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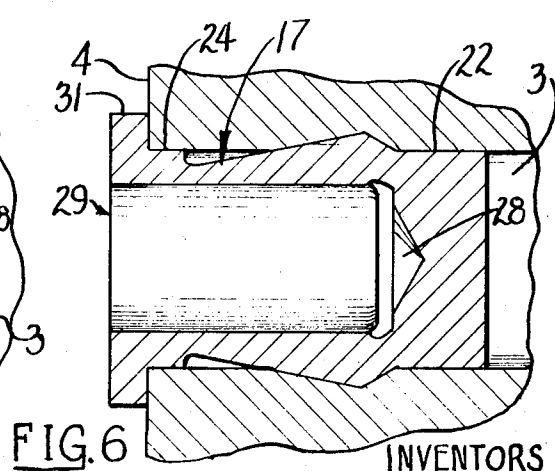
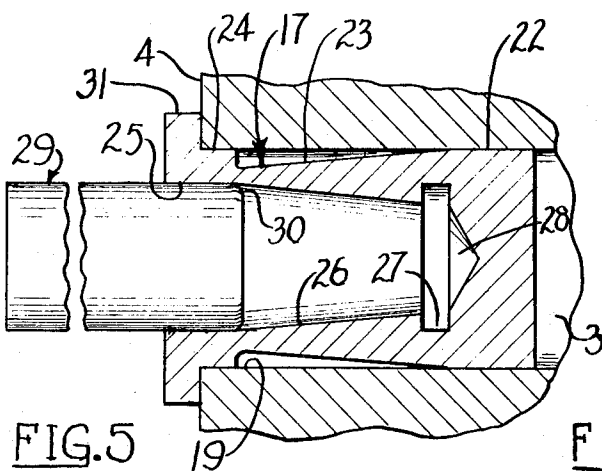
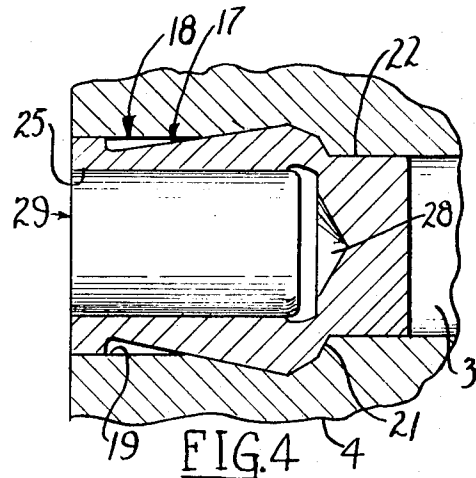
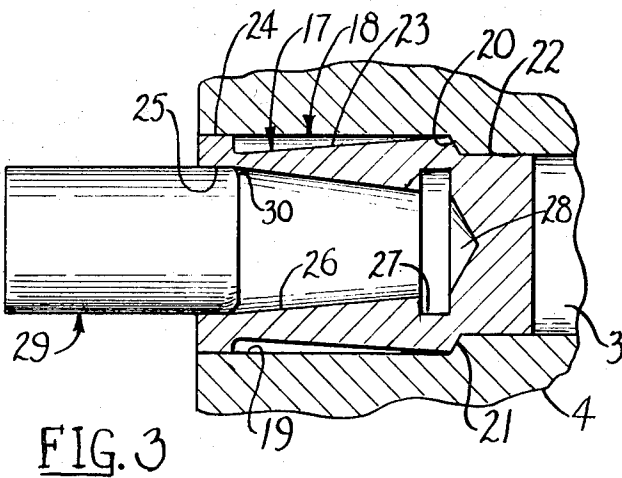
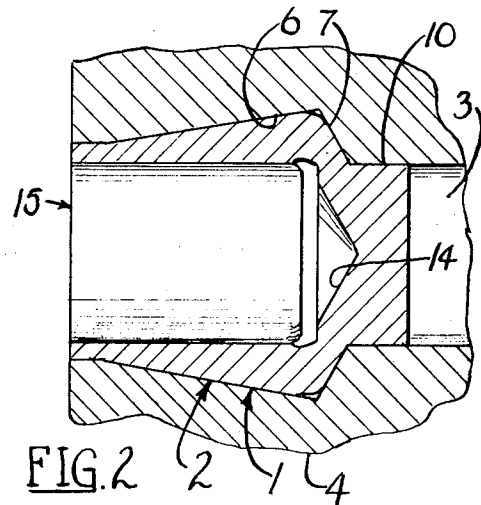
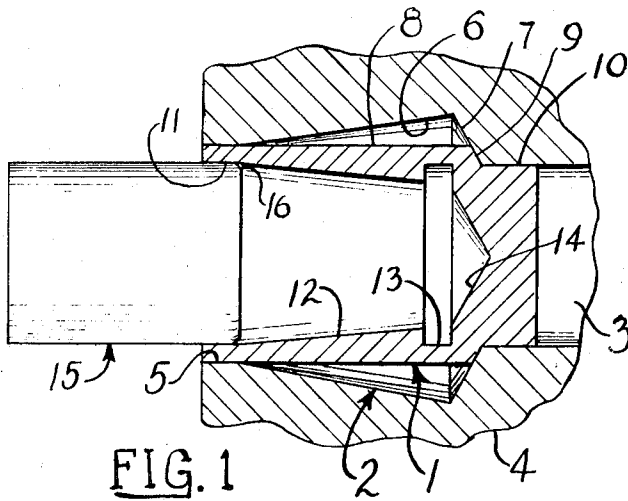
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CLOSURES

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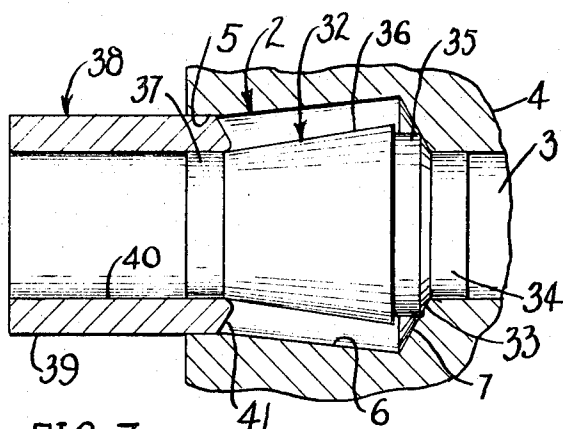


FIG. 7

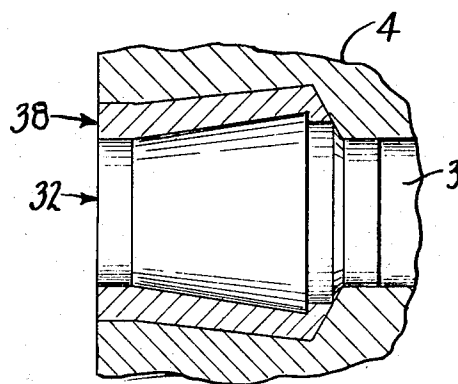


FIG. 8

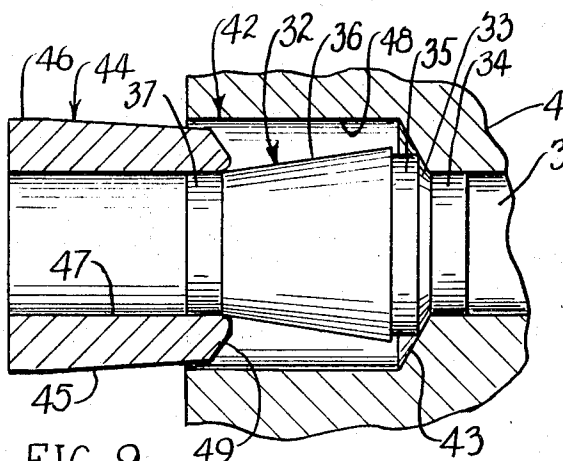


FIG. 9

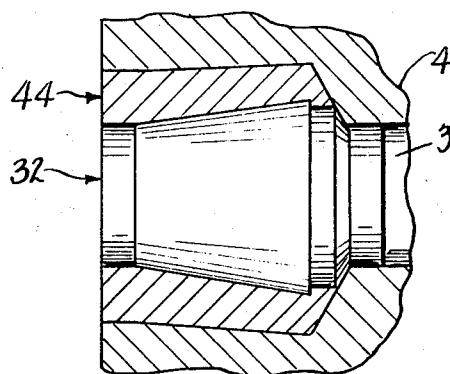


FIG. 10

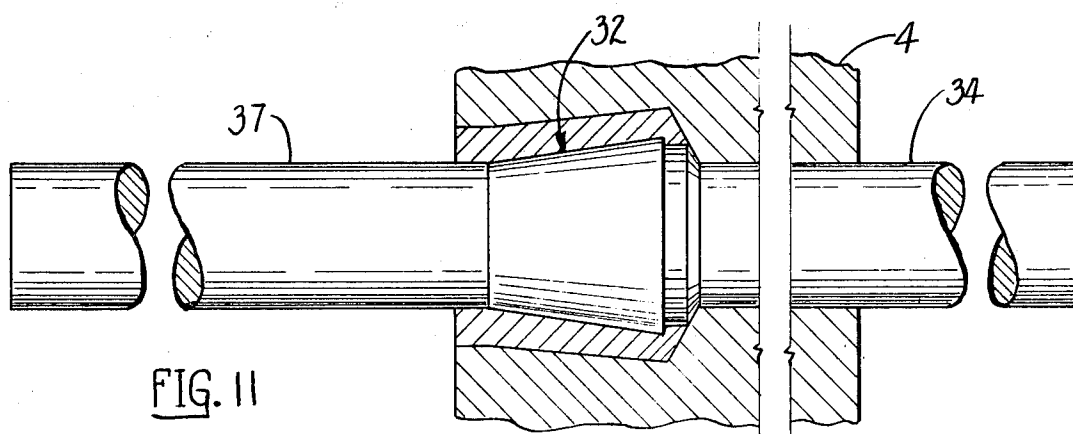


FIG. 11

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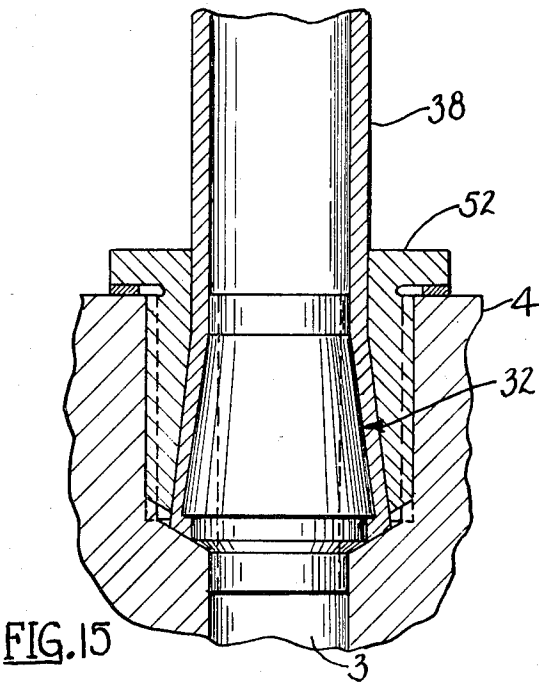
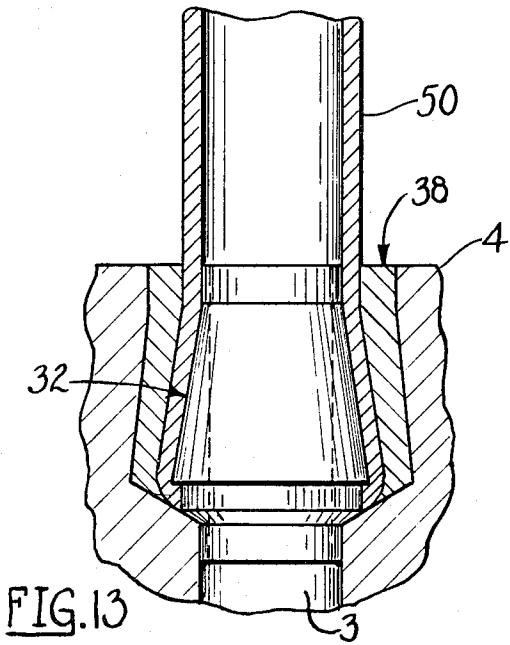
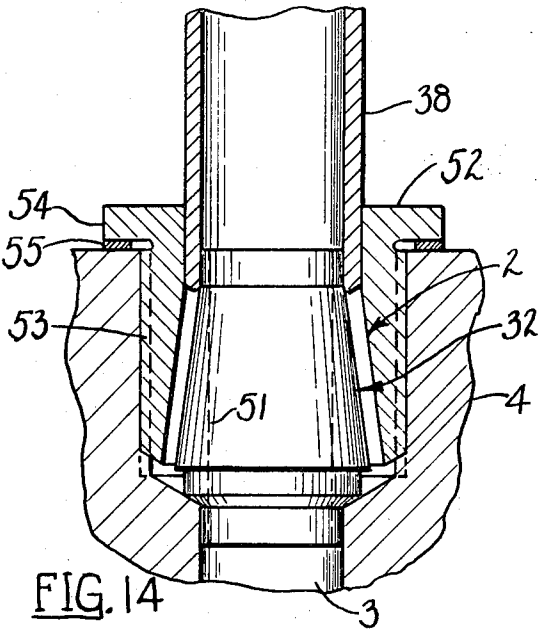
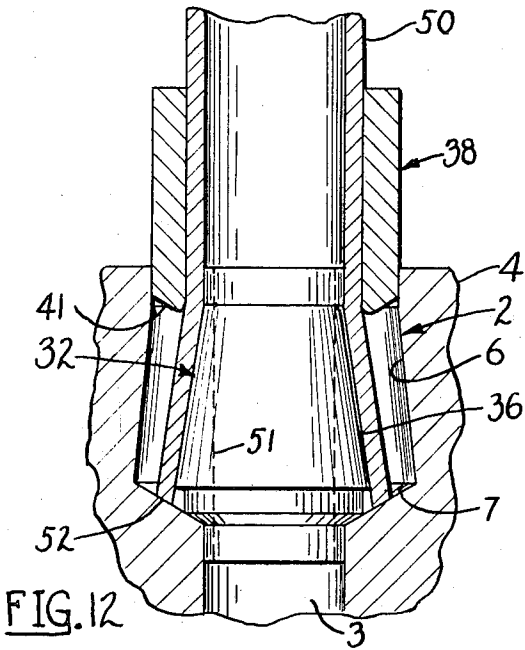
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FIG. 16

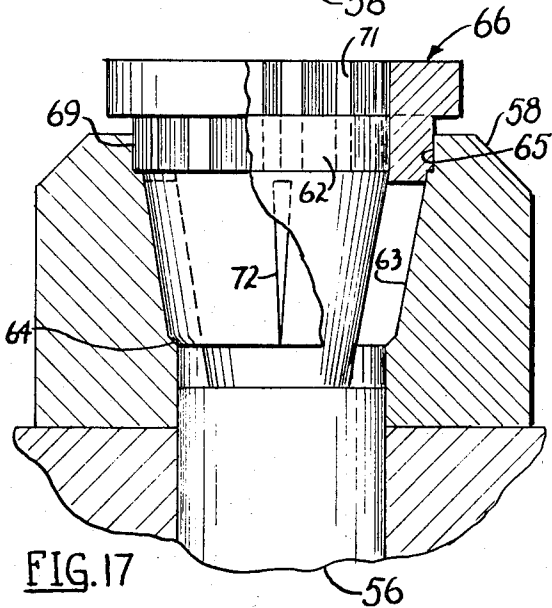
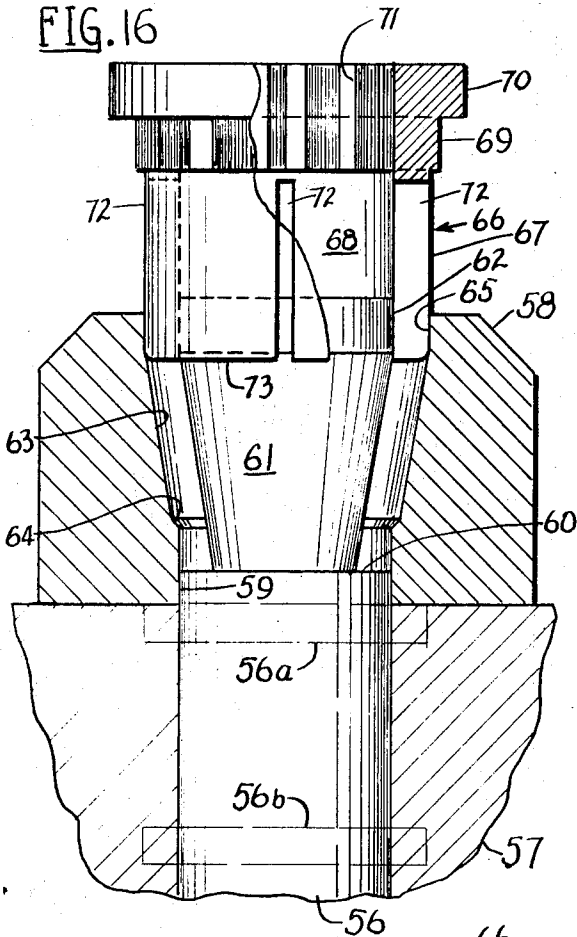


FIG. 18

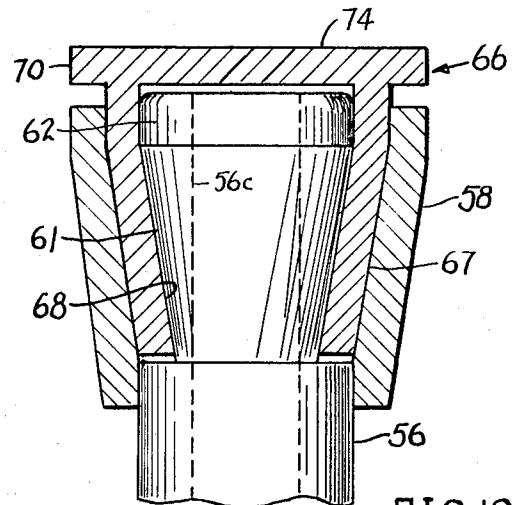
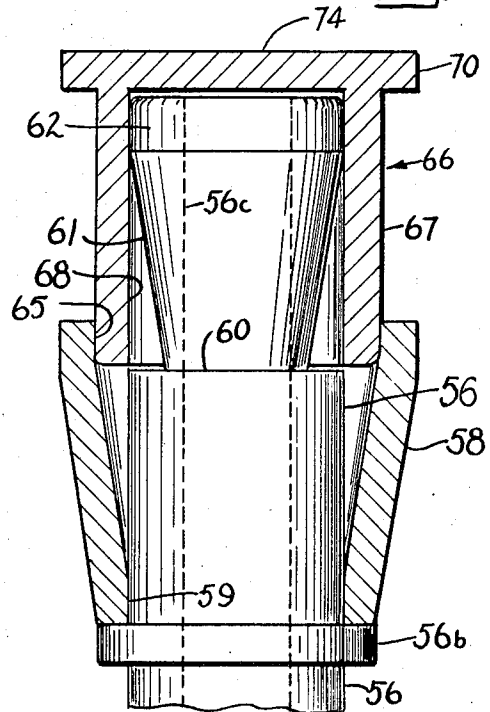


FIG. 19

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Filed May 11, 1967, Ser. No. 637,663

Int. Cl. B25g 3/28

U.S. Cl. 287—20.3

7 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to closures and fastening devices that can be used to plug entrance holes in manifolds and the like, to anchor stud, shaft and tube members in holes in a body, and to anchor tube, cap or wheel members to a shaft of the like. The invention provides means for obtaining dovetail-like locks between the sealing or anchoring members, whereby internal pressure or ejecting force causes the sealing contact stress or the pull-out resistance to increase.

This invention relates to fastening devices that can be used to plug entrance holes in manifolds and the like, to anchor stud, shaft and tube members in holes in a body, and to anchor tube or wheel members to a shaft and the like.

When a cylindrical plug is used, which is not brazed or otherwise bonded to the wall of the hole, the effectiveness of the seal that it makes with the hole and the resistance to blow-out is largely dependent on the contact stress between the plug and the hole. If the contact stress is obtained through thermal or mechanical expansion of a cylindrical plug after insertion in the hole, the resulting contact stress is largely dependent on the original dimensions of the plug and the hole. This great dependence of the contact stress, and consequently of the blow-out resistance, on the precision of manufacture of the components makes the use of cylindrical plugs costly and even hazardous when the fluid to be sealed is under high pressure. For similar reasons many other cylindrical inserts, tube anchors, and pipe and container-nipple caps cannot be used reliably in the presence of internal pressure or ejecting force.

It is an object of this invention to provide a non-bonded, non-threaded plug or insert that is mechanically expanded into a cone that expands inwardly into a preformed, inwardly expanding, conical entrance hole, the inwardly expanding cones of the plug and the hole providing a dovetail-like lock between the two members.

It is a further object of the invention to provide a plug that deforms a cylindrical entrance hole into a mating, inwardly expanding cone as the plug is expanded.

It is still another object of the invention to provide apparatus, for fastening stud, shaft and tube members in conical sockets in bodies, through which a dovetail-like lock between the members and the bodies is obtained.

It is yet another object of the invention to provide apparatus, for anchoring a tube or wheel member to a shaft or the like, or for fastening a cap member to a pipe or bottle or the like, through which a dovetail-like lock between the members and the shaft is obtained.

The conical sockets and the mating members in the apparatus of this invention provide a means through which the contact stress between the locked member and the socket or the clamping force between the members and the socket increases as the outward force increases. This feature permits the use of much wider manufacturing tolerances than is possible with cylindrical members

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and holes, and greatly expands the field of use of non-bonded, non-threaded fastenings.

Other important objects, features and advantages of this invention will be more fully apparent from the following detailed description taken in conjunction with the following accompanying drawings in which:

FIG. 1 is a schematic fragmentary cross section of a manifold, illustrating a plug, in accordance with this invention, for insertion into a preformed, inwardly expanding conical counterbore to an entrance hole; and

FIG. 2 is a cross-sectional view, as in FIG. 1, after the plug has been expanded; and

FIG. 3 is a schematic, fragmentary cross section of a manifold, illustrating a plug, in accordance with this invention, for insertion into a cylindrical counterbore to an entrance hole; and

FIG. 4 is a cross-sectional view, as in FIG. 3, after the plug has been expanded; and

FIG. 5 is a schematic, fragmentary cross section of a manifold, illustrating a plug, in accordance with this invention, for insertion into an unmodified entrance hole; and

FIG. 6 is a cross-sectional view, as in FIG. 5, after the plug has been expanded; and

FIG. 7 is a schematic, fragmentary cross section of a manifold, illustrating a second form of a plug, in accordance with this invention, for insertion into a preformed, inwardly expanding, conical counterbore to an entrance hole; and FIG. 8 is a cross-sectional view, as in FIG. 7, after the plug has been expanded; and

FIG. 9 is a schematic, fragmentary cross section of a manifold, illustrating a second form of a plug, in accordance with this invention, for insertion into a cylindrical counterbore, to an entrance hole; and

FIG. 10 is a cross-sectional view, as in FIG. 9, after the plug has been expanded; and

FIG. 11 is a fragmentary cross section of a body, illustrating the use of the mechanism illustrated in FIGS. 7 and 8 to anchor a stud or projecting pin; and

FIG. 12 is a schematic, fragmentary cross section of a manifold, illustrating the use of the mechanism of this invention to anchor a tube in a preformed, inwardly expanding counterbore to an entrance hole; and

FIG. 13 is a cross-sectional view, as in FIG. 12, after the members have been driven into a locked position; and

FIG. 14 is a schematic, fragmentary cross section of a manifold illustrating a modification of the mechanism illustrated in FIG. 7 which permits release of a plug or tube after locking; and

FIG. 15 is a cross-sectional view, as in FIG. 14, after the members have been driven into a locked position; and

FIG. 16 is a fragmentary cross section of a body and a second member illustrating the use of the mechanism of this invention to fasten a second member to a body; and

FIG. 17 is a cross-sectional view, as in FIG. 16, after the members have been driven into locked position; and

FIG. 18 is a schematic fragmentary cross section of an assembly, illustrating a pipe or bottle cap in accordance with this invention; and

FIG. 19 is a cross-sectional view, as in FIG. 18, after the members have been driven into locked position.

In the illustration presented in FIG. 1, first member 1 of a plug that utilizes the principles of this invention sets in a preformed, inwardly expanding, conical counterbore 2 to a typical entrance hole 3 in body 4. Counterbore 2 has a short cylindrical entrance 5. The inwardly expanding wall 6 of counterbore 2 intersects cylindrical entrance 5 and conical seat 7 of counterbore 2. Conical seat 7 terminates at its intersection with hole 3. Cylindrical surface 8 or member 1 has a diameter that is equal to or slightly smaller than the diameter of entrance

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5. Conical shoulder 9 of member 1 mates with conical seat 7 and the diameter of cylindrical projection 10 of member 1 is equal to or slightly smaller than the diameter of hole 3. As illustrated in FIG. 1, the external end of member 1 lies substantially flush with the external surface of body 4 and member 1 is constrained to be substantially coaxial with counterbore 2 by the engagements with entrance 5 and hole 3. Cylindrical entrance bore 11 of member 1 has a length that is approximately equal to the length of entrance bore 5 of counterbore 2. Inwardly contracting conical bore 12 in member 1 initiates at bore 11 and terminates at groove 13. The diameter of groove 13 is preferably made to equal to the diameter of bore 11 and its length is preferably made small compared to the length of conical bore 12. Bore 11 and 12 and groove 13 are coaxial with surface 8. Conical bore 14 in member 1 is required only as a manufacturing aid. The cone angle of bore 12 is preferably made slightly greater than the cone angle of wall 6.

In the illustration presented in FIG. 1, second member 15 is placed in the entrance bore 11 of first member 1. Second member 15 is a solid cylinder, the diameter of which is equal to or slightly smaller than the diameter of bore 11 and the length of which is slightly greater than the depth of the bores in member 1 to groove 13. Rounded edge 16 of member 15 eases its entry into bore 12.

Member 1 is expanded to mate with the conical wall 6 of counterbore 2 when cylindrical member 15 is driven into bore 12 to substantially the depth shown in FIG. 2. This expansion is the result of the circumferential stretching of the wall between surface 8 and bore 12. Groove 13 releases the wall from the circumferentially rigid inner end of member 1. The groove substantially disappears in the expansion process as illustrated in FIG. 2. Because the cone angle of bore 12 is initially greater than the cone angle of wall 6 and initial contact stress between member 1 and wall 6 can be induced through the expansion process. The dovetail-like lock formed between counterbore 2 and the expanded member 1 provides the means whereby the contact stress is increased by fluid pressure in hole 3.

In the illustration presented in FIG. 3, first member 17 of a plug that utilizes the principles of this invention sets in preformed cylindrical counterbore 18 to entrance hole 3 or body 4. Cylindrical surface 19 of counterbore 18 terminates at its intersection with hole 3. First member 17 has a conical shoulder 21 that mates with seat 20. The diameter of cylindrical projection 22 of member 17 is equal to or slightly smaller than the diameter of hole 3. Conical surface 23 of member 17 converges outwardly from shoulder 21 to cylindrical collar 24. The diameter of conical surface 23 at its intersection with conical shoulder 21 and the diameter of collar 24 are equal to or slightly less than the diameter of surface 19. Surface 23 is joined to collar 24 preferably by a small fillet. As illustrated in FIG. 3 the external end of member 17 lies substantially flush with the external surface of body 4 and member 17 is constrained to be substantially coaxial with counterbore 18 by the engagements with surface 19 and hole 3. Cylindrical entrance bore 25 in member 17 has a length that is substantially equal to the length of collar 24. Inwardly contracting conical bore 26 of member 17 initiates from entrance bore 25 and terminates at groove 27. The diameter of groove 27 is preferably made equal to the diameter of bore 25 and its length is preferably made small compared to the length of bore 26. Bore 25 and 26 and groove 27 are coaxial with surface 23. Conical bore 28 in member 17 is required only as a manufacturing aid. The cone angle of bore 26 is preferably made slightly greater than the cone angle of surface 23.

In the illustration presented in FIG. 7, first member 29 is placed in entrance bore 25. Second member 29 is a solid cylinder the diameter of which is equal to or slightly

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less than the diameter of bore 25 and the length of which is slightly greater than the depth of the bores in member 17 to groove 27. Rounded edge 30 of member 29 eases the entry of member 29 into bore 26.

Member 17 is expanded into a broader flare when member 29 is driven into bore 26 to substantially the depth shown in FIG. 4. This expansion is the result of the circumferential stretching of the wall between surface 23 and bore 26 as a member 29 moves into bore 26. Groove 27 releases the wall from the circumferentially rigid inner end of member 17. The groove substantially disappears in the expansion process, as illustrated in FIG. 4. Because of the initial conical form of surface 23 the expanding surface 23 does not contact surface 19 until member 29 has been driven part way into bore 26. As member 29 is driven inward beyond this point the expansion of member 17 causes deformation of the inner part of counterbore 18, whereby a substantially conical dovetail-like mating of member 17 with counterbore 18 results.

The plug configuration illustrated in FIG. 5 and in FIG. 6 utilizes the same method of plug and entrance hole expansion as was described in the configuration illustrated in FIGS. 3 and 4. Parts having identical functions are given the same identifying numbers in FIGS. 3, 4, 5 and 6. In the configuration presented in FIGS. 5 and 6, collar 31 provides the insertion stop for member 17 and the diameters of collar 24 and cylindrical projection 22 are made equal to or slightly less than the diameter of unmodified hole 3.

In the illustration presented in FIG. 7, first member 32 of a plug that utilizes the principles of this invention sets in preformed, inwardly expanding counterbore 2 to entrance hole 3 in body 4. The counterbore illustrated in FIG. 7 is identical to the counterbore illustrated in FIG. 1 and accordingly the parts of the counterbores are identically numbered. Conical shoulder 33 or member 32 mates with conical seat 7 of counterbore 2 and the diameter of cylindrical projection 34 is equal to or slightly smaller than the diameter of hole 3. Member 32 also comprises cylinder 35, cone 36 and cylinder 37. The diameter of cone 36 and cylinder 37 are equal at their intersection and cone 36 projects over cylinder 35. All the surfaces of revolution of member 32 are coaxial. As illustrated in FIG. 7, the external end of member 32 lies substantially flush with the external surface of body 4. The length of cylinder 35 is preferably made small compared to the length of cone 36. The cone angle of cone 36 is preferably made slightly greater than the cone angle of wall 6 of counterbore 2 to provide a substantially constant annular area between cone 36 and wall 6.

In the illustration presented in FIG. 7, second member 38 is placed in the entrance bore 5 of counterbore 2 and is in initial contact with cone 36. Member 38 has an outer cylindrical surface 39 and a coaxial bore 40. The diameter of surface 39 is equal to or slightly less than the diameter of bore 5 of counterbore 2 and the diameter of bore 40 is equal to or slightly greater than the diameter of cylinder 37 of member 32. The leading edge of member 38 is preferably rounded to ease engagement with cone 36. The leading end 41 of member 38 is conical with a cone angle that is slightly greater than the cone angle of seat 7 of counterbore 2. Member 32 is constrained to be coaxial with counterbore 2 by the engagements with bore 5 and hole 3.

Member 37 is expanded to mate with conical wall 6 and member 32 when member 38 is driven into counterbore 2 to the depth shown in FIG. 8. This expansion results from the circumferential stretching of the wall of member 38 as member 38 is driven onto member 32. The substantially constant annular area between cone 36 and wall 6 permits this stretching to occur uniformly and without excessive driving force. The cone angle of cone 36 may be made slightly greater than that required to achieve constant annular area between cone 36 and wall 6 to

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induce an initial contact stress between members 32 and 38 and wall 6. As in the previously described configurations, the dovetail-like mating between members 32 and 38 and wall 6 provides the means whereby the contact stress is increased by pressure in hole 3.

As illustrated in FIG. 8, the wedging action between edge 41 of member 38 and seat 7 of counterbore 2 causes plastic flow of member 38 under the projecting edge of cone 36. The resulting mechanical lock between members 32 and 38 adds to the friction bond between the two members and increases the security of the plug against the event that fluid passes beyond conical shoulder 33 and pressure acts on the inner edge of member 38.

In the illustration presented in FIG. 9, first plug member 32 of a plug that utilizes the principles of this invention sets in cylindrical counterbore 42 to entrance hole 3 in body 4. The plug configuration illustrated in FIGS. 9 and 10 utilizes a member that is identical with member 32 of the configuration illustrated in FIGS. 7 and 8. Accordingly this member and its component parts are identically numbered in FIGS. 7, 8, 9 and 10. In FIG. 9 as in FIG. 7 cylindrical end 34 of first member 32 pilots in hole 3 and conical shoulder 33 of member 32 mates with conical seat 43 of counterbore 42.

In the illustration presented in FIG. 9, second member 44 is placed at the entrance to counterbore 42 and in initial contact with cone 36. Member 44 comprises an outer conical surface 45, an outer cylindrical surface 46 and a coaxial cylindrical bore 47. The diameter of bore 47 is equal to or slightly greater than the diameter of cylinder 37 or member 32. Conical surface 45 has its maximum diameter at its outer end, this diameter and the diameter of cylindrical surface 46 being equal to or slightly less than the diameter of cylindrical surface 48 of counterbore 42. The cone angle of surface 45 is preferably slightly less than the cone angle of cone 36. The length of cylindrical surface 46 is preferably equal to the length of cylinder 37. The leading edge of member 44 is preferably rounded to ease engagement with cone 36. The leading end 49 of member 44 is conical with a cone angle that is slightly greater than the cone angle of conical seat 43 of counterbore 42.

Member 44 and counterbore 42 are expanded into mating, substantially dovetail-like cones when member 44 is driven into counterbore 42 to the depth shown in FIG. 10. This expansion results from the circumferential stretching of the wall of member 44 as member 44 is driven onto member 32. The initial taper of surface 45 permits member 44 to be driven part way into counterbore 42 before the expanding surface 45 contacts cylindrical surface 48 of counterbore 42. As member 44 is driven inward beyond this point the expansion of member 44 causes deformation of the inner part of counterbore 42, whereby a substantially conical, dovetail-like mating of member 44 with counter bore 42 results. As illustrated in FIG. 10, the wedging action between edge 49 of member 44 and seat 43 of counterbore 42 causes plastic flow of member 44 under the projecting edge of cone 36.

The apparatus that have been described thus far have illustrated the use of the principles of this invention in fastening plugs in entrance holes in a body. In this instance, the outer ends of the plug members are usually made flush with the outer surface of the body. The use of the principles of this invention in fastening projecting members to a body will now be described.

Referring to FIGS. 1 and 2, it is herein noted that a stud or projecting rod can be formed merely through the use of an elongated member 15. Similarly, a projecting rod can be anchored to a body through the use of an elongated member 29 in the configuration illustrated in FIGS. 3, 4, 5 and 6.

Referring to FIGS. 7 and 8, it is herein noted that the elongation of member 38 transforms member 38 into a tube. This tube, in turn can communicate with hole 3 merely through the forming of an axial passageway

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through member 32. Similarly, member 46 in FIGS. 9 and 10 can be transformed into a tube that can communicate with hole 3. Elongation of cylinder 37 or cylinder 34 in FIGS. 7, 8, 9 and 10 provides a projecting rod in either direction as illustrated in FIG. 11. As shown in FIG. 11, the elongated cylinder 34 may be made to project through body 4. Similarly, cylinder 10 in FIGS. 1 and 2 and cylinder 22 in FIGS. 3, 4, 5 and 6 can be elongated to project through body 4.

As already noted, the plug configuration illustrated in FIGS. 7, 8, 9 and 10 can be readily utilized to fasten tubular members to a body. FIGS. 12, 13, 14 and 15 now illustrate an additional manner in which the components of these configurations can function to fasten tubes and the like.

In FIGS. 12 first member 32, functionally identical with member 32 of FIGS. 7 and 8, sets in preformed, inwardly expanding counterbore 2 to entrance hole 3 in body 4. The component parts of member 32 are identically numbered in FIGS. 7 and 12. The counterbore illustrated in FIG. 12 is functionally identical to the counterbore illustrated in FIG. 7 and accordingly the parts of the counterbore are identically numbered in FIGS. 7 and 12. In FIG. 12 the relative diameters of counterbore 2 and of member 38 have been increased to accommodate tubular member 50 and axial passageway 51 has been placed in member 32. Tubular member 50 has been flared to approximately mate with member 32 prior to the inserted position illustrated in FIG. 12. As illustrated, a conical edge 52 is preferably placed on member 50. By the action previously described in conjunction with FIGS. 7 and 8, member 38 is caused to expand over member 32 and tubular member 50 when member 38 is driven into counterbore 2, whereby member 50 is clamped between wall 6 of counterbore 2 and cone 36 of member 32. As illustrated in FIG. 13, the wedging action of conical edges 41 and 52 on seat 7 of counterbore 2 forces member 50 under the projecting edge of cone 36.

The relative diameters of counterbore 42 and member 46 in the configuration illustrated in FIG. 9 may also be increased to accommodate a tubular member in the same manner as illustrated in FIG. 12.

The configuration presented in FIG. 14 is functionally identical to the configuration presented in FIG. 7 and accordingly the functionally identical parts are identically numbered in FIGS. 7 and 15. In the configuration of FIG. 14, counterbore 2 is formed from member 52 and body 4. Member 52 is fastened to body 4 by mating screw thread 53. Member 52 has a wrench flange 54. Washer 55 which is set between flange 54 and body 4 may be varied in thickness to adjust the axial spacing between member 52 and member 32. FIG. 15 illustrates the fastened position of the members after tubular member 38 has been driven into counterbore 2. Because of the screw thread construction of counterbore 2 in FIG. 14, this configuration can utilize a preflared member 38 and member 38 can be readily removed after it has been fastened to body 4. In refastening, the thickness of washer 55 may be reduced or washer 55 may be omitted.

FIGS. 16 and 17 illustrate the utilization of the principles of this invention for fastening a shaft to a body, whereby two or more bodies can be clamped together or a wheel, or the like, can be fastened to a shaft. Comparison of FIG. 16 with FIG. 11 demonstrates that fundamentally, the cone angles in the configuration of FIG. 16 are the negatives of the cone angles in the configuration of FIG. 11. Referring to FIG. 16, shaft 56 is suitably anchored (not shown) to body member 57. Second body member 58 is in loose contact with body member 57. Cylindrical bore 59 in member 58 has a diameter that is equal to or slightly greater than the diameter of shaft 56. Shaft 56 projects at this diameter, a relatively short distance into bore 59 to provide piloting between members 56 and 58. In bore 59 the diameter of shaft 56 reduces, forming shoulder 60. From shoulder 60, coaxial cone 61

of shaft 56 expands to the diameter of coaxial cylindrical land 62. Conical bore 63 in member 58 is joined to bore 59 by conical shoulder 64 and expands to the diameter of coaxial cylindrical bore 65 at the outer end of member 58. The length of the members is such that the line of intersection of bore 63 and bore 65 lies substantially level with the line of intersection of cone 61 and land 62. The cone angles of cone 61 and bore 63 are preferably equal.

Fastening member 66 has an outer cylinder 67 and a coaxial cylindrical bore 68. The diameter of cylinder 67 is equal to or slightly less than the diameter of bore 65 and the diameter of bore 68 is equal to or slightly greater than the diameter of land 62. The lengths of cylinder 67 and bore 68 are preferably equal to the slant length of bore 63. Cylinder 67 joins enlarged cylinder 69 and flange 70. Bore 68 joins diminished bore 71. Cylinder 69 and bore 71 are fluted with sharp edge grooves. Longitudinal cuts 72 carry through from cylinder 67 to bore 68, extend from leading edge 73 and run substantially the length of cylinder 67. The cuts 72 are symmetrically spaced to provide member 66 with a collet-like flexibility.

When member 66 is driven into member 58, as illustrated in FIG. 17, cylinder 67 and bore 68 are circumferentially contracted by bore 63. This contraction is accommodated principally by the closing of cuts 72, as illustrated. The equal cone angles of cone 61 and bore 63 provide a substantially constant width annular space, thereby permitting insertion of member 66 without significant distortion of the members. As shown in FIG. 17, member 66 contacts shoulder 64, whereby the inward driving force that is applied to member 66 may be exerted upon member 58 to drive member 58 into tight contact with member 67. In the final phase of entry of member 66 the sharp edge flutes of bore 71 cut into land 62 of shaft 56 and the flutes of cylinder 69 cut into bore 65 of members 58. The flexibility of member 66 provided by cuts 72 permits member 66 to be fabricated from a hard material which is suitable to accomplish the cutting function of the flutes. Preformed, mating flutes can also be provided in land 62 and bore 65 to provide the interlocking result eliminating the requirement of cutting by member 66.

If shaft 56 is shouldered at the junction with member 58, as shown in phantom in FIGS. 16 and 17 and identified by 56a, the shoulder can serve to prevent axial movement of member 58 during insertion of member 66. In this instance the fastening mechanism illustrated in FIGS. 16 and 17 can be utilized to fasten a wheel, or the like, to a shaft. When a wheel is fastened to a shaft by this mechanism it is preferable to eliminate shoulder 64 allowing bore 63 to continue to intersection with bore 59 and permitting member 66 to contact shoulder 60. Through this contact cone 61 can be driven axially into bore 63 and thereby increase the contact stress between cone 61, member 66 and bore 63. The high contact stress is desirable when radial loads are present.

The interlocking of members 56, 66 and 58 through the flutes of cylinder 69 and bore 71 augments the torque transmitting strength between member 58 and shaft 56. The high torque transmitting strength is desirable when member 58 is a gear, or the like. In the application of the principles of this invention, illustrated in FIGS. 16 and 17, where high torque transmitting strength is not required, the enlarged cylinder 69 and the diminished bore 71 and the flutes on their surfaces may be eliminated.

The dovetail-like lock provided by the conical members in the configuration of FIGS. 16 and 17 prevents the axial movement of member 58 away from member 57 or shoulder 56a. Release and removal of member 58 from shaft 56 can be accomplished through the application of a separating force between member 58 and flange 70 of member 66. Applying a separating force in this manner prevents the drawing of bore 63 into tighter clamping action with cone 61 and member 66 is released with a relatively small force. When member 57 or shoulder 56a do

not exist or can be removed, member 58 can be released from shaft 56 by applying an axial force between member 58 and shaft 56 in the direction of shaft 56. This method of release relaxes the clamping force between cone 61 and bore 63 the release is therefore accomplished with relatively small force.

It is evident from the previously described configurations that the mechanism illustrated in FIGS. 16 and 17 can also utilize a member 66 in which the cuts 72 are not inserted. When cuts 72 are not employed, it is preferable to make the cone angle of cone 61 slightly greater than the cone angle of bore 63 to provide a substantially constant annular area between cone 61 and bore 63. The substantially constant annular area permits a continuous wall between cylinder 66 and bore 68 to be circumferentially contracted without high driving force.

It is evident further member 66 can be extended in tubular fashion, indefinitely beyond flange 70 and thereby the mechanism illustrated in FIGS. 16 and 17 can be utilized for fastening a tubular member to a shaft member. In this utilization it is preferable to eliminate shoulder 64 of member 58, allowing bore 63 to continue to intersection with bore 59, in order that bore 63 may be drawn over member 66 and induce a high contact stress between member 66, cone 61 and bore 63. An axial passageway in member 56 can be provided to communicate a tubular form of member 66 with such point of contact on shaft 56 as may be desired.

The mechanism illustrated in FIG. 16 and 17 can also utilize, within the principles of this invention, a tubular form of member 66 in which: flange 70, diminished bore 71, enlarged cylinder 69 and cuts 72 are individually or collectively omitted. If member 57 and shoulder 56a are omitted and shoulder 56b, as shown in phantom in FIG. 16, is provided, a simple tubular form of member 66 can be anchored to shaft 56 as described below. (1) Member 58 is slipped onto shaft 56 until it contacts shoulder 56b. The location of shoulder 56b on shaft 56 is such that the line of intersection between bores 63 and 65 of member 58 lies slightly above (in FIG. 16) shoulder 60 of shaft 56. (2) Member 66 is slipped over land 62 and cone 61 and into bore 65 of member 58. The leading edge of land 62 is preferably rounded to facilitate step 2. (3) Member 58 is drawn over member 66 to contract member 66 over cone 61.

If tubular member 66 is provided with a wall at its outer end, the mechanism illustrated in FIGS. 16 and 17 can provide an end cap for a pipe nipple or the like, as illustrated in FIGS. 18 and 19. Members or elements having identical functions are given the same identifying numbers in FIGS. 16, 17, 18 and 19. The elements: enlarged cylinder 69, diminished bore 71 and the flutes on their surfaces, slots 72 and shoulder 64 in the configuration of FIGS. 16 and 17 have been omitted in the configuration illustrated in FIGS. 18 and 19. These elements have been preferably omitted in this case because there is usually no requirement for torque transmission and a fluid tight seal between cone 61 and the contracted bore 68 is usually important. It will be noted further that in FIGS. 18 and 19 member 58 has been drawn to proportions that are characteristic of the requirements of a cap.

In FIG. 18 member 58 is shown slipped onto member 56 and in contact with shoulder 56b and member 66 is shown slipped over land 62 and cone 61 and in bore 65 of member 58. Member 66 has been provided with integral wall 74 and an axial fluid passage in member 56 is identified at 56c.

In the illustration presented in FIG. 19 member 58 has been drawn over cylinder 67 of member 66 and bore 68 has been contracted over cone 61. Fluid passageway 56c is sealed by wall 74 and the tight contact between contracted bore 68 and cone 61. Pressure in passage 56c, acting on wall 74 urges member 66 outward, but any outward motion of member 66 causes member 58 to be drawn outward into tighter clamping action with cone 61.

Member 66 is thereby held against outward motion by the dovetail-like lock which is a basic principle of this invention. In the same manner as previously described in conjunction with FIGS. 16 and 17 release of the clamping action can be achieved through the application of a separating force between member 58 and flange 70. By this action member 58 can be returned to the position illustrated in FIG. 18 and member 66 can be drawn from cone 61 and land 62.

The method of augmenting the torque transmission strength through the addition of fluted members, as illustrated in FIGS. 16 and 17 can be applied to the stud type configurations illustrated in FIG. 11. The addition of a diminished bore for accommodation of flutes on member 38 requires only an equal reduction in diameter of the extended section of cylinder 37. A projecting flange, similar to flange 70 in FIG. 16 can also be added to member 38 to facilitate removal. Longitudinal cuts, similar to those illustrated at 72 in FIG. 16 can be provided in member 38 to permit elastic deformation of member 38 in fundamentally the same manner as member 66 of FIG. 16.

When the mechanism illustrated in FIGS. 7, 8, 9 and 10 is utilized to provide a threaded, or other torque transmitting insert, in a body by providing the appropriate axial hole in member 32 in FIG. 7 or member 46 in FIG. 9, it is of advantage to utilize the fluted provisions illustrated in FIG. 16 to members 39 and/or 44. When sealing is not essential, member 38 and/or 44 can be provided with collet-like, longitudinal cuts of the type illustrated at 72 in FIG. 16. The flange 70 of FIG. 16 can also be usefully applied to member 38 and/or 44.

The proportions and the angles that are illustrated in the figures have been chosen for ease of demonstration. In particular, the angles that are required in practice have been exaggerated in the drawings to make more evident the presence of taper. We find that with metals and plastics cone angles of 1 (one) to 3 (three) degrees are sufficient to develop very high conical bond, axial strength. These small angles of deformation are readily achieved with a wide variety of metals and plastics. By way of illustration, we have found that the push-out strength of a 3 (three) degree conical dovetail bond, when the body and the closure are of the same material, can be over 50 (fifty) percent of the shear strength of an integral wall of the same material and thickness. It will be apparent to those skilled in the art that the choice of proportions or angles, or of one of the several configurations, or combinations thereof, will depend on such factors as intensity of pressure, magnitude of force or torque and the strength and the ductility of the body and/or the closure member material.

We claim:

1. A system for securing a wheel, or head, or the like, to a shaft, comprising: a truncated-conical mandrel integral with said shaft, a conical bore in said wheel, and a substantially tubular member; said mandrel being joined to said shaft at its truncated end, the diameter of said truncated end being less than the diameter of said shaft, the free end of said mandrel terminating in a mating, coaxial cylindrical land, the ends of said conical bore terminating in open, cylindrical bores; the outer periphery of said tubular member mating with the larger of said cylindrical bores, the bore of said tubular member mating with said cylindrical land, the smaller of said cylindrical bores in said wheel mating with said shaft, said wheel being fastened to said shaft by forcing said tubular member into the annular space that is formed between said mandrel and said conical bore.

2. In the system of claim 1, said tubular member having a flange at its backward end, said flange being so dis-

posed to permit disassembly of said members through prying between said flange and said wheel.

3. In the system of claim 1, said tubular member having longitudinal cuts of constant width in its wall to provide said wall with collet-like flexibility.

4. In the system of claim 1, a shoulder being on said shaft, said shoulder being spaced an axial distance from the junction of said mandrel and said shaft, said shoulder providing an axial stop for said wheel to axially align said conical bore and said mandrel.

5. A system for securing a wheel, or head, or the like to a shaft, comprising: a truncated-conical mandrel integral with said shaft, a conical bore in said wheel, and a substantially tubular member, said mandrel being joined to said shaft at its truncated end, the diameter of said truncated end being less than the diameter of said shaft, the free end of said mandrel terminating in a mating, coaxial cylindrical land, the ends of said conical bore terminating in open cylindrical bores; the outer periphery of said tubular member mating with the larger of said cylindrical bores, the bore of said tubular member mating with said cylindrical land, the smaller of said cylindrical bores in said wheel mating with said shaft; said tubular member having a backward section of increased outside diameter and decreased inside diameter, said sections having sharp edged axial flutes thereupon, said flutes forming flutes in the larger of said cylindrical bores in said wheel and on said cylindrical land of said mandrel when said tubular member is fully driven into the annular space that is formed between said mandrel and said conical bore.

6. In the system of claim 5, said flutes in said backward section of said tubular member mating with preformed flutes in the larger of said cylindrical bores in said wheel and on said cylindrical land of said mandrel.

7. A system for securing a wheel or head or the like to a shaft, comprising: a truncated-conical mandrel integral with said shaft, a conical bore in said wheel and a tubular member of continuous wall of substantially constant cross-sectional area, said mandrel being joined to said shaft at its truncated end, the diameter of said truncated end being less than the diameter of said shaft, the free end of said mandrel terminating in a mating, coaxial, cylindrical land, the ends of said conical bore terminating in open, coaxial, cylindrical bores; the outer periphery of said tubular member mating with the larger of said cylindrical bores in said wheel, the bore of said tubular member mating with said cylindrical land of said mandrel, the smaller of said cylindrical bores of said wheel mating with said shaft, the cone angle of said mandrel being greater than the cone angle of said conical bore to provide a space of substantially constant annular area there-between, said wheel being fastened to said shaft by forcing said tubular member into said annular space that is formed between said mandrel and said conical bore.

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U.S. Cl. X.R.

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