

March 19, 1968

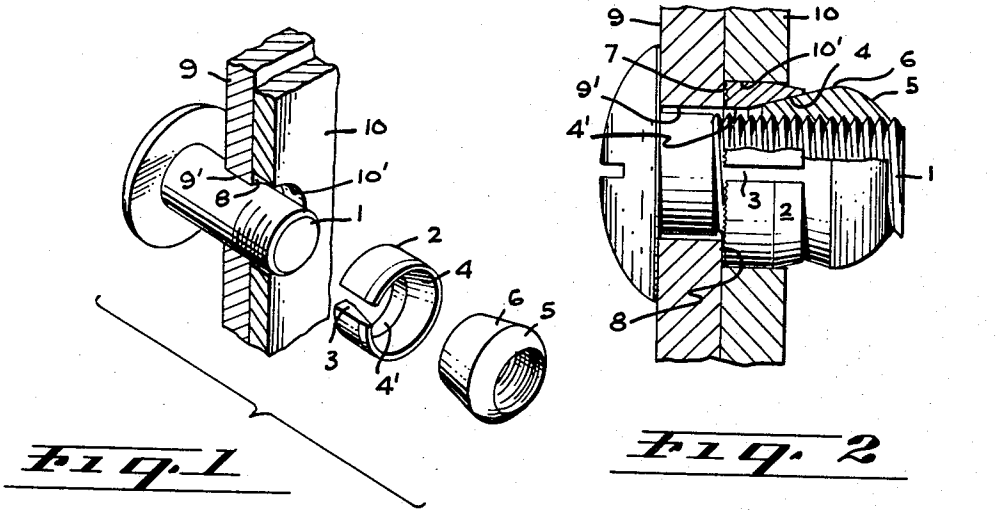
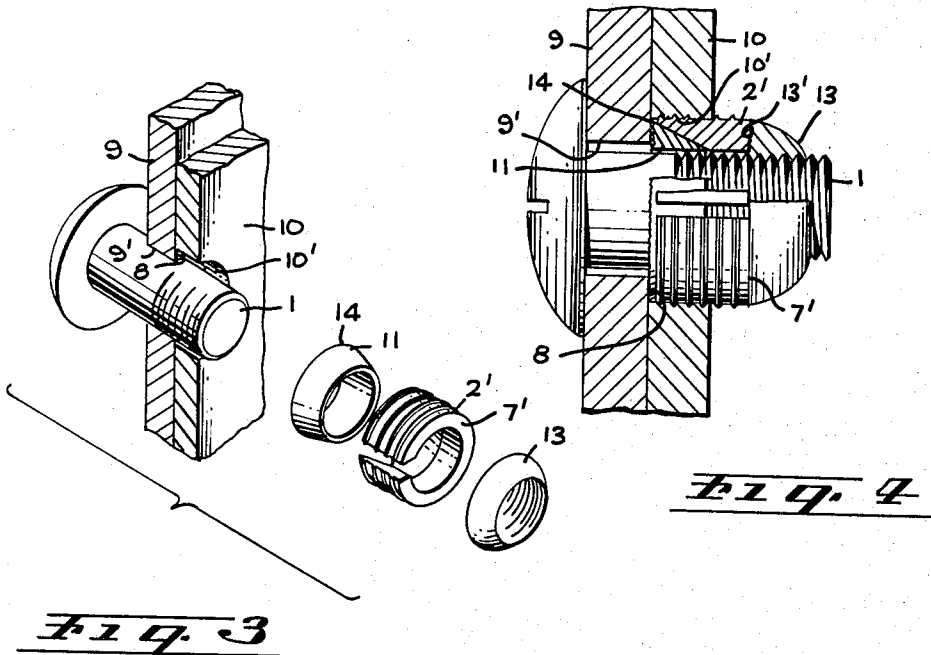
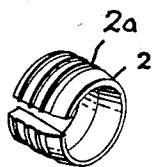
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3,373,648

FASTENERS WITH EXPANSION SLEEVE

Original Filed April 26, 1963

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

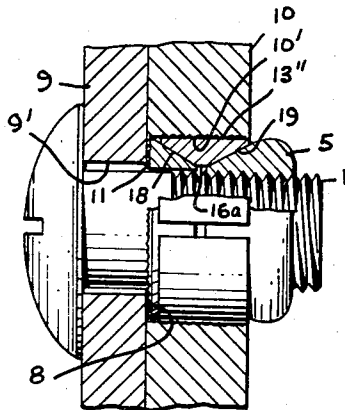


Fig. 5

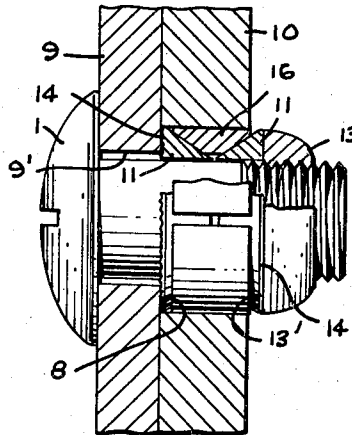


Fig. 6

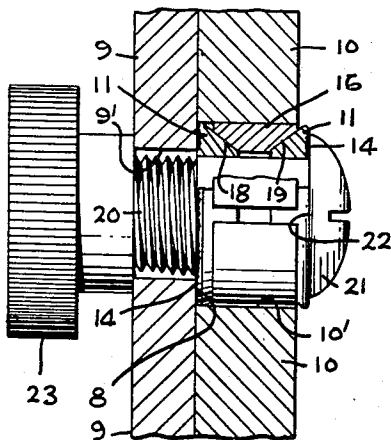


Fig. 7

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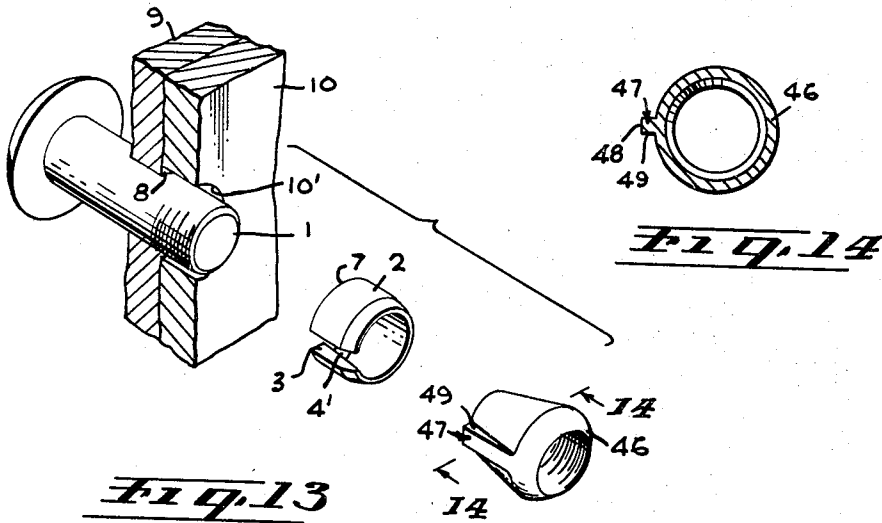
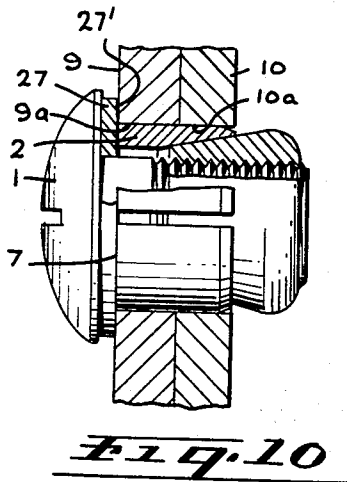
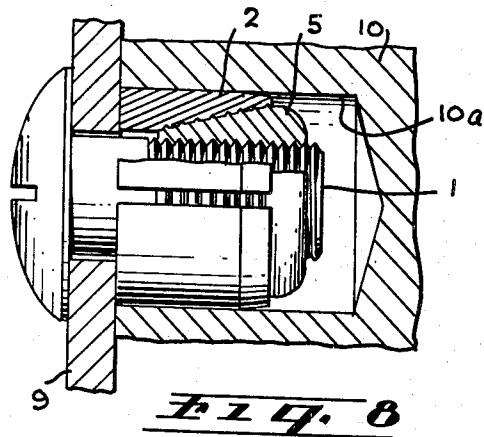
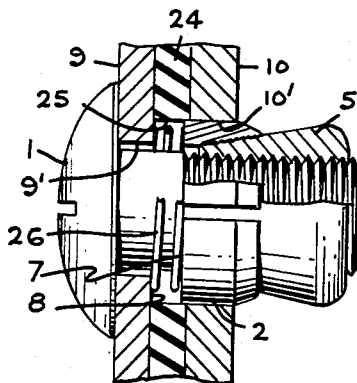
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FASTENERS WITH EXPANSION SLEEVE

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5 Sheets-Sheet 3



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FASTENERS WITH EXPANSION SLEEVE

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5 Sheets-Sheet 4

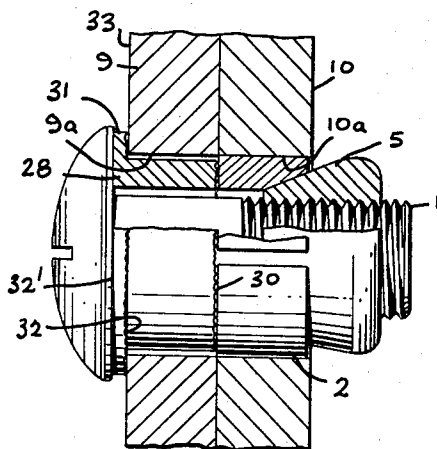


Fig. 11

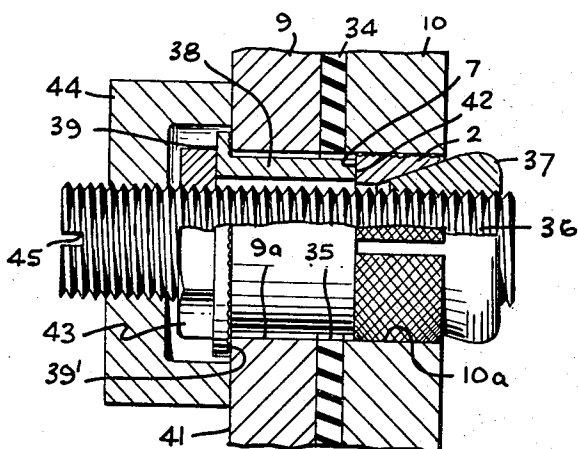


Fig. 12

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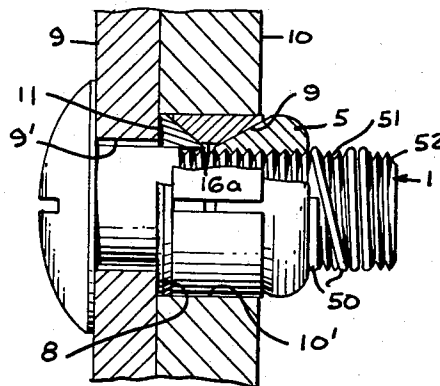


Fig. 15

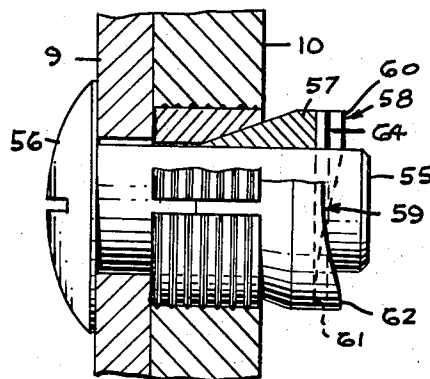


Fig. 16

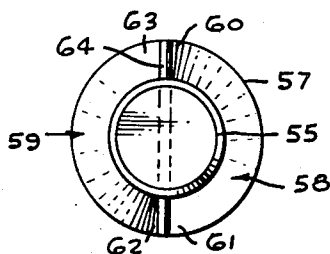


Fig. 17

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3,373,648

FASTENERS WITH EXPANSION SLEEVE

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Continuation of application Ser. No. 276,030, Apr. 26, 1963. This application June 22, 1966, Ser. No. 559,692
6 Claims. (Cl. 85-67)

This application is a continuation of application Ser. No. 276,030, filed Apr. 26, 1963, and now abandoned, which in turn was a continuation-in-part of application Ser. No. 82,944, filed Jan. 16, 1961, now Patent No. 3,192,820. The present invention is particularly related to fasteners.

The fasteners of my invention employ a threaded shaft which may be in the form of a screw, bolt or stud on which is mounted a bushing structure comprising an expandable split wedge female ring having an interior conical surface, the surface making an acute angle with the central axis of said split ring. Said bushing structure includes means axially displaceable on said shaft to expand said split ring, to be seated against the inner wall of a bore in which the fastener may be mounted; said means having a male member axially displaceable on said shaft and having an exterior conical surface, said exterior conical surface of said male member making an acute angle with the axis of such shaft and mating with the interior conical surface of said split female ring, said means mounted on said shaft for relative rotation with said shaft to exert an axial lateral thrust, to displace said male member axially and provide a lateral axial and radial thrust on said split female member, and means being provided on said members to retain the male member against rotation relative to the shaft.

In order to accomplish this result, I may employ, as the means to create the axial thrust on the male member, a nut threaded on said shaft to apply the axial thrust on the conical surfaces of the male member which are contiguous to the conical surfaces of the female member or, alternatively, any equivalent configuration, such as a cam slot in or at the end of the male or female member, with a cam rider which moves over the cam surface as relative rotation of the shaft and male member is effected, to produce the axial thrust.

The member, whether it be the male member, female member, or an auxiliary member, upon which the thrust is initially exerted and from which the thrust is transmitted to the female and male member, will hereafter be referred to as the thrust member.

I also provide, on one or more surfaces of the fastener transverse to, e.g., perpendicular to, the axis of the shaft, configurations such that any of the friction on surfaces obtaining between said work and said thrust member, herein referred to as the "train of friction" ahead of the thrust member, is greater than the friction between the thrust member and the shaft when the shaft and the thrust member are rotated relative to each other. The minimum friction in the total friction train upon such rotation is at the frictional surfaces between the thrust member and the shaft. The total friction train is that existing when the thrust member and shaft are rotated relative to each other, and includes the friction between the work and the bushing between the contiguous transverse, e.g., perpendicular surfaces of the bushing parts and also those of the thrust member, and the friction between the thrust member and the shaft, and between the mating conical surfaces in the bushing.

In such a configuration, when the conical surfaces are brought into snug engagement by a light torque applied, for example by hand, or are in snug engagement under a spring bias without any substantial expansion of the female ring, the fastener may be inserted into a hole of

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somewhat larger diameter than the female ring. A fractional turn of the shaft and thrust member relative to each other locks the fastener in place in the bore. The male ring moves laterally into the female ring slightly, but sufficiently, however, to expand the female ring so that its exterior surface is pressed against the wall of the hole in which it is positioned.

A particular advantage of the fastener of my invention is that it does not require specially shaped or threaded holes or multiple holes of complex patterns. It may fasten any desired thickness of structure, and functions equally well in blind holes and in work pieces having bores of diameter larger than the diameter of the shaft. With appropriate choice of dimensions, a fraction of a turn secures or releases the fasteners, and the complete separation of the fastener parts is not required to disassemble the work.

The fasteners of my invention include captive fasteners and non-captive fasteners. A captive fastener is designed to be mounted to connect two or more pieces of the work by providing in one of the pieces a bore of a diameter less than the bore in the other of the two pieces, the smaller bore being of a diameter sufficient to pass the shaft but insufficient to pass the bushing. The larger bore is of sufficient diameter to pass both the bushing and the shaft when the bushing is in the unexpanded position. On relative rotation of the nut and shaft, the female ring member of the bushing is expanded to be brought into forceful engagement with the wall of the larger bore. This force is sufficient to press the split female ring tightly against the wall of the larger bore and to press the surfaces of the work at the smaller bore against the adjacent annular surface of said bushing.

In such assembly the work pieces may be separated without disassembling the fastener. The non-captive fastener has a similar assembly and may be used to connect two parts of the work. By being positioned in bores in the work, the fastener may be removed without first separating the parts and without disassembling the fastener.

These and other objects of my invention will be further described in connection with the drawings, of which:

FIG. 1 is an exploded view of one form of the fastener of my invention;

FIG. 1a is a modification of a bushing employed in the form of FIG. 1;

FIG. 2 is a section partly in elevation of the fastener of FIG. 1;

FIG. 3 is an exploded view of another form of my invention;

FIG. 4 is a section, partly in elevation, of the fastener of FIG. 3;

FIGS. 5-12 are sectional views, partly in elevation, of modified forms of the fastener of my invention;

FIG. 13 is an exploded view of another form of the fastener of my invention;

FIG. 14 is a view on line 14-14 of FIGURE 13;

FIG. 15 illustrates a variation of the forms shown in FIGS. 1-14;

FIG. 16 shows a further variation of the forms shown in FIGS. 1-14; and

FIG. 17 is an end view of FIG. 16.

In FIG. 1, the fastener is of the captive type, and is shown for use in assembling two parts 9 and 10 of a work. The work part 9 has a bore 9'. The work part 10 has a bore 10' approximately aligned with the bore 9'. The bore 10' is of a diameter larger than the bore 9', to expose a surface 8 on the work part 9. The fastener is composed of a screw 1 which passes through the bores 9' and 10'. Mounted on the screw, in the bore 10', is a bushing 2. The bushing 2 in the unstressed condition is of a somewhat smaller outer diameter than the diameter of bore 10', and the cylindrical section 4' of the inner bore of the bushing is larger than the outer diameter

of the screw. The bushing is a split wedge ring with an interior conical surface 4 at one end and a cylindrical surface 4' at the other end of the ring, adjacent the flat annular surface 7, laying in a plane substantially perpendicular to the axis of the threaded shaft or screw. The nut 5 is of maximum outer diameter less than the diameter of the bore 10' and has an exterior conical surface 6. The ring 2 is split at 3 throughout its length and thickness to form a split ring. I may thus employ as the split ring the split female ring with the single conical surface disclosed in my Patent 3,009,747. The angles which the surfaces 6 and 4 make with the axis of the nut and bushing, respectively, are substantially equal acute angles. This angle is not limited by the angle of repose of the materials at the mating wedge surfaces. When this angle is more than the angle of repose, as will be described below, if the axial thrust which locks the fastener in place is relieved, the conical mating surfaces slide over each other to relieve the radial thrust on the bushing and to permit the ring to contract, and thus to unlock the fastener. When this angle is less than the angle of repose, the mating surfaces will not necessarily slide over each other, but an axial thrust on the shaft 1, applied to the head, will move the nut 5 and surface 6 sufficiently to permit the relief of the radial force and permit the unlocking of the fastener.

The bushing element 2 is elastically deformed in bending when the radial force is established by the entry of the male member, i.e., nut 5, into the female bushing element 2 when the shaft is rotated relative to the nut and bushing. Relief of this radial force, when the reverse rotation of the shaft occurs, causes the ring, due to its high elastic modulus, to regain its shape without any substantial deformation having occurred in the split ring.

The train of friction between the contacting surfaces of the fastener, starting at the work and ending at the nut, must be greater than the friction between the threads of the nut and the shaft screw threads. In order to accomplish this purpose, I may roughen one or more of the surfaces of the fastener assembly. For example, I may roughen one or both of the surface 9 and the contiguous surface of 2. Thus, I may finish this surface to an R.M.S. value of 500 or more (see How Smooth Is Smooth, by Brosheer, in American Machinist of Sept. 9 and 23, 1948, and also U.S. Patents 2,240,278, 2,345,022, and British Patent 523,436).

The above figures are given merely by way of example, the nature of the roughness will depend on the friction between the screw threads and the nut threads, when rotated relative to each other, which may be minimized by lubrication and by the smoothness of the thread surfaces of the nut and screw. The degree of roughness required is that which will make the friction between the threads of the nut and shaft less than the friction between any other surfaces of the friction train. Thus, the friction between 8 and 7 must be greater than between the threads of the nut and shaft when they are rotated relative to each other. Under these conditions, the nut does not rotate as the screw is rotated.

Conversely, I may form the surface 7 with a knurled surface or with radial or chordal ridges, or with both such ridges.

The unit is assembled by passing the screw 1 through the bore 9' and mounting the split ring, which has a larger inner diameter than the shaft, about the shaft in such manner that the inner conical surface 4 converges towards the head of the screw and the work piece 9. The nut 5 is mounted on the screw to engage with the surface 4, and surface 7 engages with the surface 8, so that the surface 6 engages and makes a fit such as may be conveniently made by hand. The nut 5 should not be entered into the split bushing in an amount to unduly distend the ring 2, as will appear from the following. The work piece 9 and the fastener assembly are mounted on work piece 10 by entering the fastener assembly into the bore 10'. By rotating the screw, the nut 5 is drawn into

the female member. The axial thrust of the nut is transmitted through the wedge surfaces 4 and 6 and imposes an axial thrust on 2, forcing the surfaces of 7 against surface 8. The axial thrust of the nut also causes an expansion of the ring 2 so that the outer surface of 2 is clamped against the wall of the bore 10. The friction set up between 8 and 7 and the clamping action of the split ring about the nut 6, occurring when the initial assembly was made, is sufficient when the screw is turned to hold the nut against rotation and permits the screw to be screwed further into the nut.

The ring 2 also is retained against rotation by friction. This action causes the split ring to be pressed more forcefully against the surface 8 and a clamping action between the surface 7 and the surface 8. The nut advance permissible is that necessary to cause the ring to open against the bore 10'. By suitable selection of the dimensions, this may occur, for example, in a 90° turn of the screw. This will convert the assembly from a "go" condition, where it may be passed or withdrawn from the hole 10', to a "no go" condition where it is clamped in the hole 10'.

It will be seen that the bore 9' should be sufficiently less than the outer diameter of 2, in order that adequate bearing surface be present between 7 and 8 and also in order that the ring 2 be not deformed so as to extrude or be wedged into the bore 9'.

In the structure described above, a force acting on the work parts, axially of the screw and in a direction to separate 9 and 10, is resisted by the friction between the ring 2 and the surface of the bore 10'. In order to increase this friction and raise the tension load necessary to separate 9 and 10, I may provide protuberances on the surface of 10. Thus, for example, as is shown in FIG. 1a, I may provide circumferential spaced ridges 2a whose vertical height and slope should be such that, when the ring is expanded against the wall of the bore 10', they will press into the wall and preferably permit the surface between the ridges to contact the surface of the bore 10'. For this purpose, the material of the piece 10 should be softer than that of the ring, so that the ridges may enter into the wall of 10'.

The result is that the train of friction at the annular end 7 of the ring 2, with or without the surface protuberances 2a, generates a friction in excess of that at the threads. This holds the nut against rotation, when the screw is turned.

FIGS. 3 and 4 show an alternative form of captive fastener. The distinction between these forms and those previously described is in the structure of the means for expanding the ring 2'. The ring 2' may be of similar structure to that of 2, either in the form of FIG. 1 or in the form of FIG. 1a, the difference being that the ring is positioned in a reversed position. The ring 2' is positioned on the screw 1 so that the conical inner surface of the female ring diverges away from the work part 9 instead of converging, as in the form of FIGS. 1 and 2. The expanding means consists if a continuous unsplit, i.e., relatively rigid, male ring 11, positioned adjacent the surface 8 of the work part 9, and has a cylindrical inner bore and a conical outer surface which mates with the conical inner bore of the female split ring 2'. The male ring has a counterpart in the split male ring shown in my Patent No. 3,009,747. The inner diameter of the cylindrical section of the ring 2' in its unstressed condition and of the male ring 11 is somewhat larger than that of the screw shaft, and the maximum outer diameter of the ring 11 at its end surface 14 is larger than that of the bore 9', for the same reason as with the ring 2 of FIGS. 1 and 2. The nut 13 has a flat end 13' which abuts the annular end 7' of the split ring 2'. One or both of the surfaces 7' and 13' may be rough, and the annular surface 14 or the contiguous surface of male member 2 may be rough, as described for the surfaces 7 of FIG. 1.

As in the case of the fastener of FIGS. 1 and 2, the screw is passed through the bore 9' in the work part 9, and the ring 11 is passed over the screw, and the split ring 2' is passed over the screw. The nut is threaded so as to make it snug against the part 2'. This imposes an axial thrust on the ring 2' and the ring 11, forcing the ring 11 into the ring 2' and the surfaces 13', 7', 14 and 8 against each other. The relative motion of the part should not be so great as to open the ring 2' unduly. The assembly may then be entered in through the bore 10' in the work part 10. The initial set will wedge the rings together and force the surfaces perpendicular to the axis of the screw against each other, so that, when the screw is turned further to enter the nut 13, the friction at the contacting surfaces 8 and 14, and at 7' and 13', is greater than that between the threads of the nut and the screw. The rings 11 and 2' and the nut are thus restrained against rotation by this friction.

As in the case of FIGS. 1 and 2, by proper choice of the dimensions of the parts, a fractional turn of the screw will cause a sufficient axial advance of the nut, retained against rotation, to expand the ring 2 to clamp it against the surface of the bore 10'. As in the case of the forms of FIGS. 1 and 2, the ring 2' may be provided with protuberances, as, for example, shown in FIG. 1a.

The form shown in FIG. 5 is a captive fastener which differs from the form shown in FIG. 4 by employing the nut 5 of FIG. 2 and a split female ring having two oppositely directed conical surfaces, forming a solid angle with each other, and meeting each other at a cylindrical surface 16a spaced from the exterior surface of the screw threads, surface 19 converging and surface 18 diverging in the direction of the axial thrust. The conical surface 19 mates with the conical surface of the nut 5, and the conical surface 18 mates with the conical surface of the male ring 11.

As in the form of FIGS. 3 and 4, the surface 13'' is roughened. As previously, the friction at the contacting surfaces 8 and 13' is larger than the friction at the threads of the nut and screw. The screw may thus be turned while the nut is restrained from rotation. The parts are assembled in a manner similar to that previously described.

By employing the structure of the form of FIG. 5, the length of the bore 10' may be increased without the wedged surfaces approaching the angle of repose. In the forms of FIGS. 1 and 2, the axial length of the bushing for any given diameter is limited by the angle of repose of the wedged surfaces, if it is desired that the surfaces disengage without employing an axial thrust, as described above.

In the form of FIG. 5 (see also FIGS. 6 and 7 below), the axial length of the expansible bushing may be increased and still seat against the bore 10' throughout its length when the bushing is expanded. In the forms shown in FIGS. 2 and 4, the opening of the ring is concentrated at the wedged surfaces of the ring and diminishes in an axial direction away from the conical surface at the cylindrical surface of the ring. The ring will be clamped against the bore 10' adjacent the conical section. It may not be so tightly clamped at the cylindrical portion of the inner surface of the female ring.

Thus, in the forms of FIGS. 2 and 4, the axial length of the conical surface being substantially that of the bore 10', the female ring with the single conical surface may be inadequate for bores of longer lengths. In the forms of FIGS. 5, 6 and 7, if the axial length of the bore 10' is such as to be too long for the single conical surfaced rings, such as 2 above, the double-wedged female ring permits of the attainment of a suitable angle for the selected diameter and assures that the ring will be clamped against the wall of the bore 10' along the whole length of the bushing.

FIG. 6 is a captive fastener which is similar to FIG. 4, but employs the two male rings 11 and converging and

diverging conical female ring 16, as in FIG. 5, and the nut 13 of FIG. 4. As in the forms previously described, the annular surfaces 14 and 14' may be roughened, or the surface 14' against the surface 8, and only the surface 13' of the nut roughened, in the manner previously described for like function. The train of friction of the contacting surfaces 8 and 14, and at 14' and 13', is, as in the case of FIG. 6, greater than at the threads of the nut and screw, so that the screw may be turned without turning the nut.

FIG. 7 shows a captive fastener which employs the male and female ring bushing shown in FIG. 6, but employs a different arrangement of screw and nut for generating the axial thrust. The threaded shaft 20 has an upset head 21, having a surface positioned against the surface 14 of the male ring. The outer diameter of the head is made sufficiently large to be positioned against the surface 14 and small enough to pass through the bore 10'. A nut 23 is mounted exteriorly of the work part 9. The parts are assembled in the bore 9' and the nut 23 rotated to draw the head 21 towards the work part, but not sufficiently to expand the female ring 16 unduly. The surface 14 against the surface 8 is roughened, as explained above, and either or both surface 14 and the surface 22 of the head 21 may be roughened in the manner previously described for the other forms of FIG. 6. The train of friction then set up at the surfaces 14 and 18 and 19 being greater than between the threads of the nut 23 and the threads of the shaft 20, the rings and the shaft are restrained against rotation when the nut 23 is rotated. The head and the nut thus approach each other, to provide an axial thrust on the ring 14 and the split ring 16. The ring 16 opens to be clamped against the wall of the hole 10'.

FIG. 8 shows a captive fastener of a form similar to that of FIG. 1, showing the split ring having a roughened outer surface, as in FIG. 1a, showing its application to work piece 10, having a blind hole 10a, instead of a through hole 10' as in FIG. 1. The construction and function are similar to that described in FIG. 1.

In the forms shown in FIGS. 1-6 and 8, the clamping action as between 9 and 10 is limited by the axial displacement of the screw and nut which causes the split ring to open and seat against the wall of the bore 10'.

In FIG. 7 clamping is provided by the nut 23. When the limit of expansion of the ring 16 is obtained, the rotation of the nut 23 acts to compress the parts 9 and 10 until the nut is tight against 9 and 9 is tight against 10.

FIG. 9 illustrates a variation of captive fastener where the clamping action may be magnified. Thus, in FIG. 9 the work pieces 9 and 10, having the bores 9' and 10', as in FIG. 1, are shown separated by compressible member, such as a gasket 24, to illustrate a case where a displacement is desired which requires a larger displacement of the nut and screw. The gasket 24, placed between the work pieces 9 and 10, has a bore 25. The screw 1 is passed through the bores 9' and 25, and the spring 26 mounted over the screw, and the female ring and the nut 5 mounted as in the case of FIG. 1, and the assembly passed through the bore 10'. The ends of the spring are roughened where they contact the surface 8 and the annular surface 7, and 7 may also be roughened, as described previously for like functions. The assembly is snugged up by hand, as previously described for the other forms, and mounted in the bore 10'. The screw thus may be turned through many more degrees than in the previous case. The advance of the screw into the nut expands the ring 2 against the wall 10' and compresses the spring and gasket. The roughened ends of the spring, with or without the roughened annular end 7, retain the spring against rotation. The train of friction at the surfaces 8 and 7 being larger than at the threads of the screw and nut, the female ring and the nut 5 are also restrained against rotation. The entry of the screw into the nut forces the ring 2 against the spring 26 and also expands the ring 2. The parts 9 and 10

are thus clamped together and the ring 2 clamped in the bore 10'.

In the previous forms, the frictional force acting to aid in holding the nut against rotation was imparted in part by frictional surfaces between the work and the bushing assembly. To do so, one of the parts of the assembled work was provided with a hole larger than that in the companion work part.

In all of the above forms, FIGS. 1 to 9, when the screw is rotated in the opposite direction, the tension in the split ring, where the slope of the conical surfaces is greater than the angle of repose, causes the wedged surfaces to slide over each other to relieve the axial and radial thrust. The bushing thus becomes loose in the bore 10' or 10a. The split ring will regain its original shape without any substantial deformation, since the stress has not exceeded the yield point. The ring is elastically stressed in bending when expanded. The fastener assembly, however, is retained in the bore 9', since, when the spring female ring has recovered its original position, the continued rotation of the screw in the forms of FIGS. 1-6, 8 and 9, or the nut in FIG. 7, causes the other member parts to rotate free of the bushing segment, the fastener is thus captive in part 9 when the parts are disassembled. In order to remove the assembly from part 9, the nut must be restrained from rotation, for example, manually. It will be observed that in all of the above forms the fastener is installed by entry into the bore 9', and both work parts may be assembled by an operation performed from only one side of the two or more work pieces. Thus, all manipulations to enter the work piece 10 and to lock the fastener to the work piece 10, or to unlock the fastener or remove the work pieces, is accomplished by a manipulation at the same one end of the fastener, to wit, from the exterior of 9. It is not necessary to manipulate both ends of the fastener.

FIG. 10 illustrates the non-captive fastener in which the bores in the work pieces 9 and 10 are each of a diameter to pass the fastener when the split ring is in the unstressed condition. FIG. 10 shows the same fastener as is shown in FIG. 1. The holes 9a and 10a are both of substantially the same diameter. The ring 2 is of sufficient length to be positioned in, and extend entirely through the bore 9a and sufficiently far into the bore 10a to permit it to grip the interior surface of the bore 10a. A washer 27 is provided between the screwhead and 9. The surface of the washer 27' contiguous to the exterior surface of the workpiece 9 is relatively rougher than between the screwhead and the exterior surface of the washer 27. One or the other of the contiguous surfaces of the washer and 7 are roughened. The train of friction between the surface 27', the surface 9 and at 7 is greater than the friction between the threads of the nut and shaft and also greater than at the surface 27', when the shaft and nut are rotated relative to each other. Thus, the nut does not rotate when the screw is turned. The assembly may be mounted in a manner similar to that shown in the previous forms. Thus, the fastener may be assembled and tightened by hand and entered into the bores 9a and 10a. The rotation of the screwhead will expand the ring 2 against the bores 9a and 10a, as the non-rotating nut enters the female ring, the roughened surfaces holding the split ring and nut against rotation.

FIG. 10 illustrates a non-captive type when the screw is unthreaded, causing a release of the radial and axial thrust. As described previously in the forms of FIGS. 1 through 9, an axial separation of the male and female members occurs. The split ring contracts so that its outer diameter is smaller than the bores 9a and 10a, and the entire fastener may be removed. This form is thus a non-captive fastener.

Another form of my invention which acts as a non-captive fastener is shown in FIG. 11. The work pieces 9 and 10 may have similar diameter bores 9a and 10a, as in FIG. 10. However, the bore 9a may be larger than

bore 10a, to pass the fastener when the ring 2 is unstressed. The fastener has a screw 1 on which is mounted a cylindrical tubular bushing 28, having an outer diameter less than the bore 9a and a flanged end 31 positioned against the screw head. The back side of the flange 31, adjacent the front surface 33 of the work piece 9, is roughened, as previously described, for the surfaces perpendicular to the screw, as in the other forms of fastener. The split ring 2, as in FIG. 1, is positioned on the screw to engage the nut 5, as in FIG. 1.

It will be observed that the fastener of FIG. 11 is similar to that of FIG. 10, the washer 27 being replaced by the flange tubular member 28.

The assembly whose parts have outer diameters somewhat less than the bores 9a and 10a may be entered from one side of the work. The parts are of dimensions as shown, so that the ring 2 is in the bore 10a and the tube 28 is positioned in the bore 9. The tube 28 abuts the ring 2 at the surface 30, and the surface 32 of the flange 31 abuts the work piece 9. The vertical surfaces of the fastener at 30 and 32 are roughened, as described above. The friction at the surface 32 is greater than at the surface 32', and the train of friction at the surface 32 and 30 is greater than at the surface 32', and greater than the friction between the threads of the nut and screw, when the nut and screw are rotated relative to each other.

Thus, when the screw is rotated to enter the nut, an axial force is imposed on the ring 2 and the tube 28, causing the perpendicular vertical surfaces to be pressed together and the radial force to expand the ring 2 against the wall of 10a, the frictional surfaces acting as previously described to hold the ring 2, tube 28 and nut 5 against rotation.

It will be seen that, when the screw is rotated in the opposite direction, the axial and radial forces are relieved, and the ring 2 contracts, and the fastener assembly is loose and may be removed in its entirety.

FIG. 12 shows a non-captive fastener which will provide a clamping action on work parts 9 and 10.

The work parts 9 and 10 are separated by a gasket provided with a bore 35 which, like bores 9a and 10a, is sufficient to pass the clamping assembly, composed of the stud 36 carrying a nut 37. The bore 9a may be equal to or larger in diameter than bore 10a. The nut 37 has a conical exterior surface formed integrally with the nut 37 and mating with the split ring 2 similar to the ring 2 of FIG. 1 and a cylindrical bushing 38 whose end 42 abuts the annular end of the ring 2. The interior end of the bushing 38 carries a flange 39 whose inner surface 39' is roughened in a manner similar to bushing 28. One or both of the surfaces at 42 and 7 may also be roughened against the flange 39, and a counterbored nut 44 is threaded on the stud 36 with a nut 43 positioned in the counterbore 45. With the nut 44 removed from the assembly, the nut 43 retracted, and the nut fitted snugly into the ring 2 leaving it substantially unstressed, the assembly may be entered into the bores 9a, 35 and 10a. Holding the stud 36 against rotation by a screw driver entered into the slot 45, the nut 43 is rotated to exert a thrust against the flange 39, to force the bushing 38 against the end of the bushing 2. This causes the nut 37 to enter the split bushing and to expand the split ring 2. The train of friction at the surfaces 39', 42 and 7 is greater than at the threads and at the exterior surface of the flange 39, so that the nut does not rotate. This clamps the fastener in position in the bore 10a. The nut 44 is then threaded on the stud 36. The annular end of the nut 44 bears against the surface 41, and by holding 36 against rotation, the part 9 is pushed over the tube 38 and clamped against the gasket 34 and the part 10.

It is to be recognized that all of the forms of fasteners may be used with blind holes, as is shown in FIG. 8.

FIG. 13 shows a fastener employing a screw and split ring of FIG. 1, but employing a modified nut to insure against relative rotation of the nut and bushing. The

modification may also insure that the bushing opens at the cylindrical inner surface 4', as well as at the wedged surface. The nut 46 is formed with a key 47 extending the length of the nut and developed so that its exterior 48 is of the diameter of the exterior surface of 2 when in the unexpanded position. The width of the key is related to the width of the slotted portion 3 of the ring 2, so that, when the fastener is assembled and inserted into the work, the ring 2 is not expanded in an amount to make it too large to enter the bore 10'. When the screw is turned, the bushing 2 is locked with the nut 46 by means of the key. Thus, the bushing 2 is restrained against rotation by friction between the surfaces 7 and 8, and the nut is restrained against rotation also, when the screw is turned. The lateral surfaces 49 of the key are developed parallel to the parallel surface of both sides of the slot in the unstressed condition. The entry of the key opens the rings uniformly along its length to seat it against the inner wall of the bore 10'. This form of fastener may also be used in a blind hole.

FIG. 15 illustrates a means to prevent the withdrawal of the screw from the nut by an excessive counterclockwise rotation of the screw. The screw may only be withdrawn sufficiently to release the axial and radial thrust, but the surfaces of the male and female members will always be in touch, with a minimal friction between them. Thus, upon rotating the screw a fraction of a turn in a clockwise direction, the conical surfaces are brought into wedging contact and the fastener is locked in position.

It is to be noted that, in the form of the fastener of FIG. 9, the counterclockwise rotation of the screw will unlock the screw and, so long as the spring is compressed, the conical surfaces will remain in contact. However, the wedging action will not occur until the spring is sufficiently compressed to generate the necessary axial thrust. Additionally, it will be noted that, by rotating the screw in a counterclockwise direction, the screw may be withdrawn from the nut, and disassembly occurs.

This is prevented in the form of FIG. 15, and thus excessive loosening of the screw is prevented. In FIG. 15 the parts common to FIG. 15 and FIG. 5 are numbered as in FIG. 5 and need not be further described. The variation in FIG. 15 which distinguishes from the form of FIG. 5 is the provision of a closed ended, helically wound coil spring 50, which tightly grips in the threads at 51 of the extended end 52 of the screw 1. The end of the spring is wound with a helical pitch the same as the pitch of the threads of the screw and with an internal diameter, in the unstressed condition, designed such that, when screwed into the threads of the screw, the spring will grip the screw tightly. The spring increases in internal diameter along its length (see 53) and terminates with a flattened end 54, known as a closed end, against the end of the nut and spaced axially and radially from the gripping end 50.

The purpose of the spring is to maintain frictional engagement between the conical surfaces of the nut 5 and the female members and also between all other transverse frictional surfaces in the fastener and work pieces. This frictional engagement will occur when the screw is rotated counterclockwise. When this occurs, the axial and radial thrust on the male and female members is released, and the friction between them is reduced, so that the nut begins to rotate with the screw, and further separation of the contiguous conical surfaces is prevented.

The spring should not be so stiff as to oppose the axial and radial stresses which tend to cause the disengagement of the female and male members when the screw is rotated counterclockwise, in order that such disengagement occur. The spring may, in fact, be quite weak, since it will, even if weak, cause some pressure to be retained between the conical surfaces, so that when the nut starts to rotate with the screw a fractional reverse turn of the screw locks the unit.

The variation of FIG. 5 shown in FIG. 14 may also be applied with like effect to FIGS. 1-4, 6, 8, and 9-13.

FIG. 16 is a variation of the form shown in FIG. 1, in which the thrust member, instead of being a nut on the threaded shaft, as is the case in the forms of FIGS. 1-15, is a cam-actuated, conical male member. The parts which are the same in the forms of FIG. 1 and FIG. 16 are given like numbers and will not be further described.

The shaft 1 of FIG. 1 is replaced by an unthreaded shaft 55, having a screw head 56. The nut 5 is replaced by a male thrust cone 57 having a smooth interior bore slideably mounted on the shaft 55. The exterior end of the conical thrust member is a pair of stepped cam surfaces 58 and 59. The high point of the surface 58 is at 60, and its low point is at 61. The high point of the cam surface 59 is at 62, and its low point is at 63. The cam pin 64, mounted in the shaft 55, rides over the cam surfaces. The pin may be mounted in the shaft so that it rotates as it rides over the cam surfaces so as to minimize friction.

It will be seen that, on rotation of the shaft 55, the friction train being such that the friction between the thrust member and the shaft, and between the pin and the cam surfaces, is less than at other portions of the friction train, the thrust member will not rotate but will exert an axial thrust to enter the female member, to exert the radial thrust to expand the female member.

It will be noted that the construction of the thrust generating means of FIG. 16 may be applied to the forms of FIGS. 1-15 by replacing the threaded shaft and the nut by a thrust member having the stepped cam surfaces and the cam pin of FIG. 16.

While I have described a particular embodiment of my invention for purposes of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention, as set forth in the appended claims.

I claim:

1. A fastener adapted to be inserted into an orifice of a work piece and removed from said orifice by manipulation of only one end of said fastener, comprising a threaded shaft, means to rotate said shaft positioned at one end of said shaft, a bushing positioned on said shaft, said bushing being expansible radially of said shaft, said bushing including an elastically deformable female slit ring mounted on said shaft, said female ring having an interior conical surface and an exterior cylindrical surface, said female ring having a flat roughened annular surface adjacent to said rotatable means, said annular surface extending substantially perpendicular to said shaft having a diameter no greater than the diameter of said female ring, and thrust means mounted on said shaft to exert an axial thrust on said female ring, said last named means including a male member mounted on said shaft, said male member having a conical exterior surface mating with the interior conical surface of said female ring, said female ring positioned between said rotating means and said male member and said female ring being split by a single slot extending the full length of said female ring and from the interior to the exterior surfaces of said female ring, said thrust means adapted to exert an axial force on said bushing to move said male member into said female member and thereby exert a radial force on said slit female ring, said male and female conical surfaces making substantially equal acute angles with the axis of said shaft and said angles being substantially greater than the angle of repose of said elastically deformable female slit ring, said annular surface being adapted to engage an inner facing surface of a contiguous surface placed between said rotating means and said bushing so that the friction between said annular surface and said inner facing surface of said contiguous surface is such that the minimum frictional resistance in the train of friction between surfaces in said bushing in frictional engagement is located between said

thrust means and said shaft on relative rotation thereof, whereby on placement of the fastener in a workpiece and on rotation of said rotatable means at said one end thereof in one direction the male member and the female ring are moved towards each other to radially expand said female ring, and on reverse rotation of said rotatable means the female ring contracts axially forcing said male member to move in a direction axially away from said female ring to reduce said radial force.

2. In combination, a work comprising a first work part and a second work part, a first bore in the first part and a second bore in the said second part, said bores being axially aligned, said first bore being of a larger inner diameter than the inner diameter of said second bore, an inner facing surface of said second part, a fastener in said bores, said fastener comprising a threaded shaft, said shaft positioned in both bores, means to rotate said shaft positioned at one end of said shaft, a bushing positioned on said shaft, said bushing being positioned in the bore of greater diameter, said bushing being expansible radially of said shaft, said bushing including an elastically deformable female slit ring and a male member mounted on said shaft, said female ring having an interior conical surface and an exterior cylindrical surface, said bushing having a flat roughened annular surface adjacent to said rotatable means extending substantially perpendicular to the axis of said shaft and having a diameter no larger than the diameter of said bushing, said surface positioned contiguous to the inner facing surface of said second part and adapted to engage said inner facing surface, and thrust means mounted on said shaft to exert an axial thrust on said female ring and said male member, said male member having a conical exterior surface mating with the interior conical surface of said female ring, said female ring being split by a single slot extending the full length of said female ring and from the interior to the exterior surfaces of said female ring, said thrust means adapted to move said male member into said female member and thereby exert a radial force on said slit female ring, and said conical surfaces of said male member and female member making substantially equal acute angles with the axis of said shaft and substantially greater than the angle of repose of said female ring, such that the friction between said flat roughened annular surface and said inner facing surface of said second part is such that the minimum frictional resistance in the train of friction between surfaces in said bushing in frictional engagement is located between said thrust means and said shaft on relative rotation thereof, whereby on rotation of said rotatable means at said one end, in one direction, the male member and said female ring approach each other, and said female member expands radially against the wall of said first bore to clamp the said work parts together, and, on reverse rotation of said rotatable means, the female member contracts radially and said male member and said female ring move axially away from each other, to permit the separation of said first work part from the said fastener positioned in the bore of said second work part.

3. A fastener adapted to be inserted into an orifice of a work piece and removable from said orifice by manipulation of only one end of said fastener, comprising a threaded shaft, means to rotate said shaft positioned at one end of said shaft, a bushing positioned on said shaft, said bushing being expansible radially of said shaft, said bushing including an elastically deformable female slit ring and a male member mounted on said shaft, said female ring having an interior conical surface and an exterior cylindrical surface, said bushing having a flat roughened annular surface adjacent to said rotatable means, said annular surface extending substantially perpendicular to the axis of said shaft, and having a diameter no greater than the diameter of said bushing, thrust means mounted on said shaft to exert an

axial thrust on said female ring and said male member, said male member having a conical exterior surface mating with the interior conical surface of said female ring, said female ring being split by a single slot extending the full length of said female ring and from the interior to the exterior surfaces of said female ring, said thrust means adapted to exert an axial force to move said male member into said female member and thereby exert a radial force on said slit female ring, said roughened flat annular end surface being a frictional surface substantially perpendicular to the axis of said shaft and adapted to engage the inner facing surface of a contiguous surface placed between said rotating means and said bushing, and said conical surfaces of said male member and female member being of substantially equal acute angles and substantially greater than the angle of repose of said female member, such that the friction between said annular surface and an inner facing surface of said contiguous surface is such that the minimum frictional resistance in the train of friction between surfaces in said bushing in frictional engagement is located between said thrust means and said shaft on relative rotation thereof, whereby when the fastener is positioned in a work piece, and said rotatable means is rotated in one direction, the male member and said female ring approach each other and said female member expands radially, and on reverse rotation of said rotatable means the female member contracts radially, forcing said male member and said female ring to move in a direction axially away from each other.

4. In combination, a work comprising a first work part and a second work part, a first bore in the first part and a second bore in the said second part, said bores being axially aligned, said first bore being of a larger inner diameter than the inner diameter of said second bore, an inner facing surface of said second part, a fastener in said bores, said fastener comprising a threaded shaft, said shaft positioned in both bores, means to rotate said shaft positioned at one end of said shaft, a bushing positioned on said shaft, said bushing being expansible radially of said shaft, said bushing including an elastically deformable female slit ring and a male member mounted on said shaft, said female ring having an interior conical surface and an exterior cylindrical surface, said bushing having a flat roughened annular surface adjacent to said rotatable means said annular surface extending substantially perpendicular to the axis of said shaft and having a diameter no greater than the diameter of said bushing, thrust means mounted on said shaft to exert an axial thrust on said female ring and said male member, said male member having a conical exterior surface mating with the interior conical surface of said female ring, said female ring being split by a single slot extending the full length of said female ring and from the interior to the exterior surfaces of said female ring, said thrust means adapted to exert an axial force to move said male member into said female member and thereby exert a radial force on said slit female ring, and said conical surfaces of said male member and female member being of substantially equal acute angles and substantially greater than the angle of repose of said female member, said annular surface adapted to engage said inner facing surface of said second part such that the friction between said flat roughened annular surface and said second work part placed between said rotating means and said bushing is such that the minimum frictional resistance in the train of friction between surfaces in said bushing in frictional engagement is located between said thrust means and said shaft on relative rotation thereof, whereby on positioning of said fastener in a work, and, rotating of said rotatable means in one direction, the male member and said female ring approach each other and said female member expands radially, and on reverse rotation of said rotatable means the female member contracts radially, forcing said male member and said female

ring to move in a direction axially away from each other.

5. A fastener comprising a threaded shaft, a bushing positioned on said shaft, said bushing including an elastically deformable female slit ring mounted on said shaft, said female ring having an interior conical surface and an exterior cylindrical surface, a male member mounted on said shaft, said male member having an exterior conical surface mating with the interior conical surface of said female ring, said female ring being split by a single slot extending the full length of said female ring and from the interior to the exterior surfaces of said female ring, thrust means on said shaft to exert an axial force on said bushing to move said male member into said female member and thereby exert a radial force on said slit female ring, said bushing having a frictional surface transverse to the axis of said shaft, said transverse surface having a roughness finish of at least 500 R.M.S. such that the friction between said surface and a contiguous surface is such that the minimum frictional resistance in the train of friction between surfaces in said bushing in frictional engagement is located between said thrust means and said shaft on relative rotation thereof, when the fastener is positioned in a work, in which said thrust means is a nut threaded on said shaft, a coil spring mounted at one end of said threaded shaft, the other end of said spring abutting the end of said nut.

6. A fastener comprising a threaded shaft, a bushing positioned on said shaft, said bushing including an elastically deformable female slit ring mounted on said shaft, said female ring having an interior conical surface and an exterior cylindrical surface, a male member mounted on said shaft, said male member having an exterior conical surface mating with the interior conical surface of said female ring, said female ring being split by a single slot extending the full length of said female ring and from the interior to the exterior surfaces of said female ring, thrust means on said shaft to exert an axial force on said bushing to move said male mem-

ber into said female member and thereby exert a radial force on said slit female ring, said bushing having a frictional surface transverse to the axis of said shaft, said transverse surface having a roughness finish of at least 500 R.M.S. such that the friction between said surface and a contiguous surface is such that the minimum frictional resistance in the train of friction between surfaces in said bushing in frictional engagement is located between said thrust means and said shaft on relative rotation thereof, when the fastener is positioned in a work, in which said thrust means is a nut threaded on said shaft, a coil spring mounted at one end of said threaded shaft, the other end of said spring abutting the end of said nut, said spring having an increasing inner diameter between the end gripping said threaded shaft and the end abutting the nut.

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