April 27, 1965 K. A. McHENRY 3,180,435

SOCKET RETAINER FOR IMPACT WRENCH

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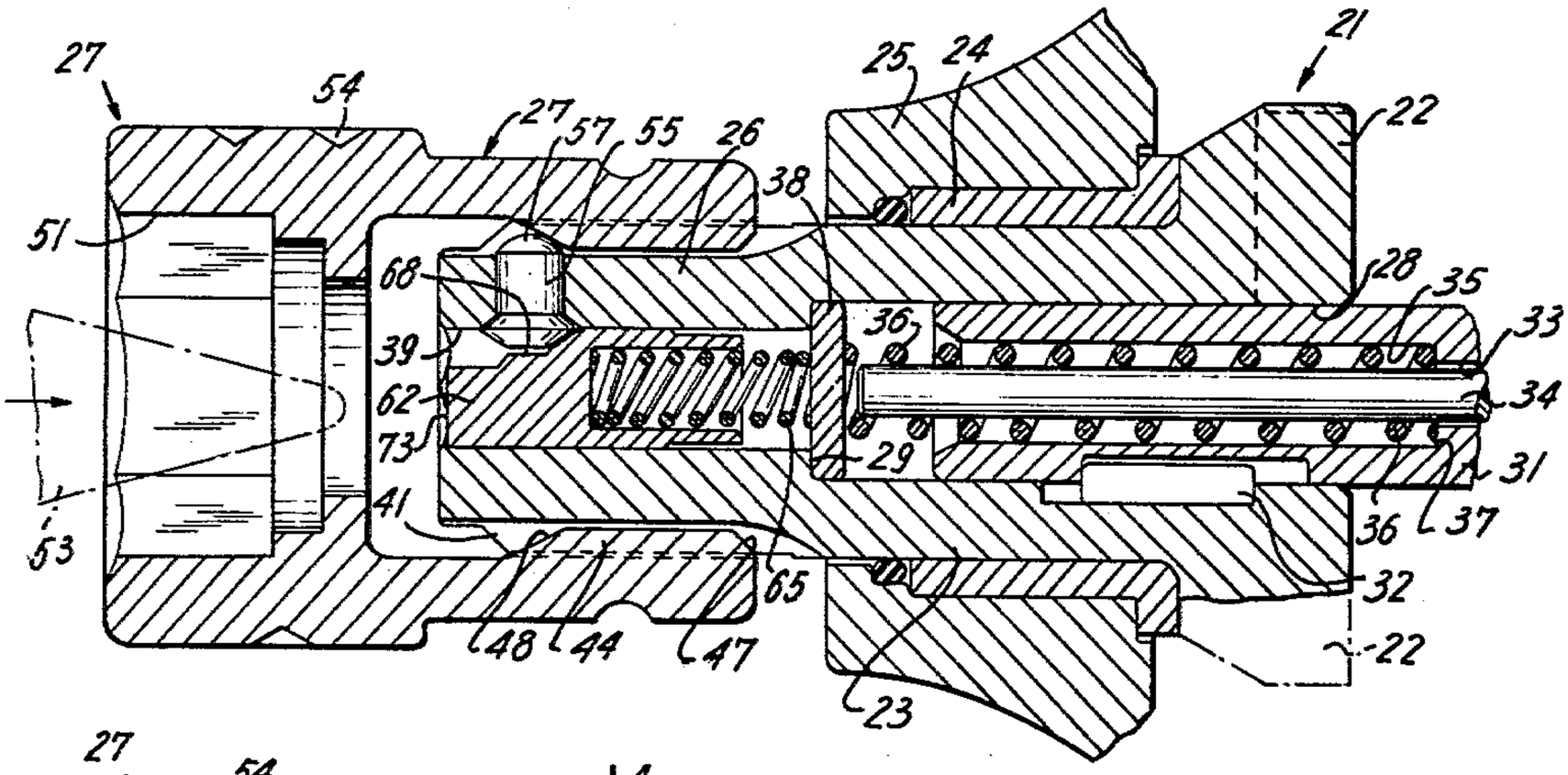
FIG. 1



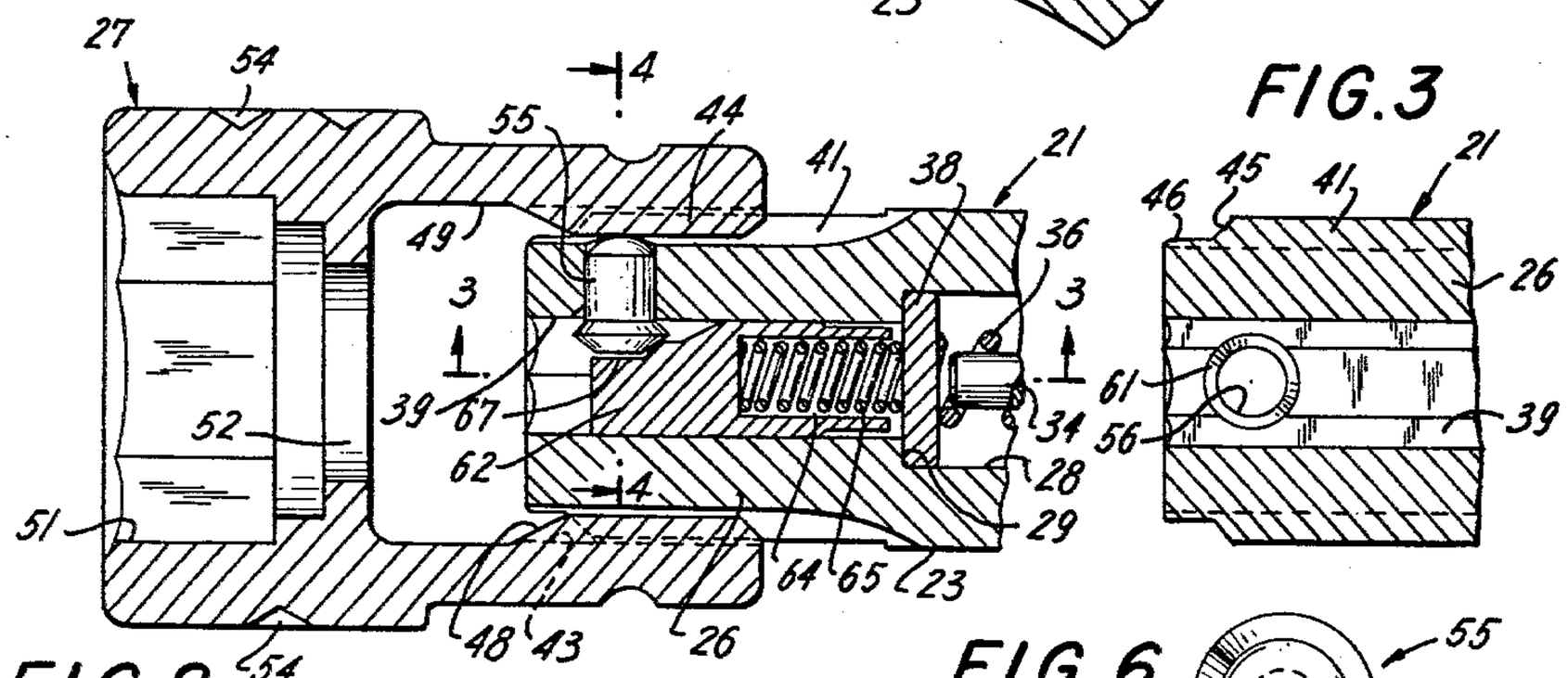


FIG. 2

FIG. 3

FIG. 6

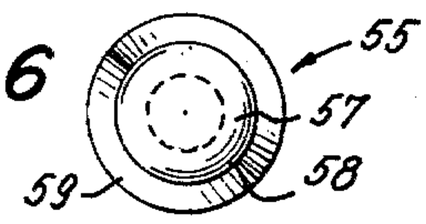


FIG. 5

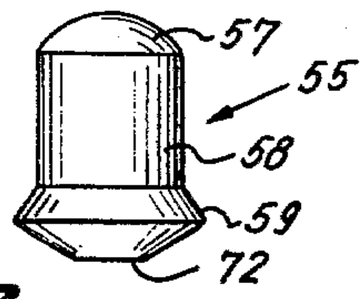
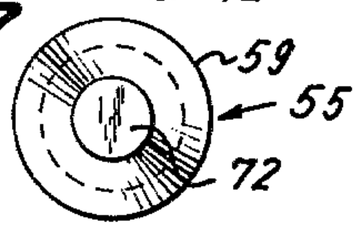


FIG. 7



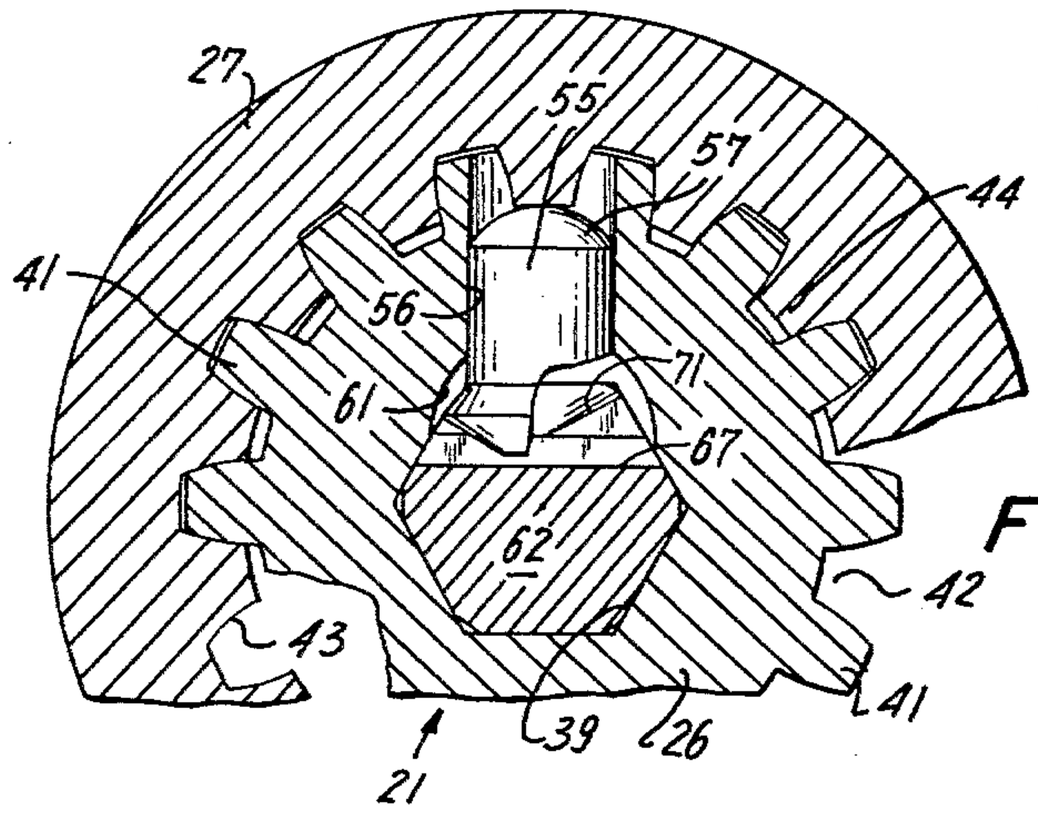


FIG. 4

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FIG. 8

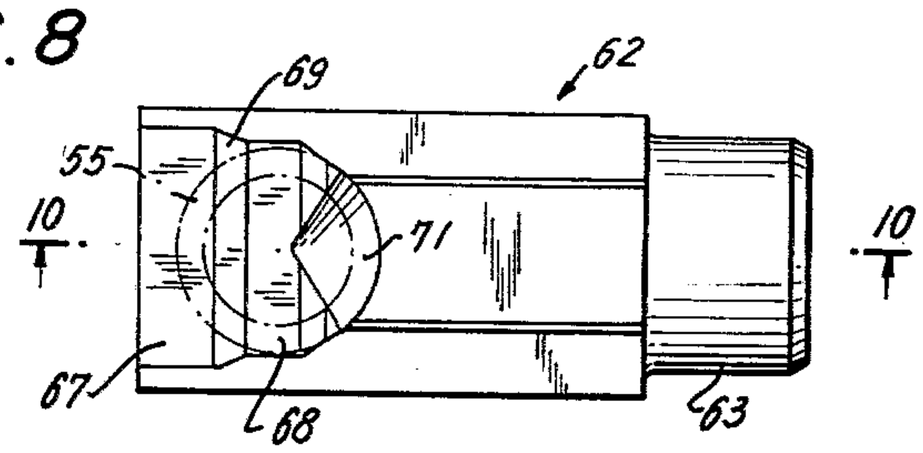


FIG. 9

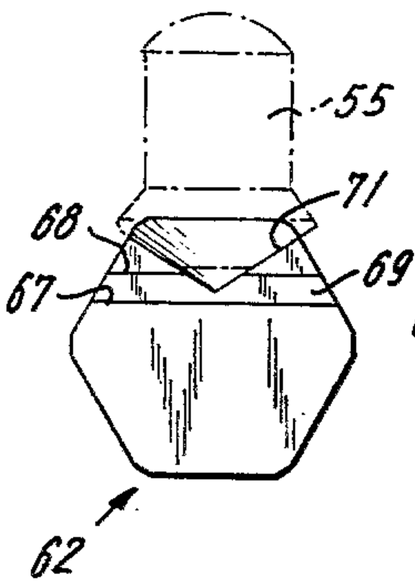


FIG. 10

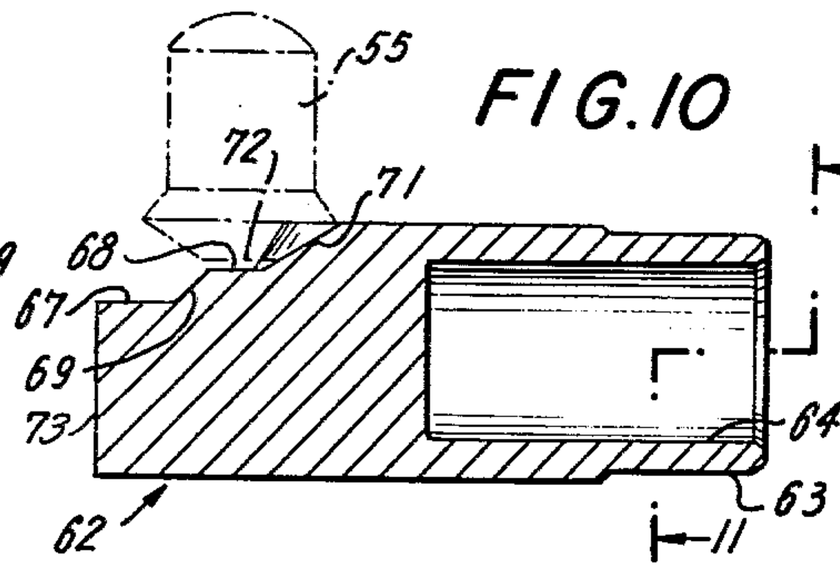


FIG. 11

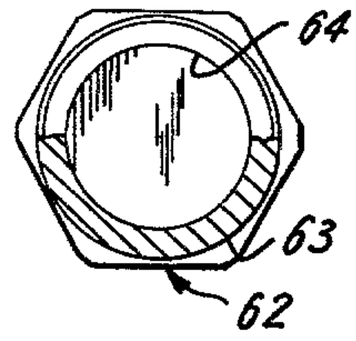


FIG. 12

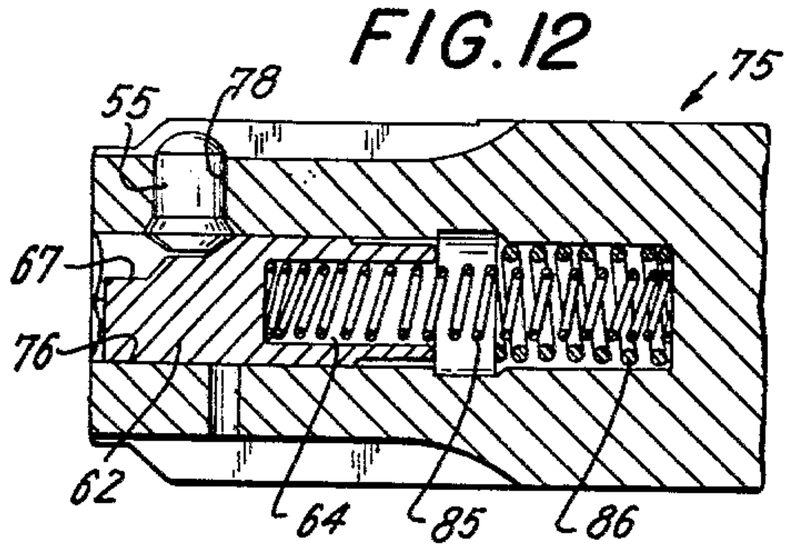


FIG. 13

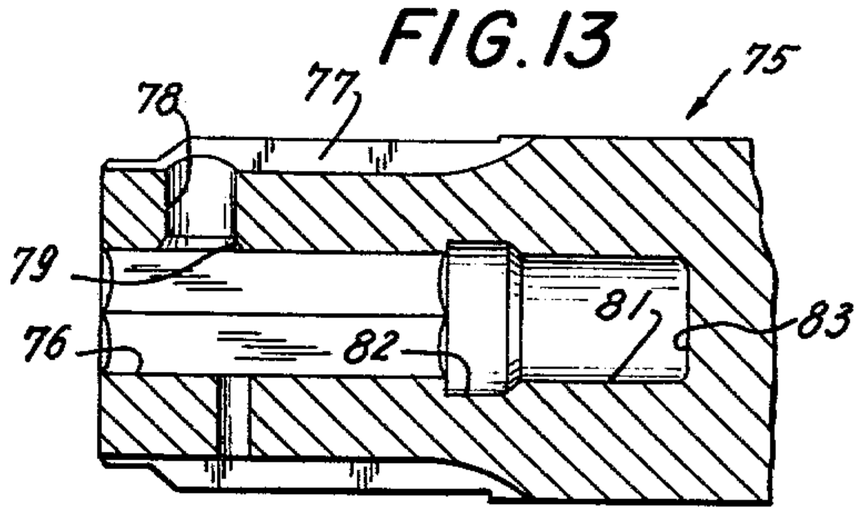


FIG. 14

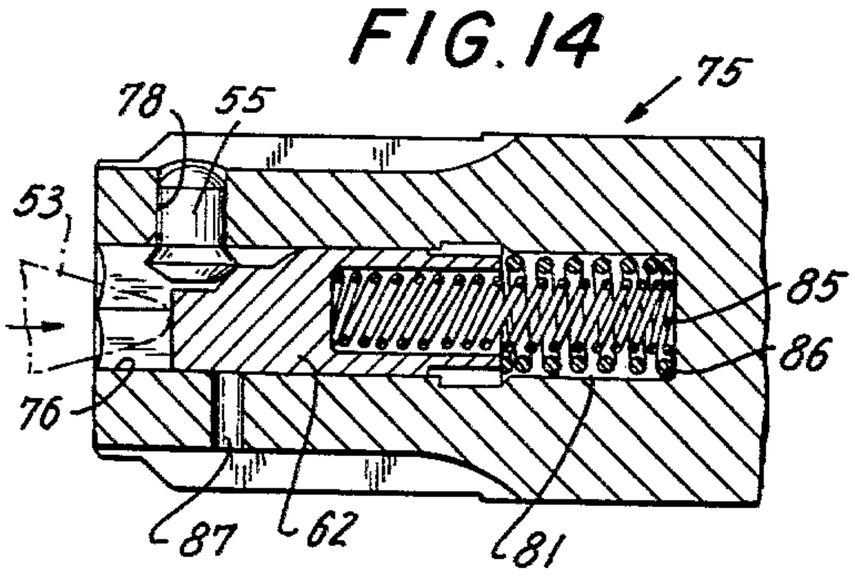
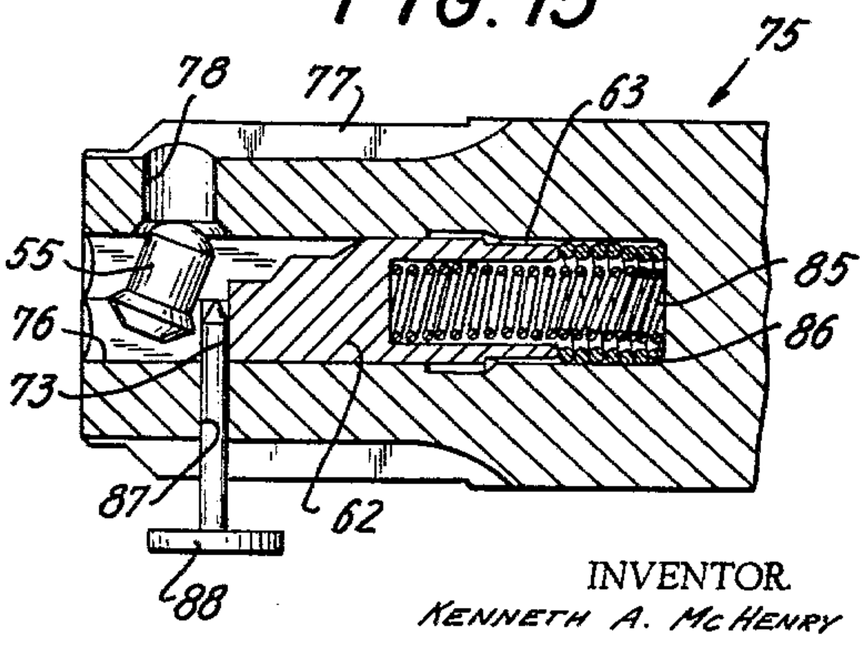


FIG. 15



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SOCKET RETAINER FOR IMPACT WRENCH

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Filed May 25, 1962, Ser. No. 197,697
27 Claims. (Cl. 173—93)

This invention relates to power operated wrenches and more particularly to an arrangement for retaining a detachable socket member on the shank end of the driven shaft. It has especial, though not exclusive, application to impact wrenches of the type which have a splined connection between the shank and socket member.

In the usual spline drive impact wrench, the socket member is locked on the shank by a detent movable in a transverse bore in the shank, the detent being engageable with a plunger mounted in an axial bore, the plunger having a front face accessible through the socket member whereby the plunger may be displaced rearward to release the detent. A spring presses the plunger forward at all times and when the socket member is in assembled condition, the thrust of the spring is transmitted through the plunger to a snap ring supported by a counterbore at the front end of the axial bore. The plunger has a portion extending within a recess in the detent and provides the sole means for restraining the detent from swivelling about the axis of the transverse bore. In one commercial form of retainer assembly, the detent conversely has a portion extending into a recess in the plunger and provides the sole means for restraining the plunger against swivel movement about the axis of the axial bore.

At its rear end, the shaft has an anvil portion provided with jaws arranged for the reception of rotational impacts. These impacts also have an axial component with the result that the entire shaft vibrates axially as well as rotationally. As the shank vibrates the plunger oscillates with both rotary and axial components of motion relative to the shank. The detent also has a tendency to oscillate about the axis of the transverse bore. In the prior art arrangements above described, the plunger and socket recesses are designed to prevent these elements from rotating about their respective axes but are not always effective, and the edges of the recess in the detent are worn away by contact with the vibrating plunger and vice versa. Moreover, the snap ring of the prior art, although intended as a seat for the plunger, does not effectively prevent it from reciprocating but rather causes it to rebound against the light load of the spring and reengage with a series of hammer blows delivered to the ring. The result of the oscillatory movements of the plunger and detent are to cause premature wear on the interengaging surfaces of these elements, also on the snap ring and the adjacent portions of the shank. In some instances, the worn parts of the socket retainer lose their effectiveness and the socket member is accidentally detached from the impact wrench as the latter is moved from one driven bolt to the next. The snap ring has a further objection in that it requires a special tool and special skill to remove it from the shank when it is desired to remove the plunger.

An object of this invention is to eliminate the foregoing disadvantages of prior arrangements of socket retainers.

Another object is to minimize the vibration and wear of the retainer elements and thereby prolong the life of the retainer assembly.

A further object is to provide a positive means, independent of the detent, for preventing the plunger from rotating independently of the shank. In accordance with this object, the conventional cylindrical bore and counterbore arrangement for receiving the plunger are replaced by an hexagonal opening of uniform cross section arranged to receive and slidably fit a plunger in the shape of a hexagonal prism, whereby any tendency of the plunger to rotate relative to the shank is positively prevented by direct engagement with the shank walls instead of by loose engagement with the detent as in prior art devices.

A still further object is to eliminate the sharp corners on the detent. In accordance with this object, the detent is constructed of symmetrical shape about its axis, being circular in circumference in every cross sectional plane, whereby rotation of the detent about its axis does not present any different shaped surface for engagement with the plunger.

Still another object is to dampen the longitudinal vibrations of the detent and plunger. In accordance with this object, the snap ring is omitted and the plunger is seated in snug engagement with the detent under the spring pressure which previously was expended in seating—or frequently impelling—the plunger against the snap ring. A feature of this invention is a wedging surface on the plunger inclined inwardly and forwardly and engageable with the detent to convert the forward thrust on the plunger into a reactive force moving the plunger laterally away from the detent and towards the opposite wall of the hexagonal opening to engage the latter frictionally and thus dampen the longitudinal vibrations.

The detent serves not only as a vibration damping means for the plunger but also as a positive limit stop which prevents the plunger from being removed from the front end of the hexagonal opening as long as the detent is positioned in the transverse bore. This creates a new problem because the detent cannot be removed from the transverse bore as long as the plunger lies in a position for locking the socket member, or lies in its normal socket releasing position. This problem is solved by arranging the plunger to be displaced from its forward locking position to a normal rearward unlocking position upon application of a moderate pressure to overcome the spring but to be moved rearwardly of the normal rearward position in response to some extraordinary effort when it is desired to remove the detent inwardly from the transverse bore and through the hexagonal opening. In one embodiment of this invention the extraordinary effort resides in the application of a much greater force to move the plunger beyond the normal rearward position than the force necessary for overcoming the aforementioned spring, such greater force being produced by the reaction of a second and stronger spring which becomes effective only after the plunger is moved beyond the distance necessary for releasing the socket member.

In another form of this invention, the extraordinary effort requires the opening of the wrench housing and the removal of the driven shaft therefrom, whereby the

plunger is released for movement toward, or through, the rear end of the shaft.

Another object of this invention is to provide a more positive means resisting inward movement of the detent regardless of the force which the operator may impose on the socket member in tugging rearwardly on the housing. In accordance with this object, the plunger is provided with a flat locking surface engaging a flat face on the inner end of the detent, said locking surface engaging said face over a substantial area and obstructing any movement of the detent inwardly from a locking position. The plane of engagement between the locking surface and the flat face lies perpendicular to the axis of the transverse bore and parallel to the opposite wall on the hexagonal plunger whereby the inward thrust of the detent against the plunger does not produce any camming component of force tending to move the plunger axially.

A further object is to simplify the construction and reduce the manufacturing cost of the retainer elements.

In the accompanying drawings, which illustrate two alternative embodiments of this invention:

FIG. 1 is a longitudinal section of a splined shaft and socket member in assembled relation with the retainer elements of this invention in locking position;

FIG. 2 is a view similar to FIG. 1 but with the retainer elements in releasing position, and the socket member being removed from the shaft;

FIG. 3 is a fragmentary longitudinal section of the shaft taken on the line 3—3 of FIG. 2;

FIG. 4 is an enlarged cross section on the line 4—4 of FIG. 3;

FIG. 5 is a side elevational view of the detent;

FIG. 6 is a plan view of the detent;

FIG. 7 is a bottom view of the detent;

FIG. 8 is a plan view of the plunger showing also in phantom lines the relative position of the detent when in locking engagement as in FIG. 1;

FIG. 9 is a front elevational view of the plunger showing also the detent in phantom lines and in locking position;

FIG. 10 is a longitudinal section of the plunger on the line 10—10 of FIG. 8 showing also the detent in phantom lines as in FIGS. 8 and 9;

FIG. 11 is a rear end view of the plunger partly in cross-section as indicated by the irregular line 11—11 in FIG. 10;

FIG. 12 is a longitudinal section of a splined shaft and associated retainer elements in a modified form of this invention, the retainer elements being in locking position;

FIG. 13 is a longitudinal section of the shaft shown in FIG. 12;

FIG. 14 is a view similar to FIG. 12 but with the plunger displaced, against the opposition of one spring, sufficiently to unlock the socket member (not shown) from the splined shaft but not enough to disassemble the retainer elements from the shaft;

FIG. 15 is a view similar to FIG. 14 but with the plunger displaced further from its normal position against the opposition of two springs and held in displaced position by means of an inserted pin to permit the button to be removed from the splined shaft.

FIGS. 4–11 inclusive are drawn to a scale which is double size as compared with the scale of FIGS. 1, 2, 3 and 12–15.

Referring to FIG. 1, the invention is illustrated as applied to the front end of an impact wrench of the type disclosed in United States Patent 2,881,884 granted April 14, 1959, to L. A. Amtsberg. The wrench includes a driven shaft 21 which is provided at its rear end with anvil jaws 22 positioned to receive rotational impacts from a hammer assembly (not shown). In front of the anvil jaws the shaft has a cylindrical portion 23 which is rotatable in a bushing 24, the latter being rigidly

mounted in the front end of the housing 25. In front of the cylindrical portion, the shaft has a shank 26 extending beyond the front end of the housing 25 and adapted to project into the rear portion of a detachable socket member 27, which provides a means for transmitting the torque of the shaft to a driven nut or bolt (not shown). The shaft 21 has a counterbore 28 extending from its rear extremity to a shoulder 29 which lies adjacent the front end of the housing 25. The counterbore supports the front portion of a rotatable spindle 31. A plurality of longitudinally extending pins 32 (one being shown) provide a rotation transmitting means between the spindle and the shaft, each pin being mounted in grooves in the spindle and shaft which are arranged to permit a limited amount of axial and rotative movement of the spindle 31 relative to the shaft 21. The spindle has a bore 33, slidably supporting or guiding a thrust rod 34, and has a counterbore 35 which receives a compression spring 36. The rear end of the spring seats against a shoulder 37 between the bore and counterbore, and urges the spindle rearward at all times, thereby tending to disengage the impact delivering jaws (not shown) from the anvil jaws 22 as described in Amtsberg Patent 2,881,884 above mentioned.

In accordance with this invention, the force of the compression spring 36 is utilized to perform an additional function, namely, as a retainer for a thrust plug 38 seated against the shoulder 29 at the front end of the shaft counterbore 28. The thrust plug normally serves as a closure for the rear end of a central opening 39 which extends from the shoulder 29 to the front extremity of the shaft. As long as the driven shaft 21 remains assembled with the other clutch parts in the housing 25, the spring 36 is maintained under sufficient compressive force to hold the plug 38 seated immovably against the shoulder 29. However, when the housing 25 is opened for repairs and the spindle 31 is disassembled from the driven shaft 21, the plug 38 is released for movement rearwardly along the shaft counterbore 28 thus permitting the plug to be removed through the rear end of the shaft 21. Removal of the plug permits access to the central opening 39 from the rear. The arrangement for closing the rear end of the central opening under some conditions, and opening it under other conditions, is an important feature of this invention, and its purposes and advantages will be described later.

The shank portion 26 of the shaft 21 is formed at its exterior surface with a plurality of longitudinally extending driving splines 41 separated by longitudinal grooves 42. The splines and grooves have a relatively sliding fit with complementary grooves 43 and driven splines 44 respectively in the socket member 27 as shown best in FIG. 4. The construction and shape of the driving splines and of the detachable socket member 27 may be as shown and more fully described in United States Patent 2,954,994, granted October 4, 1960, to R. T. Beers. Each driving spline has a straight crest extending parallel to the axis of rotation and an inclined shoulder 45 (FIG. 3) extending forwardly and inwardly from the front end of the straight crest to a pilot portion 46 at the front end of the shaft 21. Each driven spline 44 has a straight crest extending parallel to the axis of rotation, a chamfer shoulder 47 extending from the rear end of the straight crest to the rear extremity of the socket member 27 and a locking shoulder 48 inclined forwardly and outwardly from the front end of the longitudinal crest. In the illustrative socket member 27, which is of standard commercial construction, there are fourteen of such locking shoulders which combine to form discrete segments of a frustum of a cone whose axis coincides with the axis of rotation. Each of the fourteen is adapted to serve as a locking shoulder, depending on the selected rotative position of the socket member 27 relative to the shaft 21, but only one shoulder 48 is effective at any one time. In front of

the circumferential row of locking shoulders 48 is a cylindrical counterbore 49 having a radius slightly greater than the depth of the grooves 43 measured from the axis of rotation. At its front end the socket member 27 has a hexagonal recess 51 to receive a driven nut or bolt (not shown). Between the hexagonal recess 51 and the counterbore 49, the socket member has a bore 52 of sufficient size to permit an implement such as spud wrench 53 to be inserted through the front end of the socket member 27 and into the shaft opening 39 when the shaft and socket member are assembled as shown in FIG. 1. The periphery of the socket member 27 is provided with the usual depressions 54 for the reception of a bright plastic material (not shown) to enable the operator to observe the number of turns, or a part of the turn, of the socket member during the transmission of rotational impacts.

Each of the locking shoulders 48 is adapted selectively to engage a detent 55 slidably mounted in a transverse bore 56 in the shank portion 26 of the shaft 21. As shown in FIG. 4, the axis of the transverse bore intersects the axis of rotation and bisects one of the longitudinal grooves 42 so that the detent 55 will register with any driven spline that happens to be inserted in that groove. Referring to FIGS. 5, 6, and 7, the detent comprises a convex upper tip 57, preferably shaped as a spherical zone, a cylindrical portion 58 lying below the convex tip and fitting the transverse bore 56, and a base portion 59 adapted to lie within the central opening 39 of the shank 26. The detent is of circular area in every plane of cross section and has its maximum diameter near the middle of the base portion. The upper half of the base portion is frusto-conical and is adapted to seat against a counterbore 61 (FIG. 3) at the inner end of the transverse bore 56. The counterbore 61 provides a seat for the base portion 59. When the latter is seated and the socket 27 is assembled on the shaft 21 as shown in FIG. 1 the tip 57 extends into the path of the associated driven spline 44 thus inhibits forward movement of the socket member. If the operator pulls the socket member 27 forward, the inclined locking shoulder 48 will engage the rounded tip 57 with a camming action, tending to displace the detent 55 inward and to unseat the base portion from the counterbore 61. However, as long as the detent 55 is locked against inward movement, it will act as a positive lock against the shoulder 48 to prevent the socket member from moving forward.

In the course of manufacturing the shaft 21, it is expedient to use a ball mill for machining the counterbore 61 with the result that the latter has the shape of a zone of a sphere, as shown in FIG. 4, and engages the frusto-conical base 59 of the detent over two thin circular areas rather than over a wide frusto-conical area. The area of contact may increase as the parts become worn. It is not necessary for the counterbore 61 to fit the detent perfectly because it is not required to sustain any substantial outward thrust of the detent 55.

A feature of this invention resides in the fact that the detent 55 is symmetrical about its axis and therefore may be rotated within the transverse bore 56 without affecting its relation to any other element. In prior art constructions of a similar nature the detent has a concave recess which receives an axially movable plunger, and the detent cannot be rotated without disaligning the surface of the recess with respect to the plunger.

Manipulative means are provided for selectively locking the detent 55 in the seated position of FIG. 1, or releasing it for inward movement to the FIG. 2 position. The manipulative means includes a plunger 62 mounted for sliding movement in the central opening 39 of the shank 26. The main body portion of the plunger has a shape, in cross-section, which is non-circular, for example, hexagonal as shown in FIGS. 4, 9 and 11. The opening 39 has a complementary shape throughout its length and fits the hexagonal portion of the plunger snugly to prevent the latter from turning about its axis independently of the shank 26. This is an important feature of the invention as will be explained later. At its rear end the plunger has a recessed cylindrical surface 63 (FIGS. 8, 10 and 11), extending from the hexagonal portion to the rear extremity of the plunger. The radius of the cylindrical surface 63 is less than the apothem of the hexagonal surface so that the cylindrical portion of the plunger 62 is out of contact with the walls of the central bore 39. Surrounded by the cylindrical surface and by a part of the hexagonal surface is a bore 64 which receives a compression spring 65 interposed between the bore 64 and the thrust plug 38.

The purpose of the spring 65 is to urge the plunger 62 forwardly at all times and it is necessary, therefore, to provide a plunger retainer for preventing the spring from expelling the plunger from the central hexagonal opening 39 when the detent 55 is seated in its outermost position. In prior art constructions, it is usual to retain the manipulative plunger by means of a snap ring detachably secured to the wall of the central opening near its mouth. The snap ring is objectionable because of the difficulty in disassembling it when replacing the plunger or spring. It has another objection in that it requires a cylindrical counterbore to support the ring. The snap ring of the prior art has a further objection in that it permits the plunger to reciprocate as the surrounding shank vibrates with the plunger repeatedly striking the snap ring. As the plunger reciprocates it wears away the loose cooperating surfaces between the plunger and detent thereby requiring frequent replacement of these elements and occasional failure of the retainer assembly to hold the socket member on the shank. In such prior art constructions, the contacting surfaces between the detent and plunger were designed to prevent the plunger from rotating relative to the detent or vice versa and any wearing away of the interengaging surfaces was aggravated by the fact that it enabled the plunger and/or detent to become rotatively disaligned, with possible loss of the retaining function.

In accordance with this invention, the conventional snap ring is eliminated and instead the function of retaining the plunger in the central opening is transferred to the detent. This novel arrangement not only overcomes the disadvantages of the prior art devices just mentioned but also creates a new result by applying a continuous spring force to hold the base portion 59 of the detent firmly against its seat 61. The novel arrangement is embodied for the most part in the shape of the interengaging surfaces on the plunger 62 and detent 55.

Referring to FIGS. 8, 9 and 10, the top of the plunger 62, near its front end, is cut away to form a forward lower step 67 and a rearward higher step 68, each step consisting of a flat horizontal surface. The lower step extends from the front extremity of the plunger while the upper step is separated from the former by an inclined face 69. Adjacent the rear side of the rear step is a concave recess 71 forming a sector of a conical surface.

As shown in FIGS. 5 and 7, and in broken lines in FIGS. 8, 9 and 10, the base portion 59 of the detent 55 has an undersurface which is of frusto-conical shape and adapted to fit the concave recess 71 and thereby provide a limit to the maximum forward movement of the plunger when the detent is seated in its outermost position. The frusto-conical undersurface terminates in a flat bottom face 72 adapted to seat on the upper step 68 of the plunger and thereby lock the detent in seated position and the socket member 27 in assembled relation as shown in FIG. 1. On the other hand, when the parts are in the FIG. 2 position with the detent 55 unseated inwardly and the plunger 62 in its rearward position, the frusto-conical bottom face of the base portion 59 of the plunger rests against the upper edge of the inclined face 69 and the latter acts as a cam under the pressure of spring 64 to

tend to move the detent 55 upward toward seated position. The camming action between the detent and plunger is irreversible. That is to say, the plunger in moving axially forward may force the detent 55 rearwardly outward, but the detent in moving radially inward does not force the plunger 62 rearward.

At its front extremity, the plunger 62 has a flat face 73 positioned for engagement by the spud wrench 53 to force the plunger rearwardly against the pressure of spring 65, from the FIG. 1 to the FIG. 2 position. Thereupon the upper step 68 moves out of locking engagement with the detent 55 and permits the latter to be unseated and moved inward. Such inward movement may be effected by pulling the socket member 27 forward on the shank 26 thereby causing the inclined shoulder 48 to ride over the convex tip 57 and cam the detent 55 inwardly. The lower step 67 on the plunger permits the detent to move a sufficient distance to clear the associated driven spline 44.

In the operation of the embodiment of invention illustrated in FIGS. 1–11, the impact wrench is started with the parts in the position shown in FIG. 1, except that the socket member 27 has been applied to a driven nut which is located in the hexagonal recess 51. The anvil jaws 22 receive rotational impacts which are transmitted through the shank 26, driving splines 41, driven splines 44, socket member 27 and hexagonal recess 51 to the driven nut. The shank 26 turns intermittently in the direction of rotation and alternately accelerates and decelerates in a rotative sense every time a hammer blow is delivered to the anvil jaws 22. Due to the hexagonal shape of the central opening 39 and of the plunger 62 which fits the opening, the plunger accelerates and decelerates rotatively in unison with the shank. This is an important advantage over prior constructions in which the plunger, due to its inertia, turned on its axis relative to the shank, and therefore relative to the detent, with resulting wear and disalignment of the interengaging surfaces on the plunger and detent.

After the driven nut has been seated and as it approaches its maximum tightness, the intermittent rotative movements of the shank 26 progressively diminish in amplitude or number of degrees of turn per blow, but the intensity of the torque being transmitted increases and, therefore, the torsional strain on the shank 26 progressively increases with each blow. The strain occurs when the anvil jaws 22 are advanced through a greater angle than the shank 26 with the result that the shaft 21 is momentarily twisted throughout the length of the cylindrical portion 23 and along the rear part of the shank 26. The angular displacement of the rear portion of the shank relative to the front portion during the torsional strain is not transmitted to the plunger 62 which continues to accelerate and decelerate in unison with the front portion of the shank. This is due to the cylindrical recess 63 (FIGS. 8, 10 and 11) which prevents any driving engagement between the rear part of the shank and the rear part of the plunger while at the same time enabling the plunger to have sufficient axial length to provide a guide for the compression spring 65. In this arrangement, the plunger 62 is not twisted to the same extent as the shank during the delivery of a torsional impulse.

During the operation of the impact wrench, the spring 65 holds the recessed portion 71 of the plunger in snug engagement with the frusto-conical face on the bottom of the detent 55, as shown in FIGS. 1, 8, 9 and 10. The interengaging frusto-concial surfaces thereby serve as a limit stop to prevent the plunger 62 from moving forwardly beyond the position shown in FIG. 1 and thereby obviate the necessity for a separate limit stop device such as the conventional snap ring at the mouth of the central recess. As in the case of prior art devices, there is a tendency for the compression spring 65 to expand and contract as the surrounding shank 26 vibrates during the delivery of impacts and as the plunger 62 tends to reciprocate. This tendency, however, is resisted by the present invention because the interengaging surfaces on the plunger and detent are inclined downwardly and forwardly as shown in FIG. 10 with the result that the force exerted on the detent through the surface 71, which is due in part to the compression spring 65 and in part to the vibratory forces, sets up a reactive force on the plunger in a downward or lateral direction forcing the plunger into tight frictional engagement with the opposite side wall of the hexagonal recess 39. This arrangement acts as a snubber to dampen the vibrations of the plunger 62 and minimize its reciprocating movement. In prior constructions, the front face of the plunger was arranged to impinge against a snap ring and the reactive force of the ring against the front face was axially directed whereby to cause the plunger to deliver a series of hammer blows to the snap ring, each hammer blow being followed by an axial rebound against the resistance of a relatively light spring. The present invention moreover inhibits reciprocation of the plunger because of the snug engagement between the plunger and detent as compared with the loose connection in the prior art. The snug engagement is maintained as the parts wear because the spring 65 takes up any looseness.

After the nut has been driven to its desired maximum tightness, the operator stops the rotation of the impact wrench and pulls on the housing 25 which acts through the shaft 21 and detent 55 to withdraw the socket member 27 from the driven nut. In case there is a tight frictional contact between the driven nut and the walls of recess 51, the operator tugs on the wrench housing 25 with sufficient force to break the socket member loose from the nut. All of this axial force must be transmitted through the detent 55 and the inclined locking shoulder 48 at the front end of the driven spline 44 with the result that the inclined shoulder exerts a caming force tending to drive the detent radially inward to an unlocking position. This force is effectively resisted over a wide flat area of engagement between the bottom face 72 (FIG. 5) of the detent and the upper step 68 on the plunger and, therefore, the operator cannot pull the shank 26 out of the socket member 27 as long as the latter is applied to the driven nut. This is an advantage over prior constructions in which the plunger is not designed to sustain heavy radial loads under the conditions just mentioned and permits the detent to be forced inward to releasing position with considerable danger to the operator and others, especially when the impact wrench is used in building construction work.

The operator moves the entire machine, including the socket member 27, from one driven nut to the next without disturbing the position of any of the socket retaining elements. However, it becomes necessary at times to remove the socket member 27, for example, in order to replace it with another socket member, having the same spline construction but a different size hexagonal recess 51. In order to remove the socket member 27 from the shank 26, the operator first removes the socket member from the driven nut thereby providing access to the plunger 62 through the front end of socket member 27, hexagonal recess 51, bore 52, counterbore 49, and central recess 39. The operator then inserts his finger or a suitable implement such as a spud wrench 53 through the socket member 27 and into contact with the flat face 73 and pushes the plunger 62 rearward.

As soon as the plunger reaches the position shown in FIG. 2, the detent 55 is released for inward movement and may be unseated by pulling the socket member 27 forward to cause the locking shoulder 48 to ride over the convex tip 57 with a camming action. The axial length of the detent is no greater than, and is probably slightly less than, the distance between the lower step 47 on the plunger and the crest of the driven spline 44, thus permitting the latter to ride freely over the convex tip of the detent as shown in FIG. 2. When the parts attain

that position, the operator may release the pressure against the plunger and continue pulling the socket member and shaft apart. The lower frusto-conical face on the detent engages the inclined face 69 of the plunger to hold the latter in its displaced condition until the socket member has been removed from the path of the detent 55, whereupon the inclined face 69 cams the detent upward to its original seated condition as the spring 65 expands to return the plunger to its forward position.

To assemble a new socket member, the pilot portion 46 (FIG. 3) of the socket member 21 is inserted into the interrupted conical surface formed by the series of chamfers 47 which acts as a funnel to guide the shaft and socket member into axial alignment, following which the pilot portion penetrates slightly into the interrupted cylindrical bore formed by the crest of the driven splines 44. Penetration is interrupted when the inclined shoulders 45 on the driving splines come into contact with the corresponding shoulder or chamfer 47 on the driven splines. The socket member is then turned about its axis through a very small angle until the driving and driven splines intermesh, after which the relative axial movement is continued until the convex tip 57 on the detent 55 strikes the chamfer 47 on the particular driven spline 44 which has been selected as the locking spline. It then becomes necessary for the operator to unlock the detent by displacing the plunger 62 as above described thus permitting the parts to be restored to the partially assembled position shown in FIG. 2 and later to the fully assembled position of FIG. 1.

The axial dimensions of the plunger 62 are so related to the detent 55 and thrust plug 38 that the plunger may be moved slightly beyond the releasing position of FIG. 2 after which the rear extremity of the plunger engages the thrust plug 38. The plug then acts as a limit stop which serves a two-fold purpose; first, to signal the operator that he has moved the plunger a sufficient distance to release the detent 55 from locking engagement with the socket member; and second, to prevent the plunger from being displaced a sufficient distance to permit the detent to drop out of the transverse bore 56. This arrangement makes the retainer assembly foolproof because the detent and plunger mutually lock each other in the shank 26 and neither can be removed, accidentally or otherwise, as long as the thrust plug 38 is seated against the shoulder 29. Should the operator try to unseat the thrust plug 38 by applying an abnormal force through the plunger 62 he would have to overcome the force of the rear spring 36 which is several times as strong than the front spring 65. As an extra precaution, the thrust plug 38 is spaced only a short distance from the thrust rod 34 which provides a positive stop that would prevent the plug from being displaced a sufficient distance to release the detent 55 from the transverse bore 56. The rear end of the thrust rod 34 is rigidly supported against axial movement relative to the housing 25 by conventional appartaus which is illustrated in Amtsberg Patent 2,881,884, above mentioned.

It will be understood that the socket member 27 is replaced frequently and can be conveniently and readily disassembled by the deliberate intervention of the operator but cannot become detached from the shank 26 accidentally. On the other hand, the retainer elements including the detent 55, plunger 62 and front spring 65 need not be removed from the shank except on very infrequent occasions because these elements are designed to minimize wear. To remove one or more of the retainer elements, the service mechanic opens the wrench housing 25 and removes the driven shaft 21 from the parts which drive it, including the spindle 31. The shaft 21, with the principal retainer elements still assembled therein, but with the thrust plug 38 as the only part remaining in the counterbore 28, is then stood on end with the rear faces of the anvil jaws 22 resting on a table or workbench. The thrust plug 38 is then free to drop to the

open end of counterbore 28 except for the peripheral friction which can be overcome easily upon application of manual pressure to the flat face 73 at the front end of the plunger. The front spring 65 and plunger 62 are then removed through the counterbore 28 thus permitting the detent 55 to be pushed radially into the central recess 39 and then removed axially in either direction.

In reassembling the retainer elements, the mechanic first holds the shaft with its axis horizontal as in the FIG. 1 position and then turns the shaft 180° on its axis until the transverse bore 56 extends downward. The detent 55 is inserted through the front end of the central recess 39 into the transverse bore, such assembly being facilitated by the frusto-conical counterbore 61 which contacts and guides the convex tip 57 in the manner of a funnel. Thereafter, the plunger 62 is inserted through the shaft counterbore 28, turned on its axis until the concave recess 71 lines up with the detent 55 and then inserted through the rear end of the central recess 39. The remaining steps of the reassembly operation are the reverse of those described in connection with the disassembly.

FIGS. 12–15 illustrate a modification in which the shaft 75 is provided at its front end with an opening 76 of hexagonal cross section like the central opening 39 but is not provided with any bore extending through the rear end of the shaft, such as the counterbore 28 of FIG. 1.

Referring to FIG. 13, the modified shaft 75 has a set of driving splines 77 like the splines 41, and has a transverse bore 78 and spherical counterbore 79 which are the same size and shape and function as the transverse bore 56 and the counterbore 61 respectively in the embodiment shown in FIGS. 1–4. The shaft 75 has a bore 81 axially aligned with the hexagonal opening 76 but spaced rearward of the hexagonal opening, the radius of the bore being approximately the same as the apothem of the hexagonal opening. Between the cylindrical bore 81 and the hexagonal opening 76 there is an enlarged recess 82 generally of cylindrical shape. The rear end of the shaft bore 81 is closed by a solid wall 83. The reason for closing the bore at the rear end is to adapt the invention to shafts of the type which are not suited for the provision of a through bore because of the extreme length of the shaft, or the circumstance that the splined shank is separated from the anvil jaws by a universal joint or extension bar arrangement. In the absence of a through bore, it becomes necessary to provide some alternative means for permitting the plunger 62 to be removed conveniently from the hexagonal opening 76 when it is desired to replace one of the retainer elements and yet prevent the plunger from being removed accidentally when it is desired only to change the socket member.

In the modified retainer assembly, the plunger 62 and detent 55 have the same shape as in the first embodiment of invention. The plunger bore 64 receives the front portion of an inner spring 85 which is similar in construction and function to the spring 65 but which is of such length that the rear portion extends into the bore 81 and seats against the end wall 83. Surrounding the rear portion of the inner spring is an outer spring 86 which is arranged to seat against the end wall 83 and which normally has a length which is approximately co-extensive with the length of bore 81. In the normal condition of the retainer assembly, as shown in FIG. 12, the inner spring 85 is slightly pre-compressed to exert a holding force on the plunger of approximately seven pounds, for example; while on the other hand the outer spring 86 is fully extended and unstressed. However, the outer spring is much more rigid or stronger than the inner spring.

When the operator desires to replace the socket member 27 without replacing any of the retainer elements, he inserts the spud wrench 53 into the front end of the hexagonal opening 76 and moves the plunger 62 rearward from the FIG. 12 to the FIG. 14 position against the opposition of the relatively weak spring 85. In the FIG. 14 posi-

tion, the lower step 67 on the plunger lies directly under the flat bottom of the detent 55 and the latter is released to the extent of unlocking the socket member 22 as in the case of the FIG. 2 arrangement. The succeeding steps of removing and replacing the socket member are the same as in the first embodiment of invention. The operator may determine readily, by feeling the resistance of the plunger, whether he has displaced the latter through a sufficient distance or through an excessive distance as required for unlocking the socket member. During the movement of the plunger from the FIG. 12 to the FIG. 14 position, the resistance of spring 85 increases slightly, to about ten pounds. However, at the end of socket releasing stroke, the rear extremity of the plunger 62 abuts against the relatively rigid spring 86 and the resistance against further movement rises abruptly. The second or detent-releasing stroke of the plunger from the FIG. 14 to FIG. 15 position, is resisted by the combined force of two springs. During such movement of the plunger the cylindrical portion 63 extends into the shaft bore 81. In the retainer releasing position of FIG. 15, the front face 73 of the plunger is positioned just in back of the transverse bore 78 thereby permitting the detent 55 to be positioned inward and dropped out of the front end of the hexagonal recess 76. This, of course, removes the obstruction which under normal conditions prevents the plunger 62 from being removed from the front end of the hexagonal opening 76.

In order to discourage untrained operators from disassembling the retainer elements unnecessarily or unwittingly, one or both of these springs are so designed that the operator cannot complete the second stroke of the plunger without considerable physical effort, for example, by applying a final force of thirty pounds. The exertion required for maintaining that pressure would require the use of both hands by a single operator while a second operator tries to push the detent 55 past the front end of the plunger. In order to eliminate the need for a second operator, the invention provides a locking device for retaining the plunger 62 at the end of its second stroke. The retaining device includes a radial bore in the shaft 75 adapted to receive a conventional pin or nail 88. The radial bore extends halfway between two adjacent splines 77 and bisects one of the flat sides of the hexagonal recess 76. In order to disassemble the retainer elements, the operator inserts the nail 88 until the point of the nail abuts against one of the flat sides on the plunger 62. He holds the shaft 77 in a convenient position, preferably with the front end pointed upward and uses an implement to press down on the front face of plunger 62 with one hand while the other hand is grasped about the shaft 75 except for one finger which presses against the head of the nail. As soon as the second stroke is completed, the front face 73 moves out of the way of the nail 88 permitting the latter to be pressed radially inward to the position of FIG. 15. The operator may then relieve the pressure and turn the shaft and retainer assembly with its front end pointing downward and, with one hand free, he pushes the detent 55 into the central opening 76.

While the invention has been disclosed in two alternative embodiment, it is apparent that other changes and modifications may be made within the spirit of the invention and the scope of the appended claims. For example, the transverse bore 78 does not necessarily have to extend at right angles to the axis of rotation but may be arranged oblique with respect to such axis. Furthermore, the retainer assembly may be embodied in wrenches of the non-impacting type and in wrenches which have a square drive instead of a spline drive between the driven shaft and the socket member. As stated previously, the invention, and particularly the modified form of FIGS. 12–15, is adapted to be embodied not only in a shaft which has an integrally connected shank portion and anvil portion, but also in an extension bar or universal coupling.

What is claimed is:

1. An impact wrench comprising a driven shaft having an anvil portion provided with one or more jaws for the reception of rotational impacts and having a shank portion in front of the anvil portion, said shank portion having longitudinal splines on its periphery adapted for detachable connection with a splined socket member, the shaft having a central opening extending axially from its front extremity and having a transverse bore extending from the central opening to the splined periphery, a detent slidably mounted in the transverse bore for movement into locking and releasing positions with respect to the splined socket member, a plunger slidably mounted in the central bore and connected to the detent for controlling the movements of the latter, manipulative means for moving the plunger rearward, a spring in said shank portion for urging the plunger forward, said rotational impacts tending to cause the plunger to vibrate with axial and rotary movements relative to the shank portion, means engageable with the plunger for inhibiting such relative rotary movements, and means for damping the axial vibratory movements, said damping means comprising a wedging surface on the plunger inclined forwardly and inwardly and engaging the detent to wedge the plunger laterally away from the detent and into frictional engagement with the opposite side wall of the opening upon thrust of the plunger in a forward direction against the detent, said spring being arranged to hold the plunger and detent continuously in wedging engagement during the delivery of such rotational impacts.

2. An impact wrench according to claim 1, in which the inhibiting means comprises a non-circular portion of the walls of the central opening having a sliding fit with a complementary shaped portion of the plunger to act as a positive means, independent of the detent, to lock the plunger against rotation relative to the shank portion while permitting relative axial movement.

3. An impact wrench according to claim 2, in which the complementary non-circular portion of the plunger and the wall of the opening have the cross-sectional shape of a regular polygon.

4. An impact wrench comprising a housing, a bushing supported in the housing near the front end of the latter, a driven shaft having a cylindrical portion journaled in the bushing, said shaft having an anvil portion rearward of the cylindrical portion, said anvil portion being provided with one or more jaws for the reception of rotational impacts, said shaft having a shank portion projecting beyond the front end of the housing, said shank portion being adapted for driving engagement with a detachable socket member, said shank portion having an opening for the reception of a plunger, a plunger mounted for reciprocation in said opening, the shaft having a counterbore extending from the shank portion opening to the rear end of the shaft and having a shoulder between the counterbore and the opening, a thrust plug seated against said shoulder, detent means slidable in the shank portion relative to the socket member by means of the plunger in one position of the latter to lock the socket member on the shank portion, a spring interposed between the front of the thrust plug and the plunger urging the latter toward said position in which the detent means locks the socket member on the shank portion, and means for holding the thrust plug seated against the shoulder, said holding means being releasable to permit removal of the thrust plug through the counterbore and out of the rear end of the shaft.

5. An impact wrench according to claim 4, in which the anvil jaw forms part of an impact-clutch, said clutch comprising an element movable axially relative to the shaft, and in which the holding means includes a rear spring interposed between the rear face of the thrust plug and the movable clutch element, the force of the rear spring being greater than that of the aforementioned front spring in any position of the plunger and movable

clutch element as long as the elements of the impact clutch are assembled in the housing, said rear spring being removable from the thrust plug upon disassembly of the impact clutch elements relative to the housing to permit removal of the thrust plug.

6. A power operated wrench comprising a housing, a shaft mounted for rotation relative to said housing but held against relative axial movement, the forward portion of the shaft comprising a shank which extends beyond the front end of the housing, the periphery of the shank having a non-circular portion adapted for driving engagement with a detachable wrench socket member, retaining means for the socket member enclosed within the shank, the rear end of the shaft having one or more jaws forming the driven element of a clutch, a separate clutch element disposed within said housing and movable axially relative to the shaft and housing, the shaft having a front opening extending from the front extremity of the shaft and having a rear counterbore extending from the rear extremity of the shaft and having a shoulder connecting the front opening with the rear counterbore, a thrust plug seated against said shoulder, a front spring seated at its rear end against the front face of the thrust plug and engageable at its front end with a part of the socket member retaining means to urge the latter part forwardly, and a rear spring seated at its front end against the rear face of the thrust plug and engageable at its rear end with the separate clutch element to urge the latter rearward, the force of the rear spring being greater than that of the front spring in the assembled wrench, whereby to hold the thrust plug seated against said shoulder, said thrust plug being removable from the shaft through the rear end of the counterbore when the shaft is disassembled from the housing and separate clutch element.

7. An impact wrench comprising a rotatable driven shaft having an anvil portion provided with one or more jaws for the reception of rotational impacts, a shank portion in front of the anvil portion and having a periphery of non-circular shape arranged to provide a driving connection with a detachable socket member, said driving connection being arranged to transmit torsional impulses, the shank portion having a central opening extending in an axial direction rearward from the front extremity of the shank portion, the shank portion having a transverse bore extending from the central opening to the periphery of the shank portion, a detent mounted in the transverse bore for movement outwardly and inwardly into locking and releasing position respectively relative to the socket member, a plunger slidably mounted in the central opening and movable in a straight line between a forward and a rearward position, said plunger being operatively connected to the detent to condition the detent for locking the socket member when the plunger is in forward position and to condition the detent for releasing the socket member when the plunger is in the rearward position, resilient means in said shank portion constantly urging the plunger toward said forward position but yieldable to permit the plunger to vibrate longitudinally during the delivery of impacts to the anvil jaw, manipulative means for moving the plunger to the rearward position in opposition to said resilient means, plunger retaining means for preventing the plunger from moving forward beyond said forward position, said plunger retaining means comprising a plunger locking element which projects inwardly from the wall of the central recess to obstruct forward movement of the plunger, said plunger locking element and plunger having interengaging cam portions inclined forwardly and inwardly whereby the forward thrust on the plunger against the plunger locking element due to said resilient means and due to vibration creates a reactive force on the plunger in a lateral direction away from the plunger locking element to cause the plunger to frictionally engage the opposite side wall of the opening with a snubbing action.

8. An impact wrench according to claim 7, in which the plunger locking element is formed as an integral part of the detent and is effective to engage the inclined cam portion of the plunger when the detent is extended to a position for locking the socket member on the shank portion.

9. A driving coupling comprising a rotatable shaft adapted to be driven at its rear end and having a shank at its front end, the shank having a periphery of non-circular shape arranged to drive a detachable socket member, the shank having a central opening extending in an axial direction rearward from the front extremity of the shank, the shank having a transverse bore extending from the central opening to the periphery of the shank, a detent mounted in the transverse bore for movement outwardly and inwardly into locking and releasing position respectively relative to the socket member, a plunger mounted in the central opening and movable between a forward and a normal rearward position, said plunger being operatively connected to the detent to condition the detent for locking the socket member when the plunger is in the forward position and to condition the detent for releasing the socket member when the plunger is in the normal rearward position, resilient means in said shank constantly urging the plunger toward said forward position, manipulative means for moving the plunger to the normal rearward position in opposition to said resilient means, said transverse bore and detent being of such dimensions that the detent is always retained against removal through the outer end of the transverse bore, said detent being retained against removal through the inner end of the transverse bore to the central recess when the plunger lies in the normal range of movement between the limits of said forward and said normal rearward positions, said detent having a portion projecting into the central recess to obstruct or limit forward movement of the plunger in any position of the detent in the transverse bore, whereby neither the detent nor the plunger may be disassembled from the shank without first moving the plunger rearwardly beyond said normal rearward position.

10. A driving coupling according to claim 9, which includes yieldable means for preventing the plunger from being moved rearwardly beyond said normal rearward position, said yieldable means being adapted to be overcome by application of said manipulative means with a force considerably greater than the force required to move the plunger to said normal rearward position, whereby the operator may selectively release the socket member from the shank upon application of a relatively light force, or release the detent from the shank on application of a relatively heavy force.

11. An impact wrench according to claim 10, in which the yieldable means comprises a thrust plug adjacent the rear extremity of the plunger when the latter is in its rearward position, the thrust plug being seated at the front end of a counterbore which extends through the rear end of the shaft, said thrust plug being removable from the shaft through the rear end of the counterbore.

12. A coupling comprising a shank having a central opening extending rearwardly from the front extremity of the shank, a socket member having a recess detachably fitting the periphery of the shank, the shank having a transverse bore extending outward from the central opening, a detent slidably mounted in the transverse bore, the socket member having a shoulder adapted for locking engagement with the detent when the latter is in extended position, but adapted to clear the detent when the latter is in retracted position, a plunger slidably mounted in the central opening and movable between a forward and a rearward position, said plunger being operatively connected to the detent to condition the detent for locking the socket member on the shank when the plunger is in forward position and to condition the detent for releasing the socket member when the plunger is in the

rearward position, resilient means in said shank constantly urging the plunger toward said forward position, manipulative means for moving the plunger to the rearward position in opposition to said resilient means, and plunger retaining means for preventing the plunger from moving forward beyond said forward position, said plunger retaining means comprising a surface on the detent positioned inwardly of the transverse bore and within the central opening in position to obstruct forward movement of the plunger in any position of the detent relative to the transverse bore and in any position of the socket member relative to the shank, thereby preventing the plunger from being removed through the front end of the central bore as long as the detent is mounted in the transverse bore.

13. A coupling according to claim 12, in which the manipulative means comprises a face at the front end of the plunger arranged to be depressed by an implement, said face being accessible through an opening in the socket member.

14. A coupling according to claim 12, in which the detent is capable of being turned or swivelled about its individual axis in the transverse bore and in which said detent surface extends about the circumference of the detent whereby said surface may be effective as a plunger retainer in any position of the detent relative to the shank.

15. A coupling according to claim 12, in which the detent has a base portion of a diameter too large to fit within the transverse bore thereby locking the detent against removal from the shank through the outer end of the transverse bore.

16. A coupling according to claim 15, in which the shank is provided with a counterbore between the transverse bore and the central opening, said counterbore being co-axial with the transverse bore, said base portion on the detent being movable into and out of engagement with said counterbore.

17. A coupling according to claim 16, in which the counterbore has the shape of a zone of a sphere.

18. A coupling according to claim 12, which includes means for preventing the detent from being removed through the outer end of the transverse bore but permitting it to be detached from the shank by moving it first inwardly then forwardly through the front end of the central opening.

19. A coupling according to claim 18, in which the plunger has a rearward locking surface engageable with the detent to obstruct inward movement and hold the detent in its outermost position for locking the socket member on the shank, and also has a forward locking surface engageable with the detent to prevent withdrawal of the detent from the transverse bore but to permit inward movement of the detent sufficient to release the socket member, whereby neither the detent nor the plunger can be removed from the shank without first moving the plunger rearward beyond the rear position.

20. A coupling according to claim 19, which includes a limit stop device which arrests rearward movement of the plunger in response to the manipulative means when the plunger arrives at said rearward position.

21. A coupling comprising a shaft having a central opening extending rearward from the front extremity of the shaft, a socket member detachably mounted on the front end of the shaft, said shaft having a transverse bore extending from the central opening to the periphery of the shaft, a detent slidably mounted in the transverse bore and movable outwardly and inwardly into locking and releasing position respectively relative to the socket member, a locking surface on the socket member engageable with the detent to prevent the socket member from being removed from the front end of the shaft when the detent is in its outer position but to permit the socket member to be removed when the detent is in its inner position, a plunger slidably mounted in the central opening and adapted to reciprocate between a forward and a normal rearward position, said plunger having a rearward locking surface engageable with the detent when the plunger is in its forward position and the detent is in its outer position to lock the detent against inward releasing movement, said plunger having a forward locking surface engageable with the detent to permit the detent to move inwardly to release the socket member but which obstructs any further movement of the detent relative to the transverse bore when the plunger is in its normal rearward position, said transverse bore and detent having engageable surfaces to prevent the detent from being removed through the outer end of the bore irrespective of the position of the plunger, said bore and central opening being of sufficient size with relation to the detent to permit the latter to be separated from the shaft by removal from the inner end of the transverse bore and the front end of the opening whenever the detent is not obstructed by the plunger, said detent and plunger having interengaging surfaces preventing the plunger from being removed from the front end of the central opening as long as the detent is mounted in the transverse bore, resilient means constantly urging the plunger forward to said forward position in which it locks the socket member and detent and plunger in asembled relation on the shaft, said resilient means being adapted to be overcome by a normal manipulative force to move the plunger to the normal rearward position where it releases the socket member for removal from the shaft but does not release the detent for removal from the shaft, positive means for preventing the plunger from being moved rearwardly beyond the normal rearward position in response to the application of a normal manipulative force, said positive means being disabled upon manual effort differing from said normal manipulative force.

22. A coupling according to claim 21, in which the resilient means comprises a relatively weak spring and the positive means comprises a relatively strong spring, the positive means being ineffective until the plunger is moved to said normal rearward position, said strong spring being yieldable in response to an abnormal manipulative force to permit the plunger to be displaced rearwardly of said normal rearward position, thereby permitting removal of the detent and subsequent removal of the plunger through the front end of the central opening.

23. A coupling according to claim 22, in which each spring is of helical shape, the strong spring being arranged to surround the weak spring and to seat at its rear end against a wall on said shaft which defines the rear end of the central opening.

24. A coupling according to claim 22, which includes a locking device for retaining the plunger in its abnormal rearward position, thereby permitting the detent to be removed without simultaneously continuing the application of the abnormal manipulative force.

25. A coupling according to claim 24, in which the plunger locking device includes a radial bore in the shaft for the reception of a pin engageable with the front end of the plunger, said pin being arranged to hold the strong spring under compression without further manipulative effort.

26. A coupling comprising a shank having an elongated axial recess in its front end, a socket member slidable for a predetermined distance over the shank and having an internal cavity of greater diameter than the shank defining an internal shoulder, the shank having a forward end portion which is freely receivable into the cavity beyond the shoulder, a transverse bore in the said forward end portion having a detent slidable outwardly thereof and forwardly of the shoulder to effect locking engagement of the shank with the socket and slidable inwardly of the bore to effect release of the shank relative to the socket, a spring pressed plunger slidable in the axial recess having a spring pressed forward position

urging the detent to its locking condition and having a rearward position releasing the detent from its locking condition, and surface means on the detent with which the plunger is engageable regardless of the position of the detent in the bore preventing escape of the plunger through the front end of the axial recess.

27. A coupling according to claim 26, wherein the axial recess is sufficiently elongated to permit movement of the plunger against its spring rearwardly clear of the surface means on the detent, the detent being slidable from the bore into the recess and removable through the front end of the axial recess when the plunger is in the latter position, and the plunger being slidable out of the

front end of the recess subsequent to the removal of the detent.

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