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**TOOL UNIT CLAMPING APPARATUS HAVING
A LOCKING MECHANISM WITH INCREASED GRIPPING FORCE**

BACKGROUND OF THE INVENTION

5 This invention generally relates to an improved lock rod clamping apparatus for detachably connecting a tool unit to a tool supporter, and is particularly concerned with such an apparatus having an increased gripping force.

10 Clamping mechanisms for detachably connecting a tool unit to a tool supporter are well known in the art. One typical use of such mechanisms is in machining operations where the tool unit holds a cutting insert that is moved into and out of cutting engagement with a rotating metal workpiece. The clamping apparatus allows
15 different tool units holding different cutting inserts to be quickly attached to and detached from the tool supporter which in turn is connected to a device that controls the movement of the tool units with respect to the workpiece.

20 One of the most commercially successful clamping mechanism includes a cylindrically-shaped canister member that is matable with the tubular end of a tool unit and which includes apertures for admitting locking elements into locking engagement with recesses
25 present in the tool unit. The locking elements, which are typically spherical, are radially moved through the apertures in the canister member by means of cam surfaces present on a reciprocating lock rod. Examples of such a clamping mechanism are disclosed in Erickson U.S. patents

4,708,040; 4,747,735; 4,836,068, and 4,932,295, each of which is assigned to Kennametal Inc. located in Latrobe, Pennsylvania.

Such a prior art clamping mechanism is illustrated in Figure 4. Here, a side, cross-sectional view of the distal end 62 of a canister member 39 is shown which includes an aperture 54a in the form of a cylindrical bore through the wall of the member 39. The inner diameter of the circular bore forming the aperture 54a closely approximates the outer diameter of the spherical locking element 57a. A reciprocating lock rod 60 includes a cam portion 64a having a spherical depression 66 which tapers off into a ramp 68. When the spherical locking element 57a is seated in the depression 66, and the lock rod 60 is moved against the bias of the springs 74 (shown in Figure 3) toward the distal end of the canister member 39 so that its stop flange 70 is in the position illustrated in Figure 3, the spherical element 57a is in a non-locking position. This unlocking position allows the tubular shank 16 of a tool unit 10 to be inserted into the annular recess 59. However, when the springs 74 are released to pull the lock rod 60 away from this position toward the position illustrated in Figure 4, the ramp of the cam portion 64a wedgingly engages and radially raises the spherical locking element 57a into the locking position shown. In such a position, the spherical locking element will wedgingly and lockingly bear against the angled wall 30 of the tool unit 10.

While such a prior art locking mechanism has proven its capability of quickly, conveniently, and rigidly attaching a tool unit to a tool supporter, the applicant has observed an area where the performance of such a mechanism could be substantially improved. Specifically, the applicant has observed that if the clamping mechanism could be modified to increase the clamping force applied to the tool unit without



increasing the pull-back force that the spring package applies to the lock rod, then a smaller and shorter spring package could be used to achieve the same holding force. Such a smaller spring package would
5 advantageously shorten the envelope of the tool, which in turn would render the tooling system incorporating the clamping mechanism easier and more convenient to use in a working environment. Additionally, the life span of the springs used in the package (which are typically
10 Bellville washers) would be lengthened. Alternatively, if a spring package of conventional size were used, the holding force between the clamping mechanism and the tool unit would be increased, which in turn would increase tool rigidity and enhance the accuracy of the cutting
15 operation.

Clearly, it would be highly advantageous if a way could be found to increase the holding force that such a clamping mechanism generates with respect to a tool unit for a given pull-back force on the lock rod to
20 make possible either the use of a small spring package, with a consequent reduction in the overall size of the tool envelope or an increase in tool rigidity and cutting accuracy with the use of a spring package of conventional size. Ideally, such a holding force-increasing solution
25 should require only a minimal amount modification to the shapes of existing parts so that a conventional clamping mechanism of the type previously described could easily be converted into an improved clamping mechanism with a minimum amount of disassembly and machining.

30 Summary Of The Invention

Generally speaking, the invention is a clamping mechanism for detachably connecting a tool unit to a tool supporter with an improved holding force that fulfills all the aforementioned criteria.

35 The inventive clamping mechanism comprises at least one locking element, which may be in the form of a sphere; a canister matable with a tool unit and having an

aperture for admitting a locking sphere through a wall thereof; a lock rod reciprocally movable within the canister member along a longitudinal axis and having a cam portion for moving the locking sphere through the canister aperture into wedging and locking engagement with a wall of the tool unit, wherein the canister aperture walls are not cylindrical, i.e., are not orthogonal to the longitudinal axis of the lock rod, but instead are angled with respect to a line extending radially from this axis for increasing the force of locking and wedging engagement between the locking element and the tool unit.

Such an angling of the aperture walls increases the force of wedging engagement by increasing the mechanical advantage between the locking sphere and the wall of the tool unit that is engaged by this sphere when it is forced radially outwardly by the cam portion of the lock rod. In the preferred embodiment, the aperture walls are angled between about 5° and 20° with respect to a line extending radially from the lock rod axis, and more preferably between 7° and 15° with respect to this radial line. As the wall of the tool unit that engages the locking sphere is engaged between about 50° and 60° with respect to this radial line, the locking sphere wedgingly engages the wall of the tool unit at a shallower angle, thereby increasing the mechanical advantage associated with its engagement against the tool unit.

As the invention may be incorporated into a prior art clamping mechanism by merely boring the canister member apertures obliquely with respect to the axis of rotation of the canister member as opposed to orthogonally, the invention may be easily incorporated into existing clamping mechanisms with a minimum amount of machining operations. Moreover, as the incorporation of the invention into a clamping mechanism increases the

holding force by 30%, the invention allows smaller spring packages to be used with all their envelope-reducing and longevity-increasing advantages.

Brief Description Of The Several Figures

5 Figure 1 is a perspective view of a tool unit of the type secured by the clamping mechanism of the invention;

 Figure 2 is a cross-sectional side view of the tool unit illustrated in Figure 1 along the line 2-2;

10 Figure 3 is a cross-sectional side view of the clamping mechanism of the invention that detachably connects the tool unit of Figures 1 and 2 to a tool supporter;

 Figure 4 is an enlarged, cross-sectional side view of a prior art clamping mechanism connecting a tool unit to a tool supporter, and

15 Figure 5 is an enlarged, cross-sectional side view of the clamping mechanism of the invention connecting a tool unit to a tool supporter, illustrating in particular how the angling of the canister member apertures increases the wedging and clamping forces between the locking spheres and the angled walls of the tool unit.

Detailed Description Of The Preferred Embodiment

25 With reference now to Figures 1 and 2, the tool unit 10 used in conjunction with the clamping mechanism of the invention has a forward end 12 for holding a cutting tool, and a rearward tubular shank 16 for connection to a tool supporter. The forward end 12 includes a recess or pocket 14 which is conventional in design for receiving an indexable cutting insert, locking bracket, and shim (not shown). At the junction between the forward end 12 and the tubular shank 16 is an annular abutment face 17 for engagement with the annular face of a tool supporter when the tool unit is connected to such

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35 a supporter by way of a clamping mechanism. The abutment

face 17 is planar and is orthogonally oriented with respect to the axis of rotation of the tubular shank 16.

As is indicated in Figure 2, the tubular shank 16 is preferably integrally formed with the forward end 12 of the tool unit 10 from a single piece of steel, and has a frustro-conical shape. The shank 16 includes a pair of opposing openings 18a,b for receiving the spherical locking elements of the clamping mechanism which are described hereinafter. The walls 20 of the openings 18a,b are not cylindrical completely around their circumference, but instead include angled wall portions 30 (as shown in Figure 2) for facilitating the locking engagement between the shank 16 and the spherical locking elements of the clamping mechanism. The inner surface 22 of the tubular shank 16 is substantially cylindrical in shape so as to closely mate with the outer surface of the canister member of the locking mechanism which will be described shortly. The shank outer surface 24 is frustro-conical for the purposes of both centering and rigidifying the coupling between the tool unit 10 and a tool supporter. Disposed orthogonally with respect to the opposing openings 18a,b are alignment slots 26 and 28. These slots 26,28 fit into protruding keys (not shown) present in the canister member 39 of the clamping mechanism to insure alignment between the openings 18a,b with the spherical locking elements of the clamping mechanism.

With reference now to Figure 3, the clamping mechanism 35 of the invention is disposed within a tool supporter housing 37 as shown. The clamping mechanism includes a cylindrically shaped canister member 39 mounted within a housing 41 formed from a coupling member 43. The coupling member 43 terminates, at its distal end, in an annular abutment face 44 that confronts the previously discussed abutment face 17 of the tool unit 10 when the two are connected. The tool supporter housing 37 further has a support plate 45 disposed behind the

coupling member 43. The canister member 39 is affixed to the housing 41 by way of an annular flange 47 secured to the coupling member 43 by bolts 49. Coupling member 43 is in turn secured to the support plate 45 by means of
5 bolts 51. Thus the canister member 39 remains stationary relative to the lock rod 60 during the operation of the clamping mechanism 35, which will be described shortly.

The distal end 53 of the canister member 39 includes a pair of opposing apertures 55a,b for admitting
10 locking elements in the form of spheres 57a,b to the position shown in phantom. It is important to note that the walls of the apertures 55a,b are not cylindrical bores whose walls are at right angles to the axis A. Rather, they are bores whose walls 56 are angled with
15 respect to a line extending radially from the axis A (which is both the axis of movement of the lock rod 60). As will be described in more detail later, such an angling of the aperture walls increases the locking and wedging forces that the locking spheres 57a,b apply
20 against the angled walls 30 of the tool unit 10. As is indicated by the phantom representations of the locking spheres 57a,b, the angling of these walls 56 causes the spheres to move a slightly axial as well as radial direction during a locking operation.

25 In addition to the canister member 39 and locking spheres 57a,b, the clamping mechanism 35 of the invention further includes lock rod 60 which is reciprocally movable along the axis A from the unlocking position illustrated in Figure 3 to the phantom position
30 illustrated in the same Figure. The lock rod 60 has a distal end 62 concentrically disposed within and slidably movable with respect to the distal end 53 of the canister member 39. The distal end 62 includes opposing cam portions 64 for moving the locking spheres 57 in a
35 generally radial direction and into locking engagement with the tool unit 10. To this end, each of the cam portions 64 includes a depression 66 which is partly

complementary in shape to the locking spheres 57, and a ramp 68 extending from one side of the depression 66 toward the distal end 62 of the rod 60. The proximal end of the lock rod 60 includes a cylindrical shaft 72 which
5 is reciprocally slidable in a proximal end 72.5 of the canister member 39. The shaft 72 of the lock rod 60 terminates in a spring retainer 73 which may take the form of an annular flange as shown. Springs which may be in the form of Bellville washers 74 are slidably and
10 concentrically disposed around the outer surface of the proximal end 72.5 of the canister member between the plate 45 and retainer 73. These washers 74 are normally compressed to apply a longitudinally-oriented tensile force on the lock rod 60 such that the lock rod is biased
15 in a withdrawn position (indicated in phantom) that acts to extend the locking spheres 57a,b into the locking position illustrated in phantom.

The operation of the invention will now be described with respect to Figures 4 and 5. As has been
20 previously indicated, Figure 4 illustrates a prior art clamping mechanism wherein the walls 55.5 of the apertures 55a,b in the canister member 39 are cylindrical, being parallel to a line R extending radially from the axis A. In such a clamping mechanism,
25 when the lock rod 60 is withdrawn by the compressed Bellville washers 74, the locking spheres 57a,b are radially extended by the ramp section 68 of the cam portions 64a,b. When extended, the locking spheres 57a,b come into locking engagement with the angled walls 30
30 that form part of the apertures 18a,b of the tool unit 10. In such a locking mechanism, the wall 30 of the tool unit 10 is canted an angle B with respect to the radial line R of between about 30° and 40°, and most preferably 35°. Because the walls 55.5 of the apertures 55a,b are
35 parallel to the radial line R proximal portions of the

locking spheres 57a,b wedgingly and lockingly engage the angled walls 30 at angle B, shown as a 35° angle.

By contrast, in the clamping mechanism of the invention shown in Figure 5, the walls 56 of the apertures 55a,b of the canister member 39 are inclined at an angle C with respect to a line R radially extending from the axis A. In the preferred embodiment, the angle C is between 5° and 20°, and is more preferably between 10° and 15°. Consequently, when the ramp 68 of each of the cam portions 64a,b of lock rod 60 radially pushes the locking spheres 57a,b outward toward the tool unit 10, the angled walls 56 of the apertures 55a,b guide the spheres into the angled walls 30 of the tool unit 10 not at an angle B of approximately 35°, but rather at a smaller angle D which is between about 15° and 25°, and most preferably 20°. The smaller engagement angle (i.e., 20° versus 35°) between the proximal end of the locking spheres 57a,b and the angled wall 30 of the tool unit 10 creates a greater mechanical advantage in the wedging action between the rounded surface of the spheres 57a,b and the angled walls 30 of the tool unit 10. This greater mechanical advantage results in a clamping force that is on the order of 30% higher than the clamping force generated by the prior art clamping mechanism illustrated in Figure 4 when the same number and type of Bellville washers 74 are used. Alternatively, the clamping mechanism 35 illustrated in Figure 5 would be capable of generating the same amount of clamping force as the Figure 4 clamping mechanism with a spring package comprising either a fewer number of Bellville washers 74, or washers 74 that were smaller, thereby shortening the envelope of the mechanism 35. The clamping mechanism 35 of Figure 5 can also increase the longevity of the Bellville washers 74 used in the spring packet by reducing the amount of stress and fatigue that the



washers 74 must apply to the lock rod 60 to generate acceptable clamping forces.

5 While this invention has been described with respect to a specific embodiment, various revisions, modification, and variations of the invention will become evident to persons skilled in the art. All such variations, additions, and modifications are intended to be encompassed within the scope of the invention, which is limited only by the claims appended hereto.



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WHAT IS CLAIMED IS:

1. A clamping apparatus for detachably connecting a tool unit to a tool supporter, said tool unit having a wall for engaging a locking element, comprising:
- 5 a housing;
a movable locking element within said housing;
a canister member mounted with said housing matable within said tool unit and having an aperture for admitting and guiding said movable locking element through a wall of said member;
- 10 a lock rod reciprocally movable within said canister member along an axis (A) and having a cam portion for moving said locking element through said aperture of said canister member into wedging and locking engagement with a wall of said tool unit,
- 15 wherein said aperture walls of said canister member are angled with respect to a line (R) extending radially with respect to said axis (A) such that said aperture walls guide said locking element into said tool unit wall at a smaller angle that is more parallel to said tool unit wall than if said aperture walls were parallel to said line (R) for increasing the force of locking and wedging engagement between said locking element and said tool unit by increasing a mechanical advantage between said locking element and said tool unit wall.
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2. A clamping apparatus for detachably connecting a tool unit to a tool supporter, said tool unit having a wall for wedgingly engaging a locking element, comprising:

5 a housing;
at least one movable locking element within said housing;

10 a canister member having an exterior that is matable with said tool unit, and an aperture for admitting and guiding said movable locking element through a wall of said member;

15 a lock rod reciprocally movable within an interior of said canister member along an axis (A) and having a cam portion for radially moving said locking element through said aperture in said canister member into a mechanically advantageous wedging and locking engagement with said wall of said tool unit,

20 wherein the walls of said aperture of said canister member are angled with respect to a line extending radially from said axis (A) such that said aperture walls guide said locking element into said wall of said tool unit at a smaller angle that is more parallel to said tool unit wall than if said aperture walls were parallel to said line (R) for increasing the
25 force of wedging and locking engagement between said locking element and said tool unit by increasing the mechanical advantage between said locking element and said tool unit wall.

30 3. The clamping apparatus of claim 2, wherein said locking element is a locking sphere, and said aperture walls are angled greater than 5° but less than 20° with respect to said line (R) extending radially from said axis A.

35 4. The clamping apparatus of claim 3, wherein said tool unit wall is angled between about 50°





and 60° with respect to the line (R) extending radially from said axis (A).

5 5. The clamping apparatus of claim 2, wherein only a side of said aperture wall adjacent to said tool unit wall is angled.

10 6. The clamping apparatus of claim 2, comprising a pair of said locking elements, wherein said canister member includes a pair of opposing apertures and said lock rod includes a pair of opposing cam portions and said tool unit includes a pair of opposing walls for engaging said locking elements.

15 7. The clamping apparatus of claim 2, wherein said aperture walls are angled about 10° with respect to said line (R) extending radially from said axis (A), and said tool unit wall is angled about 55° with respect to said line (R).

20 8. A clamping apparatus for detachably connecting a tool unit to a tool supporter, said tool unit having a wall for wedgingly engaging a locking sphere comprising:

 a housing;

 at least one movable locking sphere within said housing;

25 a canister member mounted within said housing and having an exterior that is matable with said tool unit, and an aperture having walls for admitting and guiding said movable locking sphere through a wall of said member;

30 a lock rod reciprocally movable within an interior of said canister member along an axis (A) and having a cam portion for radially moving said locking sphere through said aperture into a mechanically advantageous wedging engagement with said wall of said tool unit that is angled with respect to a line (R)
35 extending radially from said axis (A) to lock said unit to said canister member;





wherein the walls of the aperture of said canister member are also angled with respect to said line (R) such that said aperture walls guide said locking sphere into said tool unit wall at a smaller angle that is more parallel to said tool unit wall than if the aperture walls were parallel to said line (R) for increasing the force of wedging and locking engagement between said locking sphere and said tool unit wall by increasing the mechanical advantage between said sphere and said tool unit wall.

9. The clamping apparatus of claim 8, wherein said aperture walls are angled between about 7° and 15° with respect to said radial line (R).

10. The clamping apparatus of claim 9, wherein said tool unit wall is angled between about 50° and 60° with respect to said line (R) extending radially from said axis (A).

11. The clamping apparatus of claim 8, wherein said aperture walls are angled about 10° with respect to said line (R) extending radially from said axis (A), and said tool unit wall is angled about 55° with respect to line (R).

12. An improved clamping apparatus for detachably connecting a tool unit to a tool supporter, wherein said apparatus is of the type having a housing, a canister member mounted with said housing that is matable with a tool unit and which includes at least one aperture for admitting a locking element, and a lock rod that is reciprocally movable along an axis (A) and that has a cam portion for moving the locking element radially through said canister aperture into a mechanically advantageous wedging and locking engagement with a wall of said tool unit that is angled with respect to a line (R) extending radially from said axis (A), the wall of said canister



aperture being parallel with respect to said radial line (R), wherein the improvement comprises:

5 aperture walls in said canister member that are angled with respect to said radial line (R) such that said aperture walls guide said locking element into said tool unit wall at a smaller angle than if the aperture walls were parallel to said line (R) for increasing the force of locking and wedging engagement between said locking element and said tool unit by
10 increasing the mechanical advantage between the locking element and the tool unit wall.

13. The clamping apparatus of claim 12, wherein said locking element is a locking sphere, and said aperture walls are angled between about 7° and 15°
15 with respect to line (R) extending radially from said axis (A).

14. The clamping apparatus of claim 12, wherein said tool unit wall is angled between about 50° and 60° with respect to said line (R) extending radially
20 from said axis (A).

This Sheet Has Been Replaced

