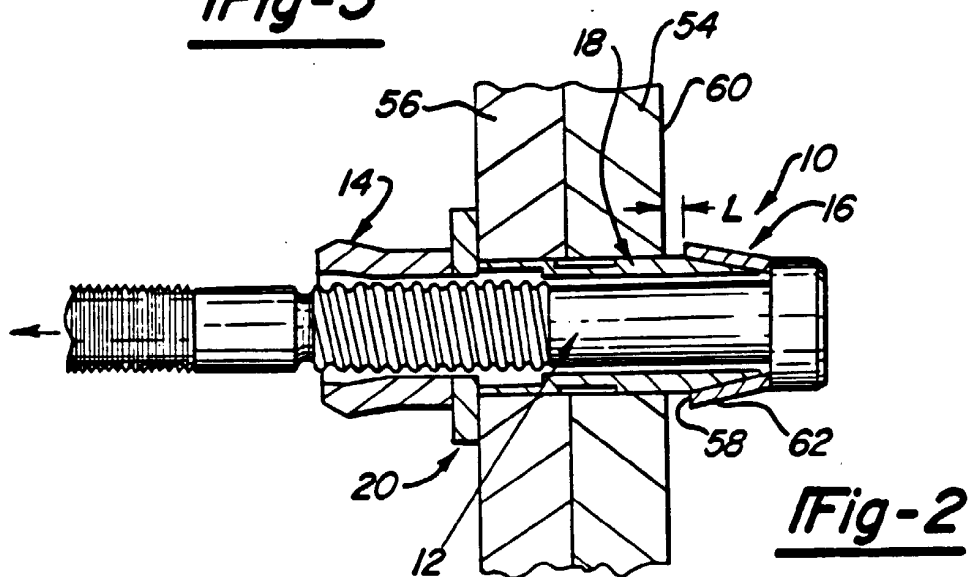
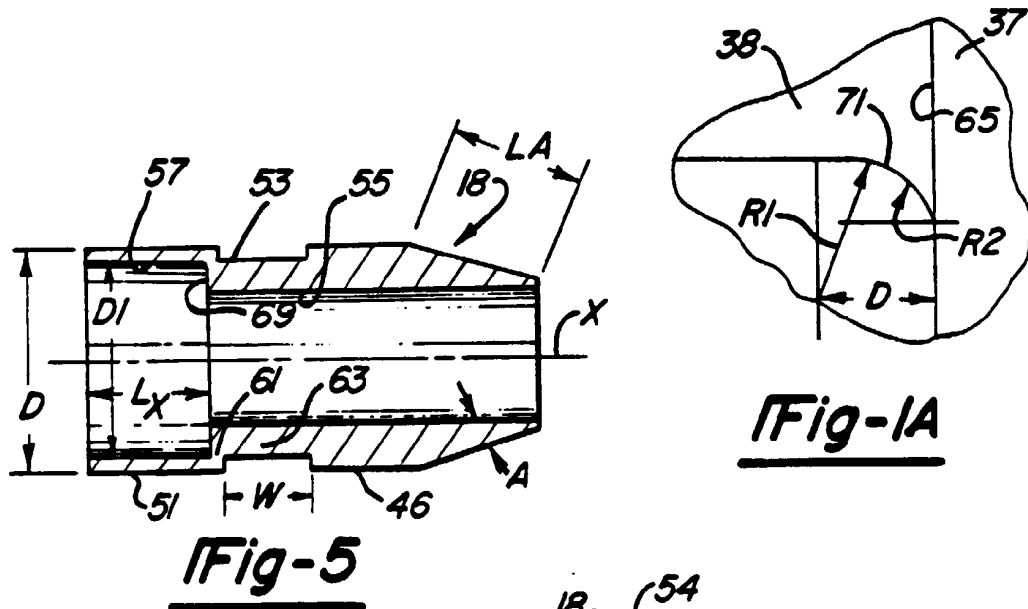
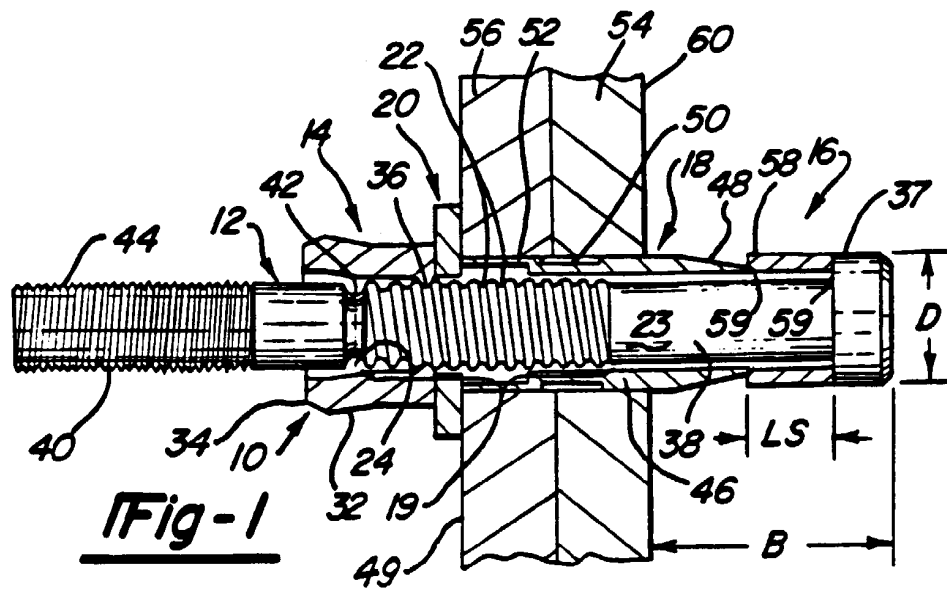
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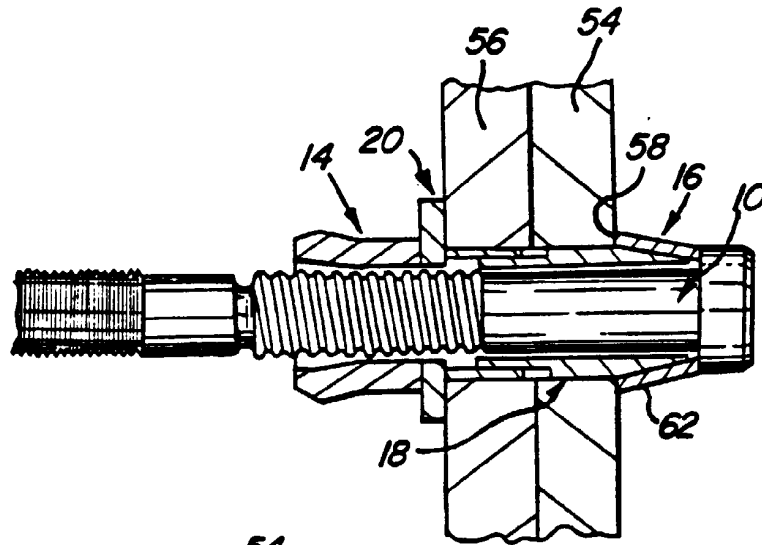


**Fig-3**

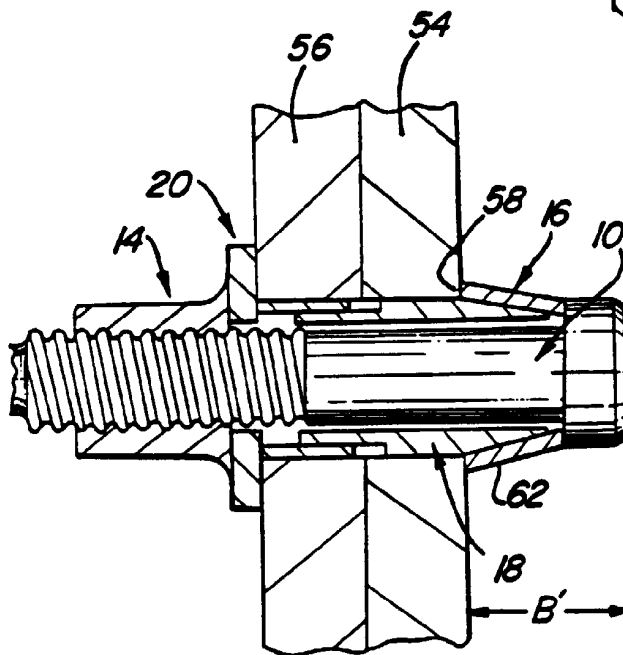


**Fig-4**

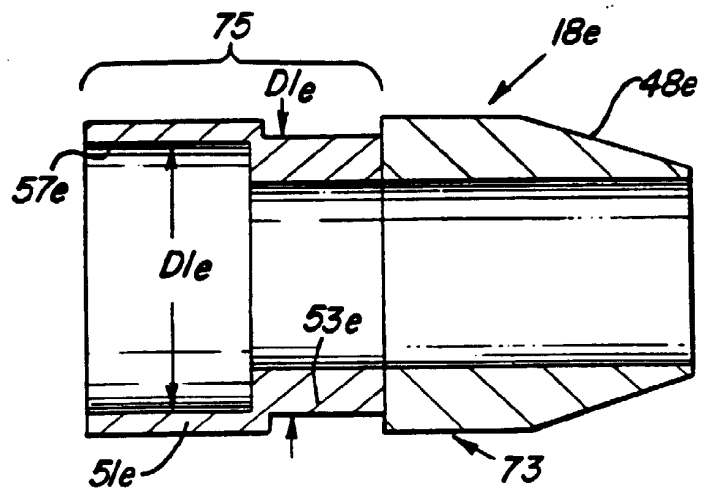


**Fig-6**

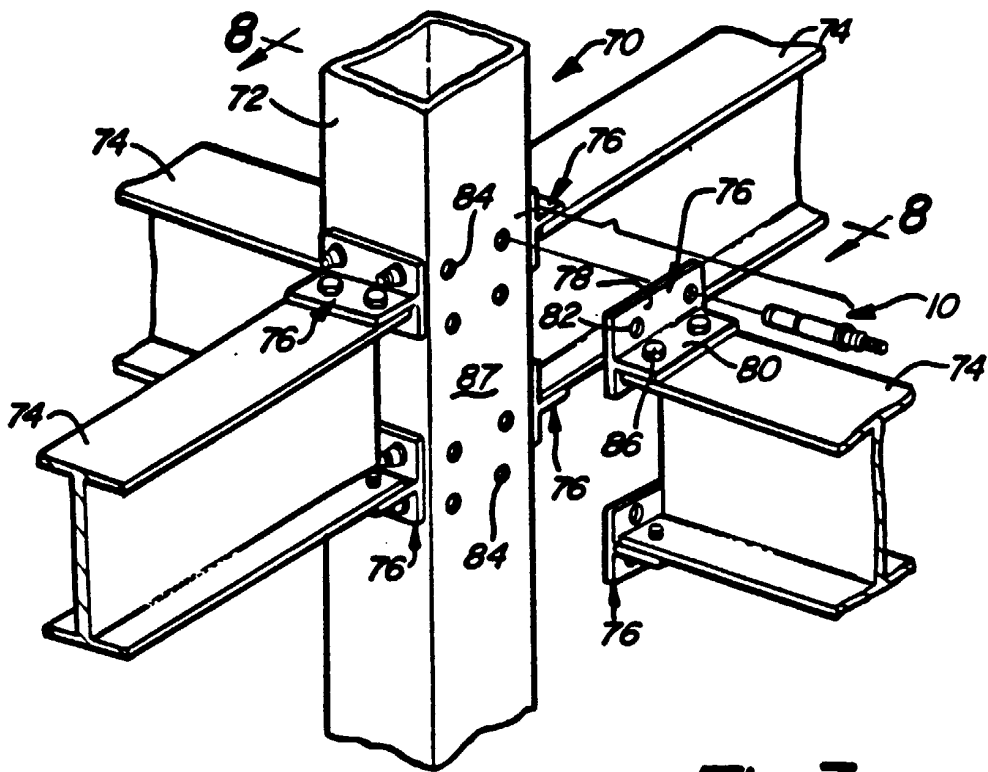


Fig-7

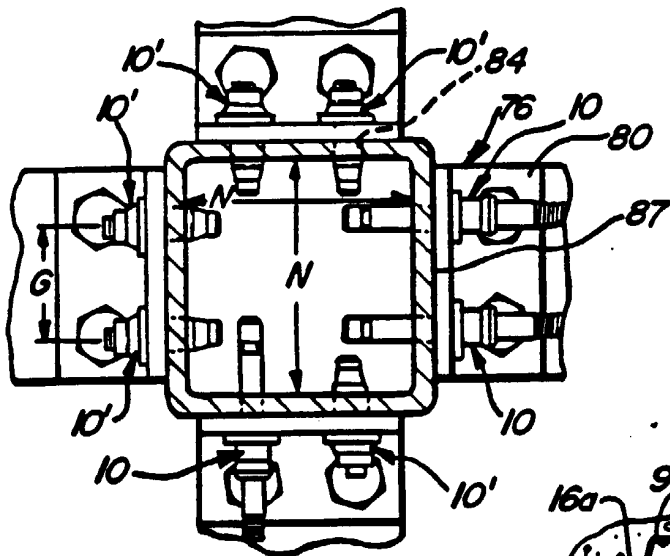


Fig-8

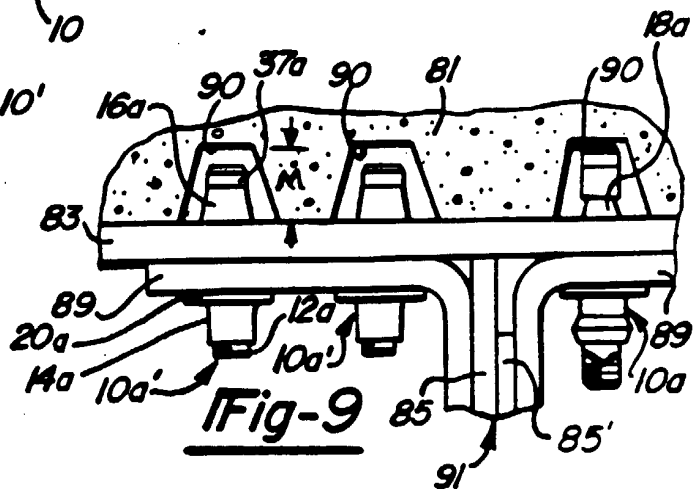
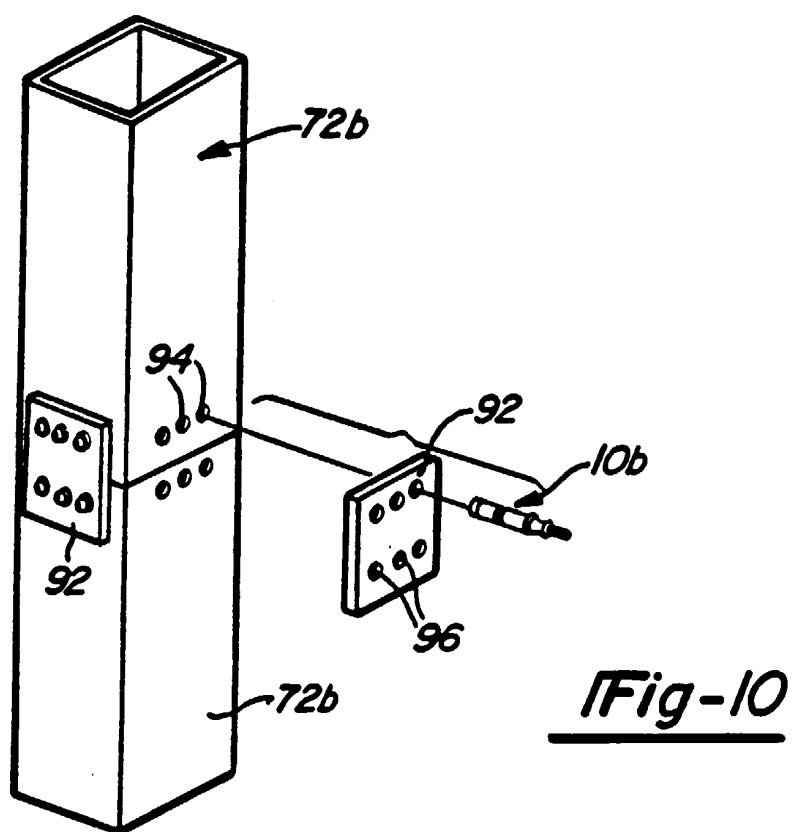


Fig-9



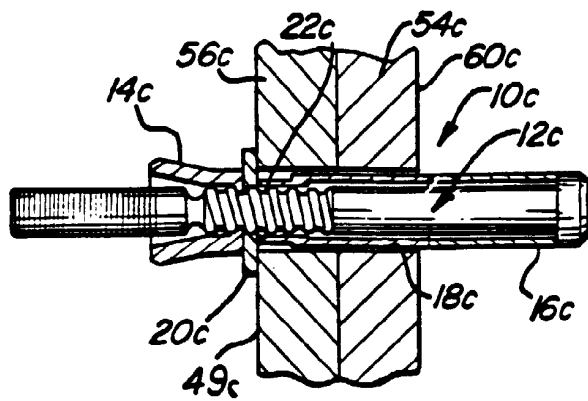


**Fig-11**

**Fig-12**

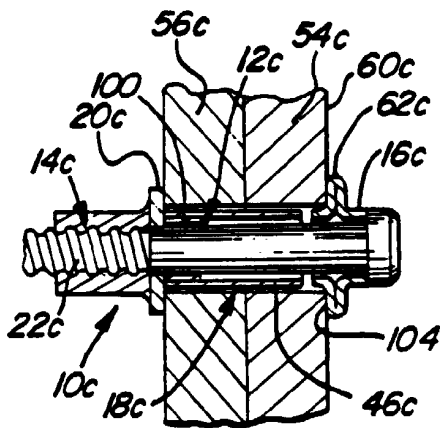
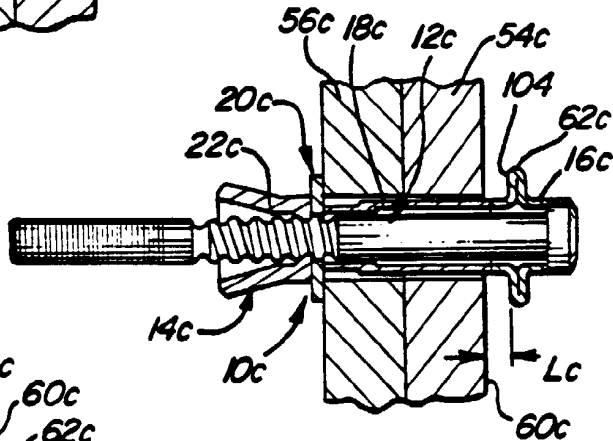


**Fig-13**

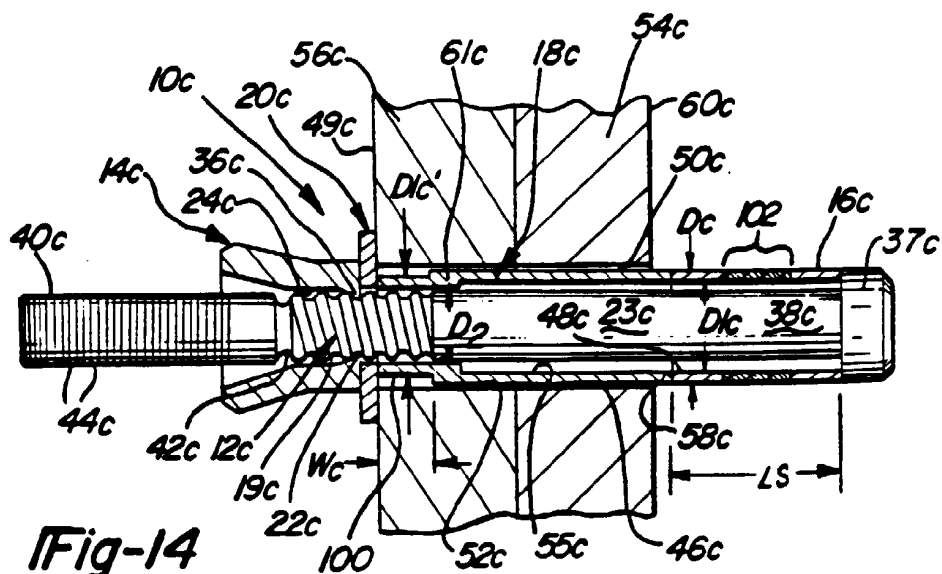
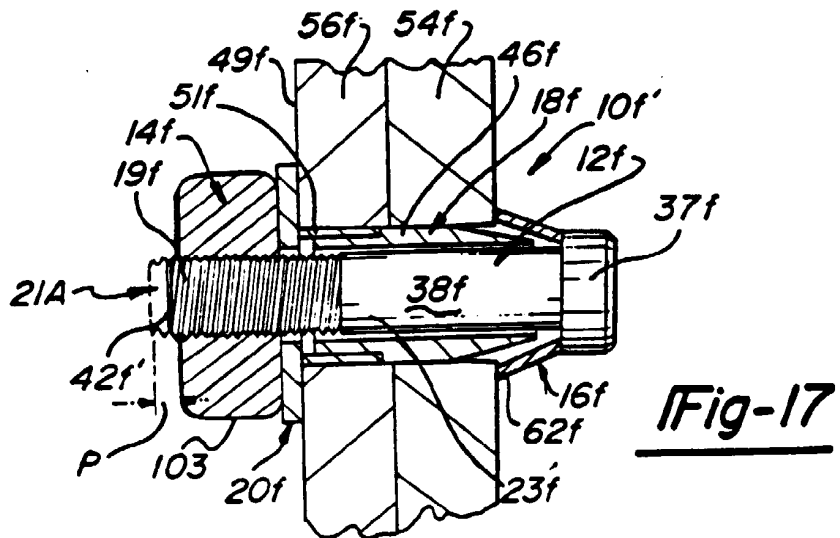
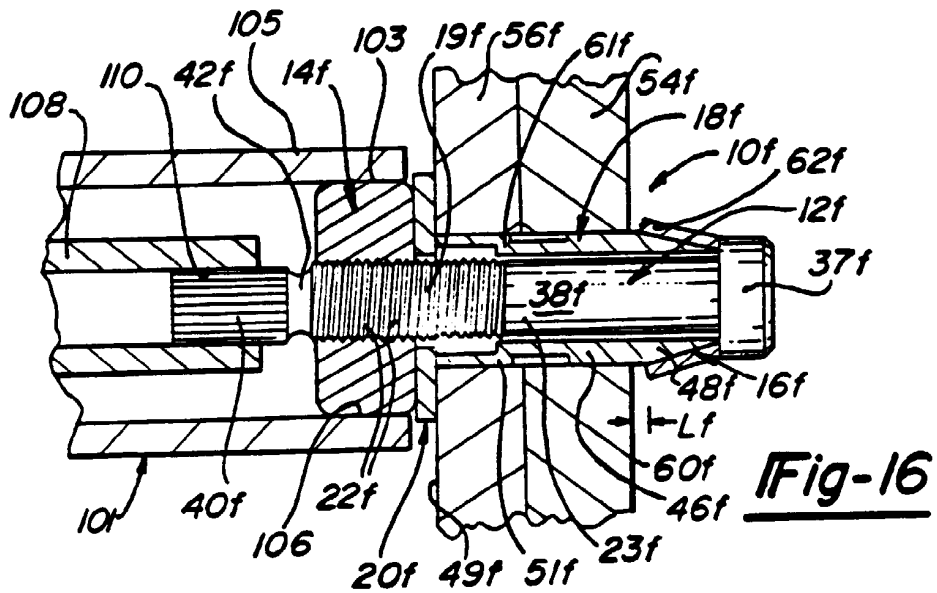
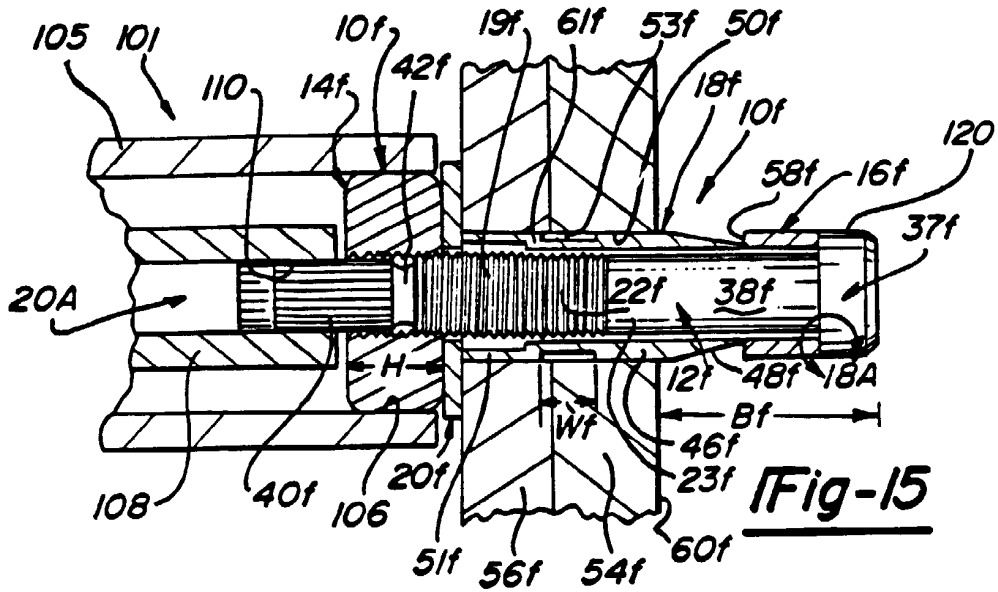


**Fig-14**



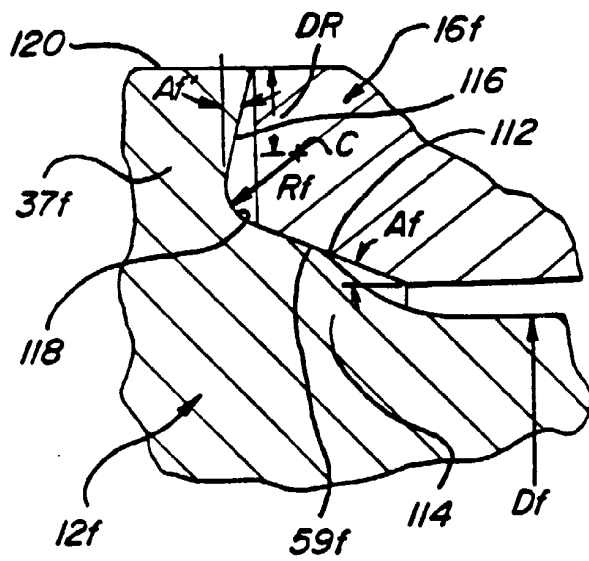


***Fig-18***

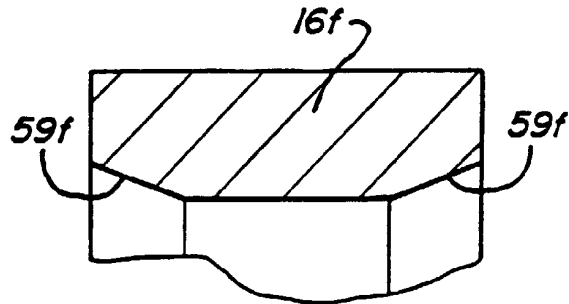


**Fig-19**

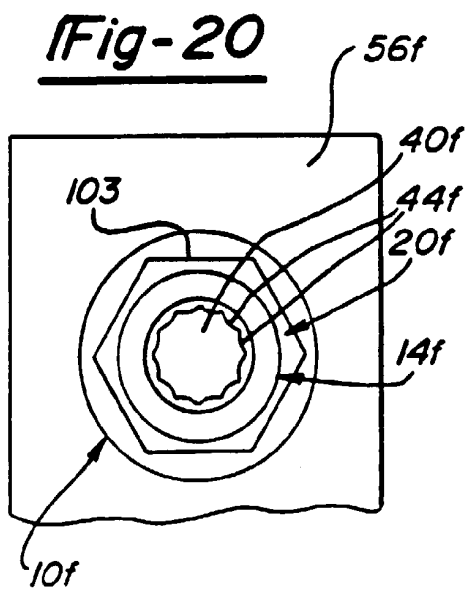


***Fig-20***

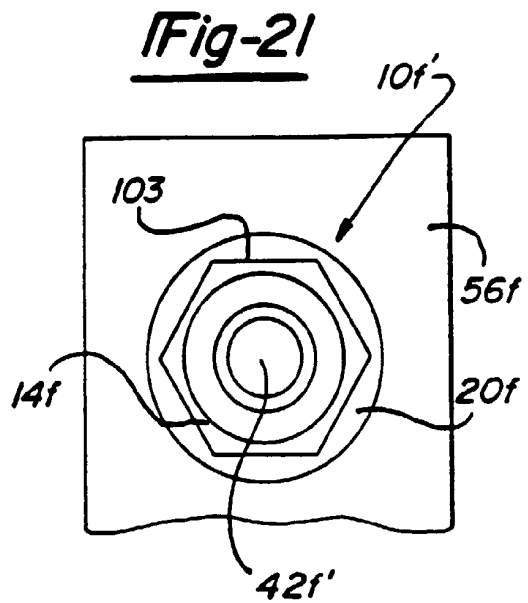


Fig-21