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(54) **Torque wrenches.**

(57) A torque wrench (100; 300; 500) having an improved arrangement (102; 302; 502) for indicating the achievement of a preselected maximum torque. When the maximum torque is reached, the torque wrench 'breaks' into a zero-torque mode and is subsequently re-set without needing reverse movement. The improvement comprises providing a dead-band or range of handle movement in the zero-torque mode which is easily recognised by the operator. The arrangement preferably has the form of a cam (118; 518) having one or more lands (126) of constant radius to provide the dead-band. The torque wrench may also have a torque setting lock (160, 194, 200) which can be selectively operated either to allow the maximum torque setting to be adjusted or to prevent the torque setting being altered.

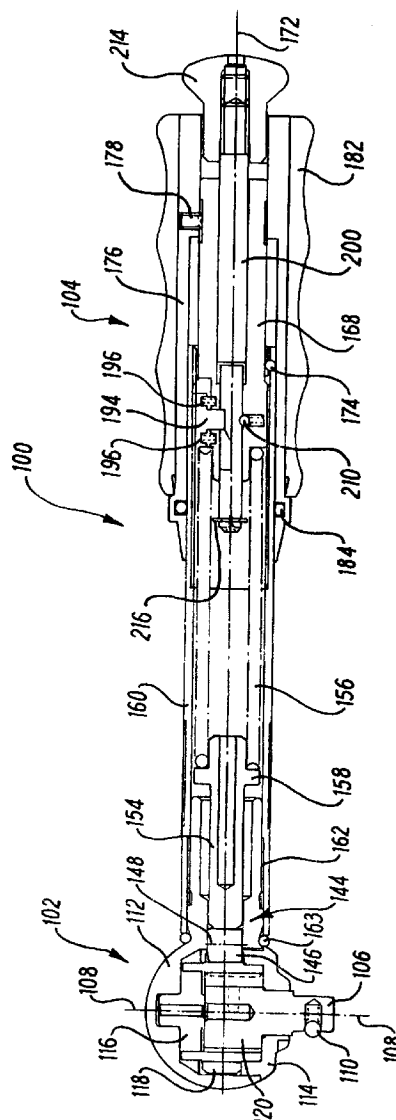


Fig. 1

This invention relates to torque wrenches, and relates more particularly but not exclusively to improvements in torque wrenches having means for indicating the achievement of a preselected maximum torque applied in use of the wrench and/or having means for controllably adjusting a preselected maximum torque to be applied by the torque wrench in use thereof.

In the field of hand tools for the controlled manual application of torque to a component (which may, for example, be a fastener), torque wrenches are known forms of torque-applying tool having torque-limiting means for inhibiting or preventing the application through the tool of torque exceeding some predetermined maximum torque; for increased utility, such predetermined maximum torque may be adjustable.

Normal manual operation of a torque wrench incorporating torque-limiting means usually involves the wrench presenting a perceptibly increasing resistance to movement as applied torque increases, up to the preselected maximum torque at which there is a readily perceptible discontinuity in resistance to movement, commonly in the form of a sharp drop in resistance to movement or "break" in the stiffness of the torque wrench. Resetting of the torque wrench may require a reverse movement of the wrench handle, and/or an increment of forward movement of the wrench handle (i.e. continuation of handle movement in the previous torque-applying direction of handle movement). If the required increment of forward movement is minimal, it may become difficult for the wrench operator to discern the "break". Torque wrenches are disclosed in our British Patents GB0674352, GB0687446, GB0744597, GB0770611, GB0856136 and GB1249590.

Where a torque wrench has a predetermined maximum torque that is controllably variable by tool-less manipulation of a maximum torque adjustment means forming part of the wrench, it is preferable that the adjusted maximum torque should not vary during use of the wrench. Accordingly it is desirable that the adjustment means should be reliably locked when the maximum torque level is not undergoing deliberate adjustment, unlocking and relocking of the adjustment means preferably requiring only a simple manipulation without the use of any tool or key.

According to a first aspect of the present invention there is provided a torque wrench comprising torque-limiting/indicating means for inhibiting or preventing the application through the torque wrench to a component or other entity of applied torque exceeding a predetermined maximum torque limit and for indicating that applied torque has at least reached said limit, said torque wrench further comprising coupling means for coupling torque from said wrench to a component or other entity to which torque is to be applied by said wrench in use of said wrench, and handle means by which said wrench may be manually operated for the application of manually generated torque

to said component or other entity, said torque-limiting/indicating means comprising an input means upon which said handle means is functionally effective, said torque-limiting/indicating means further comprising an output means which is functionally effective upon said coupling means, said torque-limiting/indicating means being constructed or adapted such that subsequent to said predetermined torque limit being reached and prior to said torque wrench being re-set for further application of torque, said torque-limiting/indicating means will transmit substantially no torque from said input means to said output means and will present substantially no back resistance to movement of said handle means in a torque-applying direction whereby to provide an indication of said predetermined torque limit having been reached by presenting a dead-band between break and reset.

Said output means of said torque-limiting/indicating means preferably comprises a rotary cam means having a camming profile rotationally linked to said coupling means of said torque wrench, and said input means of said torque-limiting/indicating means preferably comprises cam follower means resiliently biased into contact with said camming profile of said rotary cam means, said camming profile being shaped and dimensioned to interact with said cam follower means such that said torque-limiting/indicating means has a first zero-torque-transmitting configuration in a first relative angular alignment of said camming profile with said cam follower means and has a second zero-torque-transmitting configuration in a second relative angular alignment of said camming profile with said cam follower means, said torque-limiting/indicating means having a maximum-torque-transmitting configuration in a third relative angular alignment of said camming profile with said cam follower means, said third relative angular alignment lying rotationally intermediate said first and second relative angular alignments.

The torque-transmitting capacity of said torque-limiting/indicating means preferably progressively increases from zero at said first relative angular alignment of said camming profile with said cam follower means to maximum at said third relative angular alignment, said progressive increase in torque-transmitting capacity preferably being free of discontinuities.

The angular displacement from said third relative angular alignment to said second relative angular alignment is preferably minimal whereby the torque wrench tends to undergo a rapid break from maximum torque to substantially zero torque upon said predetermined maximum torque being reached in use of the wrench.

The angular extent of said second relative angular alignment (i.e. the range of relative angles between said camming profile and said cam follower means within which said second zero-torque-

transmitting configuration is maintained) is preferably substantial whereby said dead-band is correspondingly substantial. Said second zero-torque-transmitting configuration is preferably realised as a constant displacement land on said camming profile.

Said output means of said torque-limiting/indicating means is preferably rotationally linked to said coupling means of said torque wrench through unidirectional clutch means effective in use of said wrench to transmit rotation of said output means to said coupling means in one direction only. Said unidirectional clutch means preferably comprises a rotary pawl and ratchet arrangement. Said rotary pawl may be formed integrally with said rotary cam means of said output means of said torque-limiting/indicating means.

According to a second aspect of the present invention there is provided a torque wrench comprising torque-limiting means for inhibiting or preventing the application through the torque wrench to a component or other entity of applied torque exceeding a predetermined maximum torque limit, said torque-limiting means comprising a rotary cam means having a camming profile, said torque-limiting means further comprising cam follower means and resilient bias means resiliently biasing said cam follower means into contact with said camming profile of said rotary cam means, said torque wrench further comprising torque limit adjustment means for controllably adjusting the bias produced by said resilient bias means to predetermine said maximum torque limit, and selectively operable lock means for selectively either allowing movement of said torque limit adjustment means to adjust the bias produced by said resilient bias means or preventing such movement.

Said resilient bias means may comprise a double-ended compression spring having one end engaging said cam follower means and the other end engaged by said torque limit adjustment means to be moved thereby longitudinally of said spring to vary a pre-compression thereof whereby to adjust the bias exerted by said spring on said cam follower means. Said torque limit adjustment means may be a spring abutment screw-thread-mounted on an adjacent part of the torque wrench to be movable by rotation relative to said adjacent part. Said spring abutment may be retained in preferred rotational positions relative to said adjacent part of the torque wrench by means of a resiliently biased detent, said lock means being selectively operable on said detent either to permit said spring abutment to rotate relative to said adjacent part or to cause said detent mutually to lock said spring abutment and said adjacent part. Said adjacent part of said torque wrench is preferably a hollow tubular handle of said torque wrench by which said wrench may be manually operated for the application of manually generated torque to said component or other entity, said hollow tubular handle housing said spring, said spring abutment being peripherally screw-

threaded onto a matching screw thread formed on the bore of said hollow tubular handle, said detent being carried by said spring abutment and acting against said bore, said detent being urged radially outwards of said abutment when not locked by said lock means, and said detent being fixedly held in contact with said bore when locked by said lock means, thereupon to prevent relative rotation of said abutment and said handle sufficient to vary said pre-compression of said spring. Said lock means preferably comprises a bolt movable longitudinally along the axis of the handle and through said abutment, said bolt having a wedging surface effective on said detent at least in a locking position of said bolt to hold said detent fixedly against the bore of said handle, said bore preferably being formed with longitudinal grooves into at least one of which at least one projection on said detent is movable for detent action and for locking action.

Embodiments of the invention will now be described by way of example, with reference to the accompanying drawings wherein:-

Fig. 1 is a longitudinal section of a first embodiment of torque wrench in accordance with the present invention;

Figs. 2 and 3 are respectively a plan view and a longitudinal section on the line III-III in Fig. 2 of a combined rotary cam and ratchet ring forming part of the first embodiment;

Figs. 4 and 5 are respectively a longitudinal elevation and a transverse section on the line V-V in Fig. 4 of a combined pawl carrier and tool drive coupling forming part of the first embodiment;

Figs. 6 and 7 are respectively a longitudinal elevation and a right end view of a pawl forming part of the first embodiment;

Figs 8 and 9 are respectively a longitudinal section and a right end view of part of the tool housing forming part of the first embodiment;

Fig. 10 is a longitudinal elevation of part of a cam follower bias arrangement forming part of the first embodiment;

Figs. 11 and 12 are respectively an underneath view and a longitudinal section of a combined housing closure and output bearing forming part of the first embodiment.

Fig. 13 is a longitudinal section of a combined radial and thrust bearing forming part of the first embodiment;

Figs. 14 and 15 are respectively a longitudinal section and a right end view of a handle forming part of the first embodiment;

Fig. 16 is a detail of Fig. 15 to a much enlarged scale;

Figs. 17 and 17A are respectively a plan view and a left end view of a sub-assembly of the torque wrench components of Figs. 9 and 14, to show external calibration on the handle component of Figs. 14;

Figs. 18 and 19 are respectively a longitudinal section, and a transverse section on the line XIX-XIX in Fig. 18, of a combined handle part and adjustment control component forming part of the first embodiment;

Figs. 20 and 21 are respectively side detail and left end views of the component of Fig. 18, illustrating calibration markings thereon cooperating in use with the calibration markings illustrated in Fig. 17;

Figs. 22, 23 and 24 are respectively a longitudinal section, a plan view, and a left end view of a torque limit adjustment control component forming part of the first embodiment;

Figs. 25, 26 and 27 are respectively a longitudinal section, an end view, and an underneath view of a detent/lock component forming part of the first embodiment;

Fig. 28 is a part-sectioned longitudinal elevation of a locking bolt forming part of the first embodiment;

Figs. 29 is a plan view of part of the locking bolt of Fig. 28;

Fig. 30 is a longitudinal section of a control knob forming part of the first embodiment;

Fig. 31 is a longitudinal section of a second embodiment of torque wrench in accordance with the present invention.

Fig. 32 is a longitudinal section of a third embodiment of torque wrench in accordance with the present invention;

Fig. 33 is a plan view of the third embodiment;

Figs. 34 and 35 are respectively a plan view and a longitudinal section on the line XXXV-XXXV in Fig. 34 of a combined rotary cam and ratchet ring forming part of the third embodiment;

Fig. 35A is an enlarged detail of part of Fig. 35;

Figs. 36 and 37 are respectively a longitudinal elevation and a transverse section on the line XXXVII-XXXVII in Fig. 36 of a combined pawl carrier and tool drive coupling forming part of the third embodiment;

Figs. 38 and 39 are respectively a longitudinal elevation and a right end view of a pawl forming part of the third embodiment;

Figs. 40 and 41 are respectively a longitudinal section and a right end view of part of the tool housing forming part of the third embodiment; and

Fig. 42 is a bearing forming part of the third embodiment.

Before referring in detail to the accompanying drawings, it will be explained that Fig. 1 is a longitudinal section of a complete torque wrench constituting a first embodiment of the present invention, whereas Figs. 2-30 show individual components (or sub-assemblies of a small number of components) of the first embodiment. The respective scales of Figs.

1-30 are not all mutually identical; comparison of any particular individual component as depicted in any of Figs. 2-30 with that particular component as shown in Fig. 1 will disclose the correct dimensional scaling factor for comparison with other components. Similar comments in respect of scale apply to assembly sectional view Fig. 32 and component views Fig. 34 - Fig. 42.

The first embodiment will now be described in detail, principally with reference to Fig. 1, mention of any individual component being described in the context of Fig. 1 implicitly including a cross-reference to whichever of Figs. 2-30 also illustrate that component.

As shown in Fig. 1, a first embodiment of torque wrench 100 comprises a torque-limiting sub-assembly 102, a handle sub-assembly 104, and a tool coupling 106. In the operational configuration of the torque wrench 100, normal operation of the handle sub-assembly 104 drives the input (detailed subsequently) of the torque-limiting sub-assembly 102 whose output (detailed subsequently) in turn drives the tool coupling 106 around a rotational output axis 108.

As shown in Fig. 1, the tool coupling 106 is a conventional socket driver peg with a square cross-section and a built-in spring-loaded socket-latching ball 110; the tool coupling 106 could alternatively take other forms and/or be shaped for coupling direct to a fastener or other component or entity to be acted upon by the torque wrench 100.

The torque-limiting sub-assembly 102 comprises a part-spherical hollow stainless steel housing 112 closed on the output face (through which projects the tool coupling 106) by a bronze bearing bush 114. The inner end of the housing 112 opposite the bush/closure 114 mounts a bronze bearing element 116. A combined rotary cam/ratchet ring 118 is rotatably mounted between the bearings 114 and 116 coaxially with the output axis 108.

A pawl carrier 120 is formed integrally with the tool coupling 106, and disposed centrally within the rotary cam/ratchet ring 118 there to be supported by the bearings 114 and 116 coaxially with the output axis 108.

As detailed in Figs. 2 and 3, the rotary cam/ratchet ring 118 comprises an annulus whose radially outer periphery 122 is formed as eight equi-angularly spaced part-circular recesses 124 each adjacent pair of which is mutually separated by a land 126 of constant radius about the central output axis 108. The annulus 118 has a radially inner periphery 128 formed as eighteen equi-angularly spaced sawtooth-shaped teeth 130, mutually spaced at angular increments of 20°.

The pawl carrier 120 (separately detailed in Figs. 4 and 5) is formed with two pawl-mounting notches 132 (shown in Figs. 4 and 5 without pawls therein) which are mutually angularly spaced apart by 170°.

Since 170° is an integral number of angular separations of the ratchet teeth 130, plus half such an angular separation ($8\frac{1}{2} \times 20^\circ$), one of the two mutually identical pawls 134 (Figs. 6 and 7) carried in the notches 132 will fully engage a ratchet tooth 130 at every 10° increment of rotation about their common axis 108 of the rotary cam/ratchet ring 118 with respect to the combined pawl carrier 120 and tool coupling 106.

Figs. 6 and 7 show one pawl 134 of an identical pair of such pawls forming part of the torque wrench 100. Each pawl 134 has a rounded edge 136 for pivoting engagement with a corresponding concave edge 138 of each pawl-mounting notch 132 (see Fig. 5). Opposite the rounded edge 136, each pawl 134 has a dentiform edge 140 for positive engagement with one of the notched teeth 130. A respective drilling 142 intersects each of the notches 132 in the pawl carrier 120 to accommodate a respective compression spring (not shown) to urge the respective pawl 134 to pivot out of its respective notch 132 into engagement with the row 128 of ratchet teeth 130.

The function of the interaction of the ring 128 of ratchet teeth 130 on the rotary cam/ratchet ring 118 with the pawl carrier 120 and the pawls 134 carried thereon is that of a unidirectional clutch, i.e. when the wrench 100 is viewed from above and with the tool coupling 106 pointing downwards such that the ratchet teeth 130 are aligned as shown in Fig. 2, movement of the handle sub-assembly 104 upwards out of the plane of Fig. 1 (with the axis 108 remaining embedded in the plane of Fig. 1) is transmitted to the tool coupling 106 hence tending to tighten any fastener with a conventional right-hand screw-thread. Reverse movement of the handle sub-assembly 104 (which would otherwise slacken off a fastener with a right-handed thread) is not transmitted to the tool coupling 106 since the pawls 134 then slide over the ratchet teeth 130. Thus angular reciprocation of the handle sub-assembly 104 is converted by the above-described unidirectional clutch into unidirectional rotation of the tool coupling 106. This facilitates speedy tightening of fasteners, especially in circumstances where movement of the wrench handle is restricted.

Reverting to Figs. 1 and 2, a cam-follower arrangement 144 for camming interaction with the recesses 124 on the outer periphery 122 of the rotary cam/ratchet ring 118 comprises a cylindrical roller 146 having an axis 148 substantially parallel to the aforementioned wrench axis 108. The diameter of the roller 146 is substantially equal to the length of the roller 146 along its axis 148. The roller 146 is constrained to slide purely radially with respect to the wrench axis 108, while keeping the roller axis 148 substantially parallel to the wrench axis 108, by making the roller 146 a sliding fit in a square hole 150 in the root of radial projection 152 integral with the housing 112 (see Figs. 8 and 9).

The roller 146 is biased into contact with the outer periphery 122 of the rotary cam/ratchet ring 118 by a plunger 154 (Figs. 1 and 10) which also slides in the bore 150. The plunger 154 is spring-loaded towards the wrench axis 108 by an axially-elongated compression coil spring 156 whose end nearest the axis 108 sits on a peripheral collar 158 formed on the plunger 154. (Position-variable anchorage of the end of the spring 156 furthest from the axis 108 will be described subsequently).

As shown in Figs. 1 and 2, the roller 146 is shown fully seated in one of the part-circular recesses 124. Since the rotary cam/ratchet ring 118 can only move with respect to the rest of the wrench 100 rotationally about the axis 108, and since the cam follower arrangement 144, (and specifically the roller 146) can only move with respect to the rest of the wrench 100 radially with respect to the axis 108, actual or attempted clockwise rotation about the axis 108 (viewed from above) of the handle sub-assembly 104 with respect to the tool coupling 106 will force the roller 146 to move (or attempt to move) radially outwards from the axis 108 as the relative rotational position of roller 146 and the rotary cam/ratchet ring 118 alter from that shown in Fig. 2. Such alteration of relative rotational position takes place against the bias of the spring 156 and therefore manifests itself both as an applied torque and as a corresponding back-resistance to attempted movement of the handle sub-assembly 104.

The torque-transmitting ability of the above-described rotary cam/cam follower arrangement continues with increasing rotational displacement from the Fig. 2 configuration, until the roller 146 is displaced almost completely out of the particular recess 124 from which it started; at this point there is a rapid fall-off in torque transmitting ability with a small increment of rotational displacement, until the roller 146 moves onto the constant-radius land 126 immediately clockwise of the recess 124 from which displacement commenced and thereupon consequently presents a zero torque-transmitting ability. This rapid fall-off in back-resistance to motion of the handle sub-assembly 104 is a "break" point which will be readily perceptible to the operator of the torque wrench, and is immediately followed by a zero-torque dead-band equivalent to the angular extent of the constant-radius land 126 over which the roller 146 is currently moving, further increasing the tactile indication thus presented by the sub-assembly 102 to the operator.

Since the torque necessary to move the roller 146 from its radially innermost starting position in a given recess 124 onto the adjacent land 126 is, inter alia, a function of the force applied to the roller 146 (through the plunger 154) by the spring 156, the setting of the pre-compression of the spring 156 determines the peak torque that can be transmitted by the above-described arrangement, and hence determines the limit of torque applicable by the torque wrench

100. For a given setting of spring pre-compression, the torque limit will be substantially invariant from one operation of the torque wrench to the next operation, i.e. from one "break" point through re-setting to the next "break" point.

Resetting of the torque wrench 100 from the zero-torque-transmitting configuration in which the roller 146 is riding on one of the constant-radius lands 126 requires only either an increase in the relative displacement that brought the roller 146 onto the land 126 until the roller 146 enters the next recess 124, or a reversal of relative displacement to cause the roller 146 to re-enter the initial recess 124. Since the cam profile 122 has eight equally-spaced recesses 124, re-setting of the torque-wrench 100 without reversing rotation of the handle sub-assembly 104 about the axis 108 requires a handle movement of considerably less than one-eighth of a revolution but within which there is a dead-band of rotational extent sufficient to be readily discernable by the operator. This technical performance can be favourably compared with the prior art as disclosed in GB1249580, wherein the cam profile had only four repeats per revolution (compared to eight in the first embodiment of the present invention), no dead-bands between "breaks" (i.e. no dead-bands between operations of the torque limiting function), and wherein the absence of a unidirectional clutch required special measures to inhibit unwanted impulsive reverse rotation and subsequent loosening of the fastener currently being tightened.

A preferred arrangement for easy tool-free adjustment of the pre-compression of the spring 156 will now be described.

A hollow tubular handle 160 is secured to the neck 152 of the housing 112 by means of mated screw-threads 162 locked together by a suitable adhesive (e.g. the adhesive sold under the Trade Name "Loctite"). An O-ring 163, which is preferably of a contrasting colour, can be fitted between the housing 112 and the inboard end of the handle 160 for decorative purposes.

The bore of the outboard end of the handle 160 (i.e. the end of the handle 160 remote from the axis 108) is formed with an axially elongated length of screw-thread 164 intersected by ten equi-angularly spaced longitudinal grooves 166 (only one of which is shown in the enlarged-scale detail of Fig. 16).

The end of the spring 156 remote from the wrench axis 108 is mechanically located and anchored by a movable abutment 168 (Figs. 22-24) having an external screw thread 170 which engages with the internal screw thread 164 in the tubular handle 160 to enable the position of the abutment 168 along the longitudinal axis 172 of the torque wrench 100 to be varied by rotating the abutment 168 around the axis 172 with respect to the handle 160. Total withdrawal of the abutment 168 from the handle 160 after they are mutually assembled during construction of the

wrench 100 is prevented by the insertion of a steel ball 174 (Fig. 1) through the outer end of the handle 160 to form a block in the handle thread 164.

Manual rotation of the abutment 168 with respect to the handle 160 is enabled by an external sleeve 176 (Figs. 18-21) clamped to the abutment 168 by a pair of grub screws 178 (only one of which is visible in Fig. 1) passing through radial holes 180 (Figs. 18 and 19) in the sleeve 176. The sleeve 176 is encased by a shaped nitrile rubber handgrip 182 by which the torque wrench is normally manipulated. A rubber O-ring 184 fitted inside a circumferential groove 186 in the forward end of the bore of the sleeve 176 inhibits scratching of calibrations 188 engraved on the exterior of the handle 160 (Fig. 17) for cooperation with calibrations 190 (Figs. 20 and 21) engraved on the forward end of the sleeve 176 to indicate the position of the abutment 168 within the handle 160, and hence the pre-compression of the spring 156. (Final tightening of the grub screws 178 is delayed until the torque wrench 100 is correctly calibrated, and the subsequent addition of the handgrip 182 both conceals the blocking screws 178 and inhibits tampering with them).

The screw-adjustable spring abutment 168 is formed with a radially extending gap 192 (Figs. 22-24) within which a wedge-faced latching/locking member 194 (Figs. 25-27) is radially slidable. The member 194 is biased radially outwards of the abutment 168 (away from the longitudinal axis 172) by a pair of coiled compression springs 196. During adjustment of the pre-compression of the spring 156 (and hence of the predetermined torque limit of the torque wrench 100) by rotation of the sub-assembly 104 of the abutment 168, the sleeve 176, the handgrip 182 (and of the other components forming the sub-assembly 104) after a preliminary unlocking operation detailed below, the wedge-shaped outer edge 198 of the member 194 will click into successive ones of the grooves 166 as the screw threads 164 and 170 undergo relative movement, thus to provide a latching function for the torque limit adjustment function of the sub-assembly 104.

When adjustment of the torque limit is concluded, the sub-assembly 104 is locked against further adjustment by means of a locking bolt 200 inserted along the axis 172 through the hollow centre of the abutment 168 to hold the member 194 in continuous engagement with the respective groove 166 in which the outer edge 198 of the member 194 is currently engaged. The bolt 200 is formed with a notch 202 (Fig. 28) having a lower land 204 and an upper land 206. When the bolt 200 is axially inserted into its locking position as shown in Fig. 1, the upper land 206 engages a radially inner end 208 of the member 194 to hold the member 194 radially outwards into locking engagement with the respective groove 166, and thus prevent further relative rotation of the abutment 168

with respect to the handle 160. In its locking position, the bolt 200 is axially latched by latching engagement of a spring-loaded latch ball 210 (Fig. 1) with a peripheral groove 212 (Figs. 28 and 29) on the bolt 200.

When it is desired to unlock the sub-assembly 104 for adjustment of the torque limit of the torque wrench 100 by the rotational movements described above, the bolt 200 is withdrawn along the axis 172 a short distance out of the sub-assembly 104 by manually pulling on a knob 214 (Figs. 1 and 30) attached to the outer end of the bolt 200. This brings the lower land 204 on the bolt 200 under the inner end 208 of the locking/latching member 194, and thereby allows the member 194 a limited freedom of radial movement, i.e. the member 194 is no longer locked outwards by the upper land 206, but is now held outwards only by the bias of the springs 196 such that the member 194 converts from a lock to a latch or detent, permitting relative rotation of the abutment 168 and the handle 160.

When torque-limit adjustment is concluded, manual pressure on the knob 214 pushes the bolt 200 back in to its locking position as shown in Fig. 1.

Total withdrawal of the bolt 200 from the abutment 168 is prevented by a circlip 216 (Fig. 1) fitted in a circumferential groove 218 (Fig. 28) formed on the inner end of the bolt 200.

In the torque wrench 100 described above with reference to Figs. 1 - 30, the sub-assembly 102 provides a combined torque-limiting function (due to cam-out) and torque-limit-indicating function (due to the "break" and dead-band), and the sub-assembly 104 enables a tool-free calibrated adjustment of the predetermined torque limit (with simple tool-free locking of the adjustment).

Referring now to Fig. 31, this shows a second embodiment of torque wrench 300, which provides the same torque limiting/indicating facility as the first embodiment 100, but which is not intended to be frequently adjustable. In the second embodiment 300, torque-limit adjustment is intended to be carried out only as an occasional exercise (for example, as an annual re-calibration of a fixed setting of the torque wrench), and to require the use of a tool (albeit only a simple socket-turning key).

In the following description of the second embodiment, those parts of the torque wrench 300 which are equivalent to or identical to like parts of the first embodiment 100 will be given the same reference numeral but with the leading "1" replaced by a "3" (i.e. the Fig. 31 reference numerals are equivalents to Fig. 1-30 reference numerals plus 200).

As shown in Fig. 31, the left half 302 of the torque wrench 300 is identical to the left half of the torque wrench 100, and reference should be made to the foregoing description of the first embodiment for relevant details of structure and function (particularly of the sub-assembly 102).

In the right half of the torque wrench 300, the tubular handle 360 is extended almost to the outer end of the torque wrench 300, where an extended length of the handle bore is provided with an internal screw thread 364. The spring abutment 368 is formed as a short sleeve with a collar 369 to bear against the end of the spring 356.

An adjustment screw 400 is screwed into the thread 364 to anchor the abutment 368 through the intermediary of a spacer tube 402 which engages the abutment collar 369. The adjustment screw 400 is formed with a square or hexagonal bore 404 for engagement by a suitable key (not shown) to enable the screw 400 to be turned within and with respect to the handle 360, thereby to adjust the longitudinal position of the adjustment screw 400, the spacer tube 402 and the spring abutment 368. Thus the pre-compression of the spring 356 is controllably variable, enabling pre-determination of the torque limit of the torque wrench 300. (In the absence of calibration markings on the wrench 300, calibration measurements of the torque transmitted by the wrench 300 during its adjustment can be achieved by use of an external torque gauge (not shown) or any other suitable means).

A nylon ball 406 is set into the threaded periphery of the adjustment screw 400 to interfere with the thread 364 and thereby inhibit unwanted rotation of the screw 400 within the handle 360 which would otherwise degrade the torque limit setting.

Access to the adjustment screw 400 is limited by an end cap 408 screwed into the outer end of the handle 360. The cap 408 is removed for torque adjustment and subsequently replaced. The cap 408 may be given a smooth periphery and a square or hexagonal central bore 410 so as to require the use of a suitable tool before torque adjustment can be undertaken.

The tool-receiving bores 404 and 410 may be made non-standard so as to require the use of a special tool or key of restricted availability before torque-limit-adjustment can be undertaken, thus to inhibit tampering and/or unauthorised adjustments.

Referring now to Figs. 32-42, these show a third embodiment of torque wrench 500 in accordance with the present invention. The torque wrench 500 is largely similar to the first embodiment of torque wrench 100 (Figs. 1-30), with certain components of the first embodiment modified or substituted to arrive at the third embodiment 500. Accordingly, the following description of the third embodiment will concentrate on those components which differ from the first embodiment, and for those parts of the third embodiment not detailed below, reference should be made to the foregoing description of the identical or analogous components of the first embodiment. Where appropriate, components of the third embodiment will be given a reference numeral which is the reference numeral of the identical or analogous component of the first em-

bodiment but with the leading "1" (or "2") substituted by a "5" (or "6"), ie in many cases, the reference numerals for the third embodiment are the reference numerals for the first embodiment plus '400'.

Fig. 32 depicts a longitudinal section of the torque wrench 500 and should be compared to Fig. 1. Fig. 33 is a plan view, from beneath, of the torque wrench 500. The torque wrench 500 comprises a torque-limiting subassembly 502 within which are the principal detail differences with respect to the torque wrench 100.

Within the sub-assembly 502, the pawl carrier 520 (Figs. 32, 36, and 37) is axially extended (by comparison to the pawl carrier 120 of Figs. 1, 4 and 5) to the full axial extent of the combined rotary cam/ratchet ring 518. In place of the internal bearing 116 (Figs. 1 and 13) which supports one end of the annulus 118, the rotary cam/ratchet ring or annulus 518 (Figs. 32, 34 and 35) is externally supported at its upper end (as viewed in Fig. 32) by a bearing ring 516 (Figs. 32 and 42) which is set into an annular seating in a suitably modified form of the housing 512 (Figs. 32, 40 and 41; compare with Figs. 1, 8 and 9). The lower end of the annulus 518 (as viewed in Fig. 32) is supported by a bearing bush 514 (Figs. 32 and 33) which is essentially identical to the bearing bush 114 (Figs. 1, 11 and 12). Axial support of the pawl carrier 520 against typical in-use loading is provided by a bearing ball 515 (Fig. 32).

In concordance with the axial extension of the pawl carrier 520, the pawl 534 (Figs. 38 and 39) is correspondingly extended in comparison to the pawl 134 (Figs. 6 and 7). The pawl 534 is slightly tapered in profile. The internal ratchet teeth 530 (Figs. 34 and 35) formed in the radially inner periphery 528 of the annulus 518 are likewise axially extended to the full axial extent of the annulus 518 as may be seen by comparing Fig. 35 with Fig. 3. However, the teeth 530 have cross-sectional profiles which are the same as those of the teeth 130 as may be noted from the essential identity of Fig. 34 with Fig. 2.

The other major part of the torque wrench 500 is its handle sub-assembly 504 (Figs. 32 and 33) which is essentially identical to the handle sub-assembly 104 of the first embodiment 100 (compare Fig. 32 with Fig. 1).

The axial lengthening of the pawl and ratchet arrangement within the sub-assembly 502 (in comparison to the corresponding arrangement in the first embodiment) gives this part of the third embodiment a relatively greater ability to withstand static and dynamic loads in use. However, in every other respect, the torque wrench 500 functions in a manner identical to the functioning of the torque wrench 100.

While certain modifications and variations have been described above, the invention is not restricted thereto and other modifications and variations can be adopted without departing from the invention as de-

fined in the appended Claims.

Claims

1 A torque wrench comprising torque-limiting/indicating means for inhibiting or preventing the application through the torque wrench to a component or other entity of applied torque exceeding a predetermined maximum torque limit and for indicating that applied torque has at least reached said limit, said torque wrench further comprising coupling means for coupling torque from said wrench to a component or other entity to which torque is to be applied by said wrench in use of said wrench, and handle means by which said wrench may be manually operated for the application of manually generated torque to said component or other entity, said torque-limiting/indicating means comprising an input means upon which said handle means is functionally effective, said torque-limiting/indicating means further comprising an output means which is functionally effective upon said coupling means, characterised in that said torque-limiting/indicating means is constructed or adapted such that subsequent to said predetermined torque limit being reached and prior to said torque wrench being re-set for further application of torque, said torque-limiting/indicating means will transmit substantially no torque from said input means to said output means and will present substantially no back resistance to movement of said handle means in a torque-applying direction whereby to provide an indication of said predetermined torque limit having been reached by presenting a dead-band between break and reset.

2 A torque wrench as claimed in Claim 1 characterised in that said output means of said torque-limiting/indicating means comprises a rotary cam means having a camming profile rotationally linked to said coupling means of said torque wrench, and said input means of said torque-limiting/indicating means comprises cam follower means resiliently biased into contact with said camming profile of said rotary cam means, said camming profile being shaped and dimensioned to interact with said cam follower means such that said torque-limiting/indicating means has a first zero-torque-transmitting configuration in a first relative angular alignment of said camming profile with said cam follower means and has a second zero-torque-transmitting configuration in a second relative angular alignment of said camming profile with said cam follower means, said torque-limiting/indicating means having a maximum-torque-transmitting configuration in a third relative angular alignment of said camming profile with said cam follower means, said third relative angular alignment lying rotationally intermediate said first and second relative angular alignments.

3 A torque wrench as claimed in Claim 2, charac-

terised in that the torque-transmitting capacity of said torque-limiting/indicating means progressively increases from zero at said first relative angular alignment of said camming profile with said cam follower means to maximum at said third relative angular alignment.

4 A torque wrench as claimed in Claim 3, characterised in that said progressive increase in torque-transmitting capacity is free of discontinuities.

5 A torque wrench as claimed in any of Claims 2-4, characterised in that the angular displacement from said third relative angular alignment to said second relative angular alignment is minimal whereby the torque wrench tends to undergo a rapid break from maximum torque to substantially zero torque upon said predetermined maximum torque being reached in use of the wrench.

6 A torque wrench as claimed in any of Claims 2-5, characterised in that the angular extent of said second relative angular alignment (i.e. the range of relative angles between said camming profile and said cam follower means within which said second zero-torque-transmitting configuration is maintained) is substantial whereby said dead-band is correspondingly substantial.

7 A torque wrench as claimed in any of Claims 2-6, characterised in that said second zero-torque-transmitting configuration is realised as a constant displacement land on said camming profile.

8 A torque wrench as claimed in any preceding claim, characterised in that said output means of said torque-limiting/indicating means is rotationally linked to said coupling means of said torque wrench through unidirectional clutch means effective in use of said wrench to transmit rotation of said output means to said coupling means in one direction only.

9 A torque wrench as claimed in Claim 8, characterised in that said unidirectional clutch means comprises a rotary pawl and ratchet arrangement.

10 A torque wrench as claimed in Claim 9 when indirectly dependent on any of Claims 2-7, characterised in that said rotary pawl is formed integrally with said rotary cam means of said output means of said torque-limiting/indicating means.

11 A torque wrench comprising torque-limiting means for inhibiting or preventing the application through the torque wrench to a component or other entity of applied torque exceeding a predetermined maximum torque limit, characterised in that said torque-limiting means comprises a rotary cam means having a camming profile, said torque-limiting means further comprising cam follower means and resilient bias means resiliently biasing said cam follower means into contact with said camming profile of said rotary cam means, said torque wrench further comprising torque limit adjustment means for controllably adjusting the bias produced by said resilient bias means to predetermine said maximum torque limit,

and selectively operable lock means for selectively either allowing movement of said torque limit adjustment means to adjust the bias produced by said resilient bias means or preventing such movement.

12 A torque wrench as claimed in Claim 11, characterised in that said resilient bias means comprises a double-ended compression spring having one end engaging said cam follower means and the other end engaged by said torque limit adjustment means to be moved thereby longitudinally of said spring to vary a pre-compression thereof whereby to adjust the bias exerted by said spring on said cam follower means.

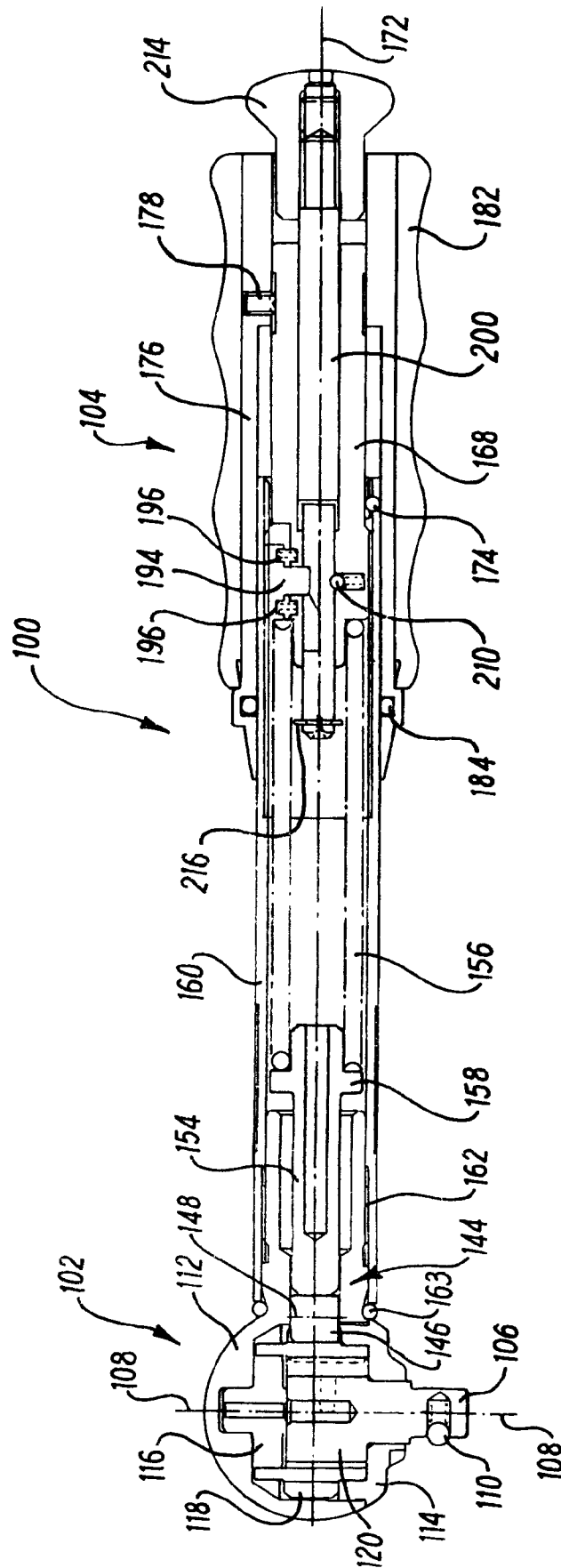
13 A torque wrench as claimed in Claim 11 or Claim 12 characterised in that said torque limit adjustment means is a spring abutment screw-thread-mounted on an adjacent part of the torque wrench to be movable by rotation relative to said adjacent part.

14 A torque wrench as claimed in Claim 13, characterised in that said spring abutment is retained in preferred rotational positions relative to said adjacent part of the torque wrench by means of a resiliently biased detent, said lock means being selectively operable on said detent either to permit said spring abutment to rotate relative to said adjacent part or to cause said detent mutually to lock said spring abutment and said adjacent part.

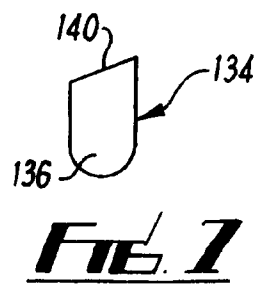
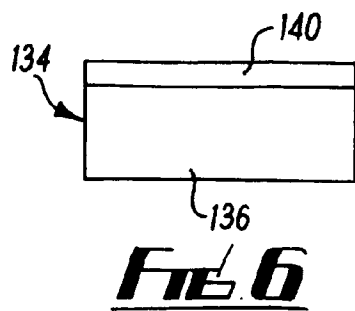
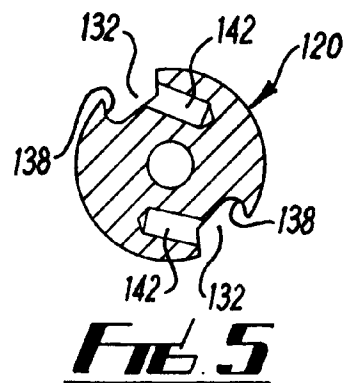
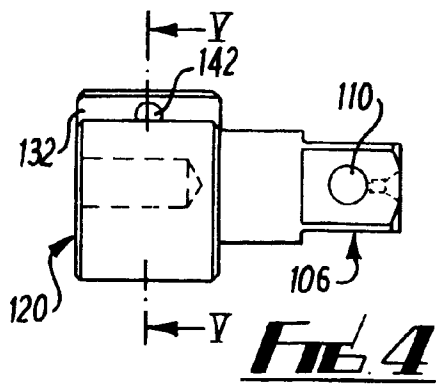
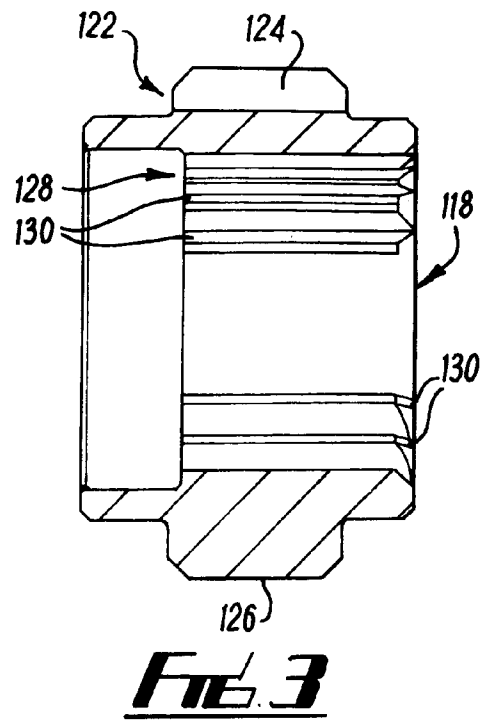
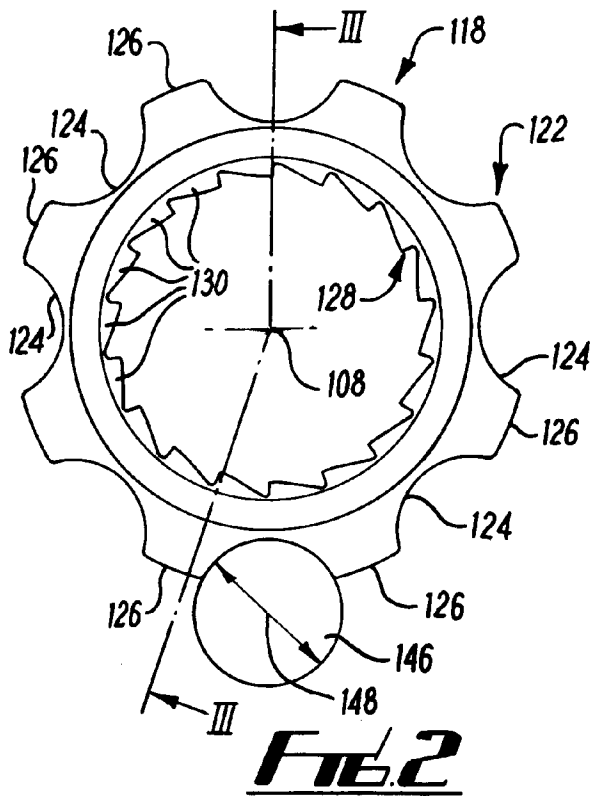
15 A torque wrench as claimed in Claim 13 or Claim 14, characterised in that said adjacent part of said torque wrench is a hollow tubular handle of said torque wrench by which said wrench may be manually operated for the application of manually generated torque to said component or other entity, said hollow tubular handle housing said spring, said spring abutment being peripherally screw-threaded onto a matching screw thread formed on the bore of said hollow tubular handle, said detent being carried by said spring abutment and acting against said bore, said detent being urged radially outwards of said abutment when not locked by said lock means, and said detent being fixedly held in contact with said bore when locked by said lock means, thereupon to prevent relative rotation of said abutment and said handle sufficient to vary said pre-compression of said spring.

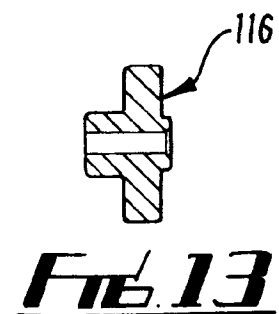
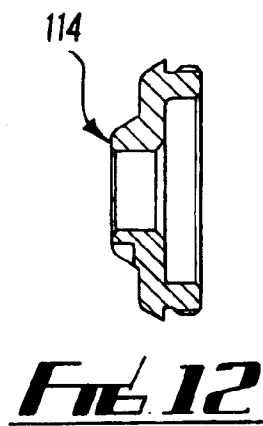
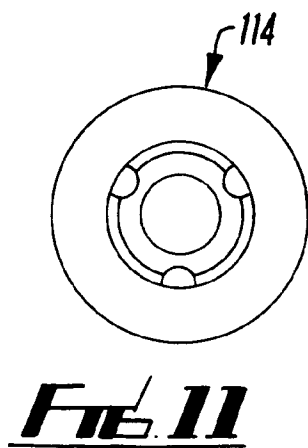
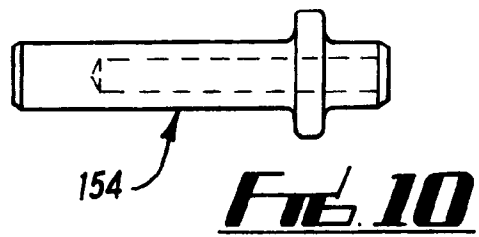
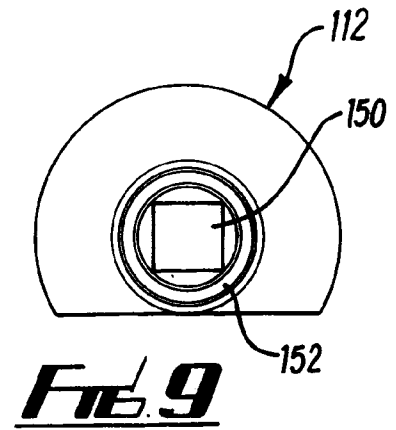
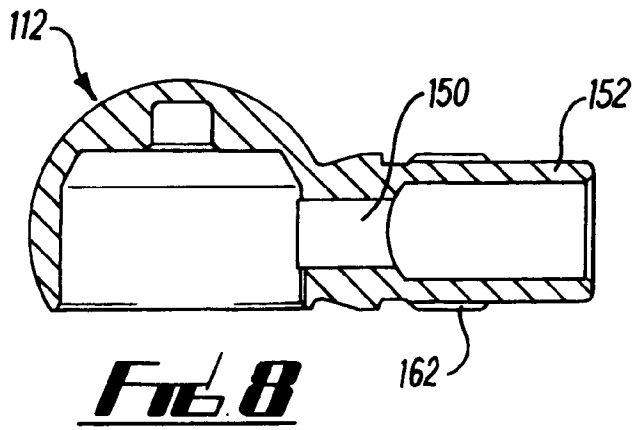
16 A torque wrench as claimed in Claim 15, characterised in that said lock means comprises a bolt movable longitudinally along the axis of the handle and through said abutment, said bolt having a wedging surface effective on said detent at least in a locking position of said bolt to hold said detent fixedly against the bore of said handle.

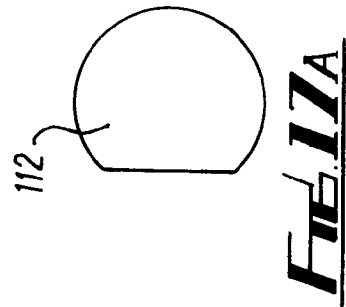
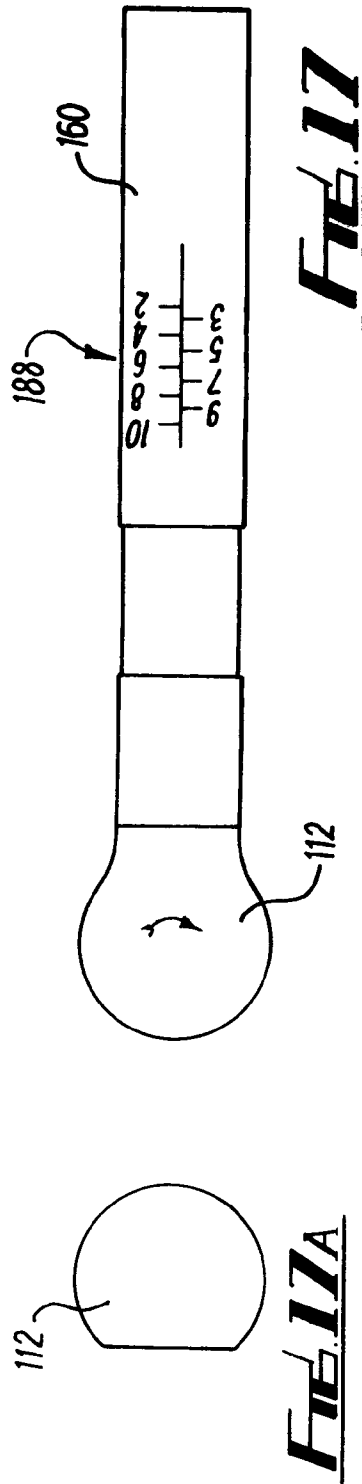
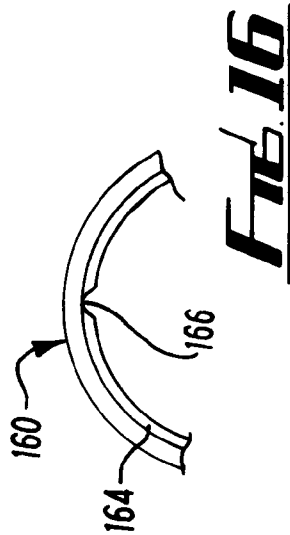
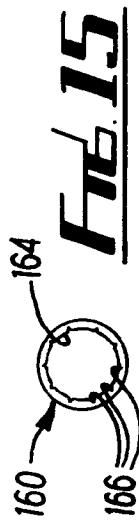
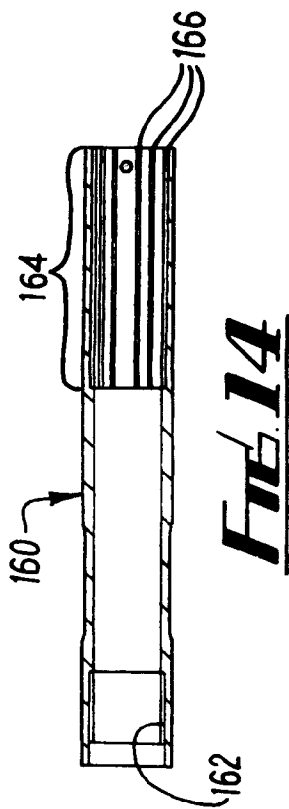
17 A torque wrench as claimed in Claim 15 or 16, characterised in that said bore is formed with longitudinal grooves into at least one of which at least one projection on said detent is movable for detent action and for locking action.

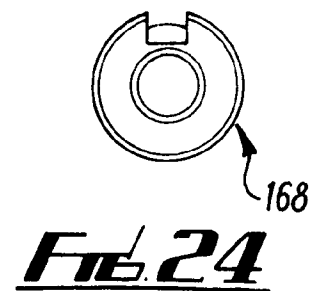
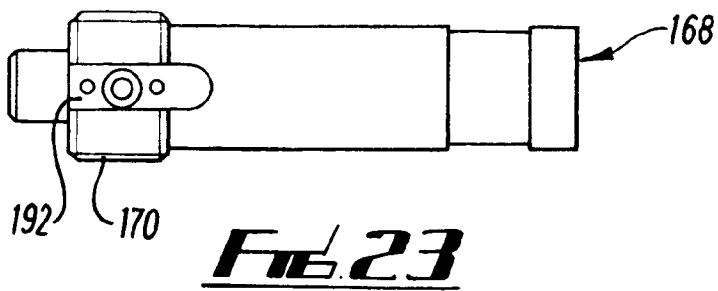
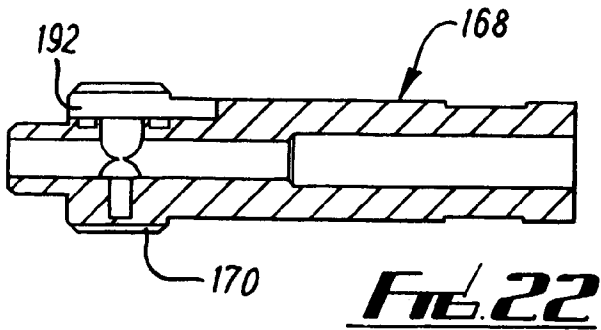
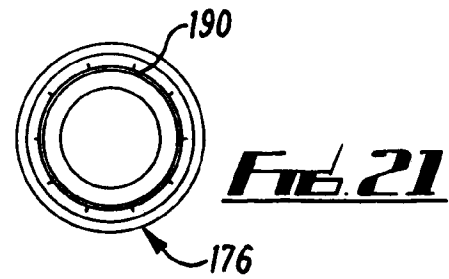
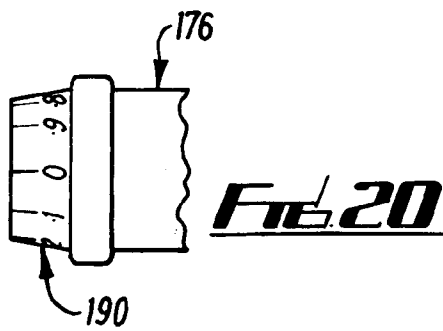
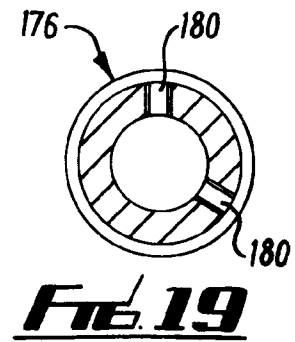
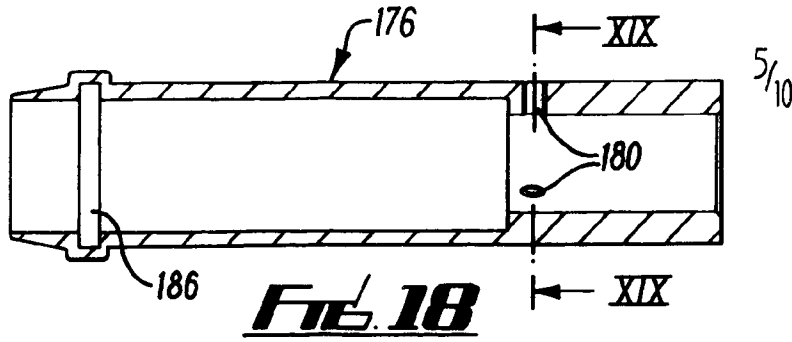


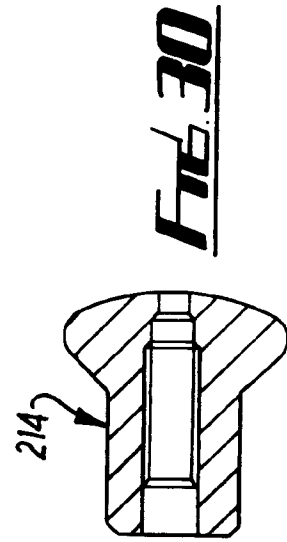
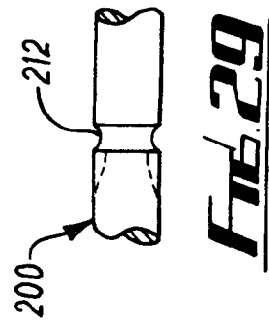
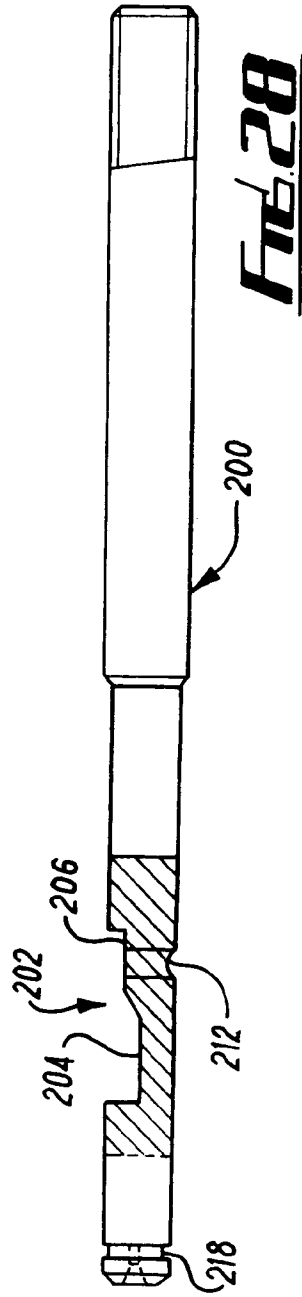
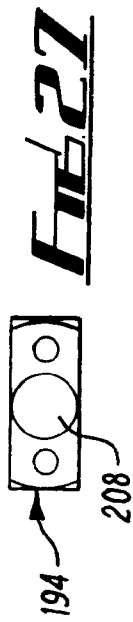
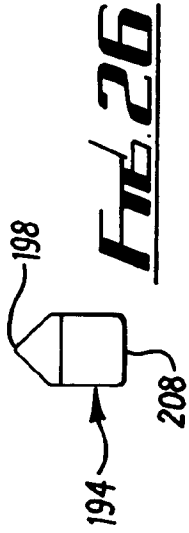
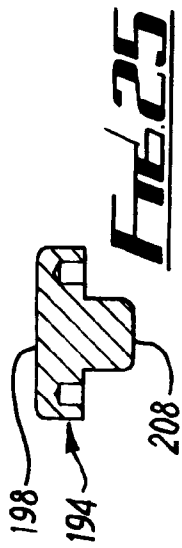
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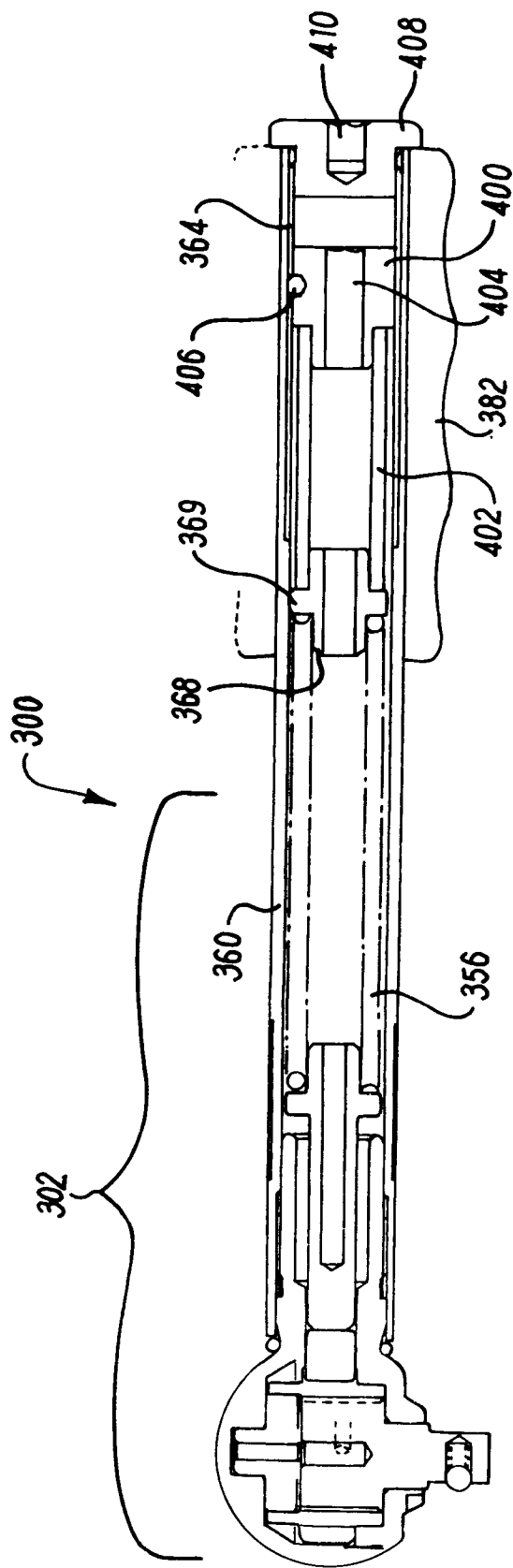
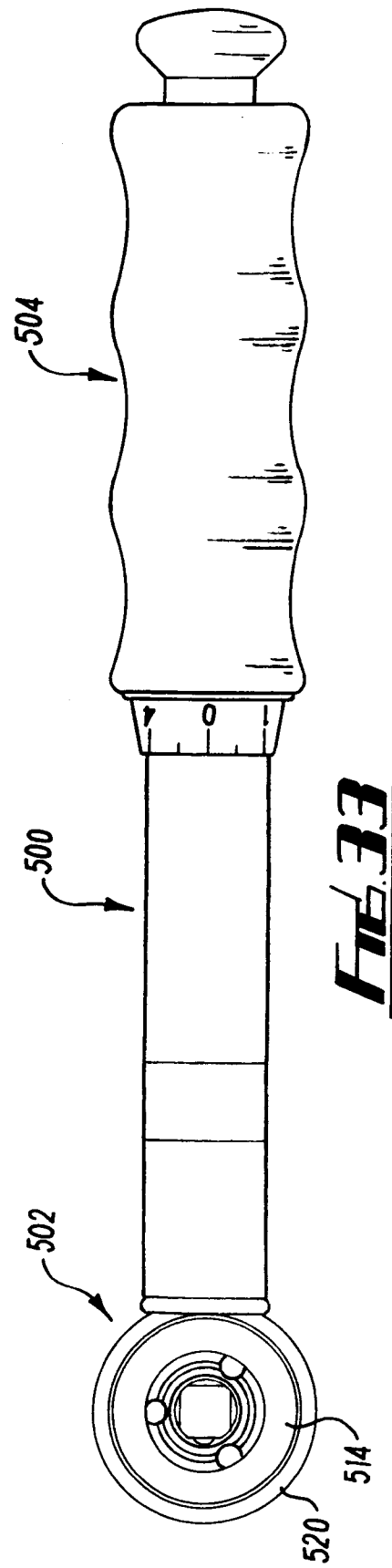
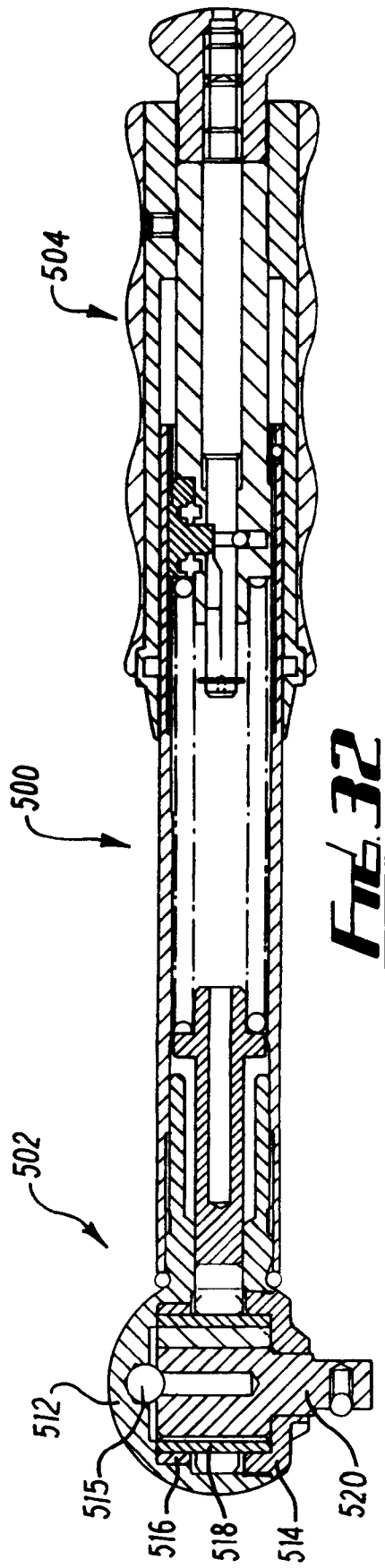
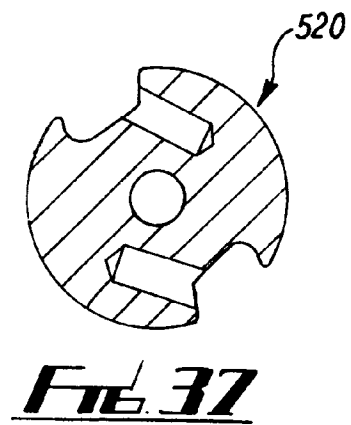
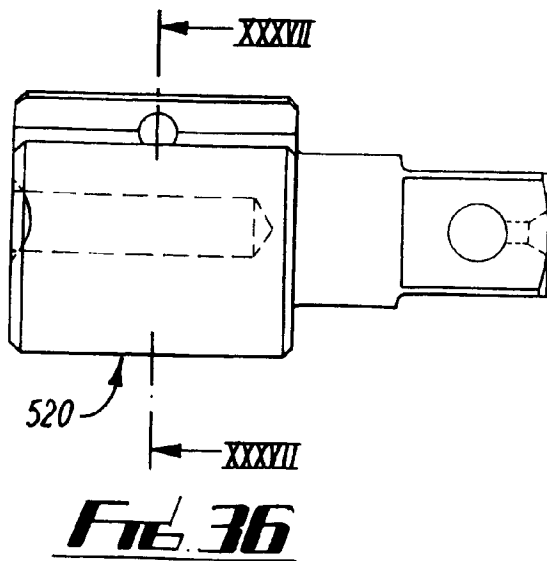
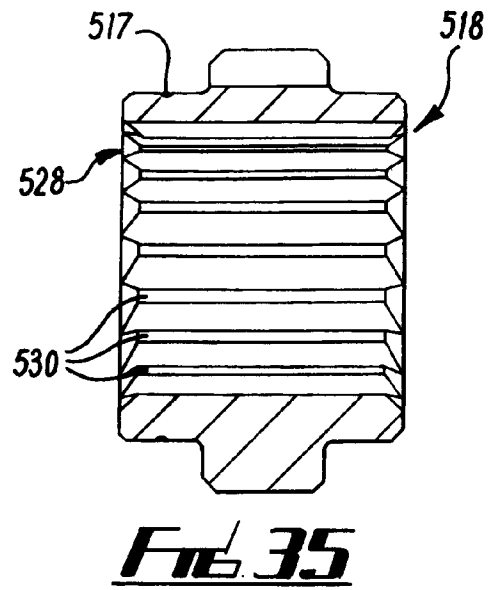
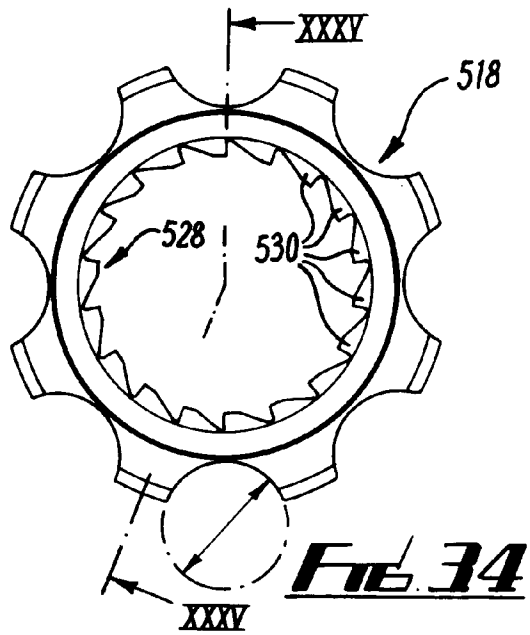
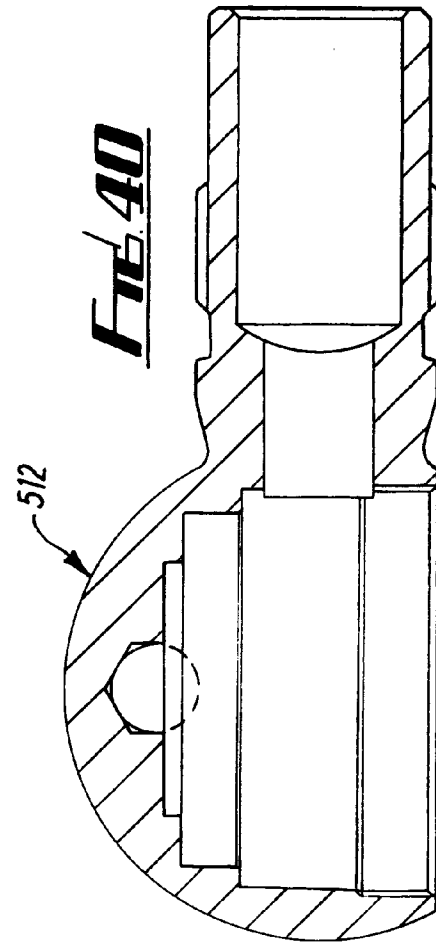
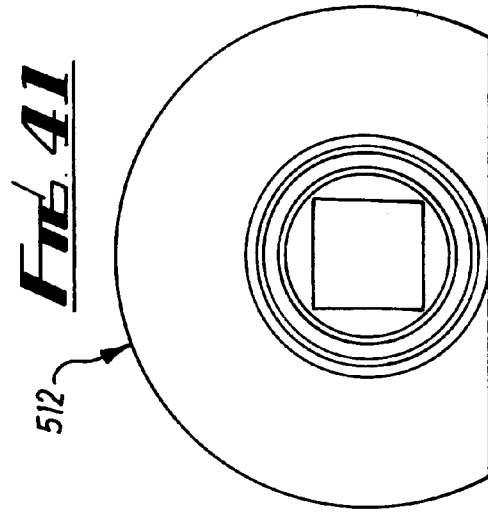
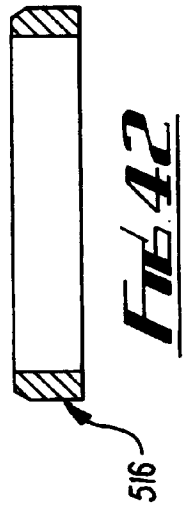
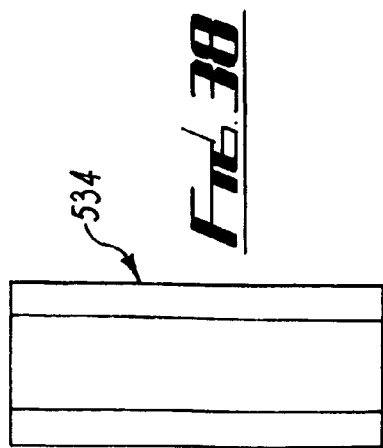


Fig. 31









European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 1217

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	DE-C-820 275 (ALBERT THODE & CO) * page 2, line 57 - line 121; figures 1-8,10,11 * * page 3, line 10 - line 15 * ---	1-10 11	B25B23/142
X	CH-A-275 537 (KEEN) * page 2, line 8 - line 43; figures * ---	1-7	
X A	US-A-1 860 871 (POULIOT) * claims; figures * ---	1-9 10,11	
X	FR-A-1 026 297 (GABÉ) * the whole document * ---	1-8	
X	FR-E-60 778 (TOURAND) * figures * ---	1	
X Y	GB-A-767 366 (DUBERNET) * the whole document * ---	11-13 14-17	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B25B
P,Y A	WO-A-94 05463 (SANDVIC) * the whole document * ---	14-17 11-13	
A	EP-A-0 274 576 (CONSOLIDATED DEVICES) * abstract; figures * ---	11-17	
A	US-A-4 485 703 (GRABOVAC ET AL) * abstract; figures * * column 10, line 12 - line 33 * ---	11-17	
D,A	GB-A-1 249 590 (M. H. H. ENGINEERING) * figures * -----	1,11	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 June 1995	Examiner Plastiras, D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			

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