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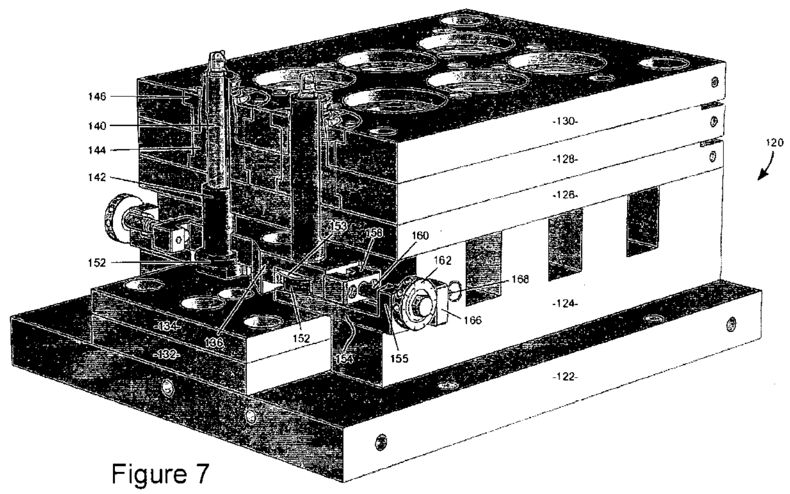

Figure 7

(57) Abstract: A manufacturing tool for use in an injection moulding machine to produce a moulded product, the manufacturing tool including first and second tool portions which attached to respective fixed and movable platens of the injection moulding machine so as to be relatively moveable along the machine axis between open and closed conditions in use. The first tool portion includes a mould cavity recess and the second tool portion includes a mould core which extends into the cavity recess when the tool is in the closed condition, the cavity recess and core together defining a mould cavity when closed to form the product when polymer material is injected therein. The product has a critical performance characteristic determined by an axial displacement between features of the cavity recess and core when the tool is in the closed condition.

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MOULDING TOOL MICROMETER ADJUSTMENT

This invention relates to a method and apparatus for fine adjustment of moulding tool parts used in the manufacture of moulded products from plastics and the like.

In the known art, an injection moulding machine comprises two parallel platens. A first platen is generally fixed in the machine, with the second platen movable along an orthogonal clamping axis toward and away from the first platen. An injection mould tool typically comprises first and second interfitting mould portions which attach to the first and second platens, respectively. In operation, the injection moulding machine and injection mould tool cooperate by closing together to form a closed mould into which molten polymer is injected under pressure to form injection moulded products. In the injection cycle, the platens move together to cause contact between opposing control surfaces of the injection tool and apply controlled clamping pressure to the mould areas.

The dimension of any detail within a moulded product is dependent directly on the dimension of the corresponding portion of the injection moulding cavity in the closed position. The degree of control of the detail within the moulded product is directly related to the variability of the dimension within the mould cavity at the critical moment in the injection moulding cycle.

In the known art of engineering manufacture, metal parts can be specified to any dimension, however the actual dimension of a metal part is variable, due to normal variation from causes such as material property, machinery wear, temperature and tool wear.

Injection mould tools typically comprise multiple components stacked together; thus the nominal dimension of each mating part must allow for normal variation of all adjacent parts.

Also, under the pressures and temperatures of injection moulding, deflection of large portions of the injection tool, and even of the machine platens themselves, can be sufficient to cause measurable differences in dimensions between multiple nominally identical parts in a multi-cavity injection tool.

Although very fine tolerance machining is possible, and a single part can be manufactured under controlled conditions to single digit micron tolerance, the practical art has tolerances in the ten micron range for each dimension.

Those skilled in the art of engineering manufacture, and specifically in the art of injection tool manufacture, will understand that a locational tolerance between the two portions (fixed and moving) of an injection tool of approximately 100 microns is the normal state of the art and is acceptable for most purposes.

For very fine tolerance injection moulded parts, the method of the current art comprises construction of the tool with the dimensional distance between critical parts lower than desired ("metal safe"), making injection moulded parts, then machining the critical tool parts until the desired dimensions are achieved.

This series of operations is very time consuming, and errors are easily made. It is also difficult to properly balance a multi-cavity tool by this method. Finally, a tool made by this method has every nominally identical metal part effectively custom made for it's location, Interchange of parts, or installation of spares, requires the whole commissioning process to be repeated.

It is also known in the art, that the moulding machine used to accommodate the injection tool can have varying clamp pressure (tonnage) used to compress the tool during the filling operation. Over time this pressure can compress the injection tool parts resulting in variation in steel dimension.

For these reasons, it is common to manufacture very fine tolerance parts in single cavity, or at least low cavitation tools to limit the complexity of tool manufacture and maintenance. This approach, however, adds cost and is not viable in commodity part manufacture.

In accordance with the present invention, there is provided a manufacturing tool for use in an injection moulding machine to produce a moulded product, the manufacturing tool including first and second tool portions which attached to respective fixed and movable platens of the injection moulding machine so as to be relatively moveable along the machine axis between open and closed conditions in use, wherein the first tool portion includes a mould cavity recess and the second tool portion includes a mould core which extends into the cavity recess when the tool is in the closed condition, the cavity recess and core together defining a mould cavity when closed to form the product when polymer material is injected therein, and wherein the product has a critical performance characteristic determined by an axial displacement between features of the cavity recess and core when the tool is in the closed condition, the second tool portion further comprising a precision position mechanism which can be manipulated by an operator with the tool in the injection moulding machine to axially advance or retract an adjustable part of the mould core so as to accurately determine said axial displacement and enable moulding of the product with the critical performance characteristic within a predetermined specification.

The invention generally provides a moulding tool having first and second tool portions movable to define a mould cavity with forming features to form a moulded product, the moulding tool including an adjustment mechanism coupled to positionally adjust the mould forming features in accordance with operator input.

In a preferred embodiment of the invention, the adjustment mechanism enables critical dimensions of moulded parts to be easily and rapidly adjusted in response to measurements of the quality of parts currently being produced. The tool of the preferred embodiment permits adjustments to be made to the mould area without disassembly of any part of the tool.

A tool in accordance with a preferred embodiment of the present invention comprises a multiple cavity injection moulding tool in which each cavity is provided with a separate adjustment mechanism. Each adjustment mechanism is individually accessible and controllable to effect positional control of the mould forming features in the corresponding mould.

The preferred injection moulding tool comprises a traditional first portion that contains the mould cavities and polymer flow channels and remains fixed to the stationary platen of the injection moulding machine, in use. The second portion of the tool comprises the mould cores, where all or part of the individual cores can be accurately advanced and retracted by an operator to control part quality. Preferably, the adjustment mechanism works in the direction of the injection tool opening/closing axis.

The adjustable portion of the core may be all of the core, a core pin, or a sleeve between an inner or outer, or an insert of any design. The choice of what portion of the core should be adjustable is based on part design and is not critical to the practice of the present invention.

In the preferred tool construction, the movable portion of the core retracts into the core portion of the injection tool under the influence of spring force, until the movable portion is retracted as far as possible.

Preferably retraction of each adjustable core part into the tool is limited by the back of each individual core portion being supported by an individual movable slide wedge. The movable slide wedges are supported by a common bearing plate. The common bearing plate may also be the back plate of the core portion of the injection tool.

The rear face of the adjustable core part and the bearing surface of the individual movable slide wedge preferably have matching taper angles. Adjustment of the relative position of the movable slide wedge thus changes the effective axial position of the individual core portion in a controlled fashion.

The movable slide wedge, and the retraction spring, acting in opposition, provide control over the position of the movable core portion, and thus control over the critical dimension of the injection moulded part.

The relative position of the movable slide wedge can be controlled by any suitable means. Preferably, the movable slide wedge is controlled by a micrometer adjustment that can be locked in known incremental positions by a suitable adjuster such as a dial indicator calibrated to provide a numerical adjustment. A preferred adjustment means comprises a fine thread screw actuating the movement of the movable slide wedge.

Preferably the taper angle of the mating surfaces is less than 25 degrees, more preferably less than 10 degrees, and most preferably between 2 and 7 degrees.

Preferably, the pitch of the screw adjuster is such that a rotation of the adjustment screw of greater than 30 degrees provides a movement of the core portion in the tool opening direction of less than 25 microns.

A preferred screw pitch is 1.25mm per rotation although any other convenient pitch may be chosen.

Most preferably, the relative selection of screw pitch, locking points of the dial indicator and taper angle of the slide wedge and core part achieves an adjustment step of approximately 10 microns, or approximately 10% of the optimum critical dimension of the part, whichever is the lesser.

In one form of the invention, the critical dimension of the moulded product effected by positional adjustment of the mould forming features has a measureable affect on a performance characteristic of the moulded product.

The present invention also provides a method of operation of a moulding tool incorporating an adjustment mechanism as described above, wherein a setting of the adjustment mechanism affects a performance characteristic of moulded product from the tool in use, comprising operating the moulding tool in a moulding machine to produce moulded product, measuring a performance characteristic of a sample of the moulded product, and altering the adjustment mechanism setting based on the performance characteristic measurement.

Preferably the adjustment mechanism is set by an operator whilst the tool remains installed in the moulding machine.

The operating method may include periodically sampling the moulded product, measuring the performance characteristic, and adjusting the setting based on the most recent measurement and optionally measurements from previous samples. Preferably the sample, test and adjust procedure is utilised to maintain measured performance of the moulded product within a predetermined range.

Preferably product from each mould in a multi-cavity tool is sampled and tested and the measurements used to select the adjustment settings of the respective mould cavities.

In practice, embodiments of the present invention allow the creation of injection moulded or compression moulded parts to finer tolerances than can effectively be made in a multi-cavity injection or compression tool by traditional techniques.

The adjustment mechanism of the preferred embodiment permits adjustment in the assembled injection tool to control critical finished part dimensions to tolerances preferably less than 100 micron, more preferably less than 50 micron, and most preferably less than 25 micron.

Other features and advantages of the present invention will be apparent from the following detailed description of the preferred embodiments.

The invention in its detail will be better understood by reference to the following description of an application thereof, salient features of which are also illustrated in the accompanying drawings with reference numerals, wherein:

Figure 1 is an upper perspective view of a moulded plastic closure product;

Figure 2 shows a central vertical section of the moulded product of Figure 1;

Figure 3 is an enlarged view of Section A from Figure 2;

Figure 4 shows a central vertical section through a moulding tool suitable for manufacturing the moulded product of Figure 1;

Figures 5(a) and 5(b) illustrate in section detail of the moulding tool parts and the adjustment range, showing the parts at minimum separation and wide separation respectively;

Figure 6 is a perspective view of a multi-cavity injection moulding tool, shown in section through two mould cavities fitted with adjustment mechanisms;

Figure 7 is a perspective view of the fixed (core) portion of the multi-cavity moulding tool, shown with some components cut-away to illustrate the core adjustment mechanism;

Figure 8 is a diagrammatic view of the core adjustment mechanism in elevation;

Figures 9 and 10 are side and end perspective views, respectively, of the core adjustment mechanism;

Figure 11 is an end view of the core adjustment mechanism screw adjuster and dial indicator; and

Figure 12 is a flowchart diagram outlining a process for operation of a multi-cavity tool with core adjustment.

A non-limiting example of a part requiring fine tolerance control of dimensions is the closure body described in the specification of Australian patent application AU2004205263. The closure 10, which is illustrated in upper perspective view in Figure 1, is injection moulded from a plastics material, and comprises generally a base portion 20 and a protruding removable portion 30. The base portion 20 includes an internally threaded skirt 22 (internal thread not visible in Figure 1) for securing the closure to a container, and optionally a tamper-indicating band structure (not shown) as is known in the art. The protruding removable portion 30 is attached to a top panel 24 of the base portion by a frangible ring 26 of thinned wall-section around the base of the protrusion. The thin section of material comprising the ring 26 must be continuous around the protrusion 30 in order to provide a seal, but must be thin enough to rupture upon a transverse breaking force being applied to the protrusion.

The frangible ring section is formed by moulding ring-shaped grooves into opposing surfaces of the closure body structure to create a ring of thinned wall section therebetween.

The moulded grooves and resulting thinned wall section can be best seen in Figures 2 and 3 which show the moulded closure in cross-section. In particular, Figure 2 shows the moulded product in central cross-section, including the threaded skirt 22 and top panel 24 of the base portion 20, and the centrally protruding removable portion 30 attached to the top panel 24 by the frangible ring 26. Figure 3 is an enlarged section through the juncture of the top panel 24 and removable protrusion 30, from which can be seen the profile of moulded upper and lower grooves 28, 29 between which is formed the frangible thinned-wall section 26.

The thickness of material in the frangible ring 26 determines the magnitude of breaking force required to snap the protrusion 30 away from the base portion 20 by rupturing the thin section of plastic. A thicker frangible ring will make the closure more secure but difficult to unseal. A thinner ring section, on the other hand, will allow the protrusion to snap off more easily, but care must be taken that the membrane forms completely during injection. As a result, the frangible ring 26 is significantly thinner in section than any other feature of the moulded closure body. In order to achieve reliable membrane formation and maintain snap-off break forces within a desired range, significantly lower manufacturing tolerances are required for the frangible ring section as compared to the rest of the closure body.

It will be understood by those skilled in the art that the permissible tolerance in the thicknesses of other portions of the closure body is generally in excess of 100 microns, and even in excess of 200 microns. Such tolerances are readily achieved by the application of the known art. It may be less well known, but readily understood by the skilled practitioner, that the required minimum dimension in the frangible ring 26 will be less tolerant of variation. In fact, ring wall thicknesses of less than 200 micron, or even less than 100 micron, will be required to meet performance specifications for the closure product. Tolerance levels of 100 micron, achievable by the known art, are unacceptable. Tolerances of less than 25 micron in this portion of the moulded product may be not merely desirable but essential for reliable manufacture.

In Figure 4 there is shown a central cut-away section through the mould cavity and surrounds of an injection moulding tool constructed to produce closures 10 as described above. The fixed and movable moulding tool portions are shown in Figure 4 in their closed configuration, defining a mould cavity 40. Reference numerals 42, 43 and 45 indicate the mould cavity features constructed to form the closure skirt, a top panel and a removable protrusion, respectively. The frangible membrane feature of the closure is formed in the mould as indicated at 44.

The fixed portion of the moulding tool includes a cavity block 110 which is provided with cavity forming features to shape the upper and outer surfaces of the product. The complementary, movable, portion of the moulding tool includes a mould core 140, 142, 144 with forming features detailed to shape the underneath and interior surfaces of the product. The mould core in this instance comprises three concentric core parts: a central core 140, an adjustable core sleeve 142 and an outer core 144. An injection nozzle 112 is arranged to inject molten liquid plastic material into the cavity 40 through the cavity block 110 at injection point 46.

Enlarged detail of the section 'B' from Figure 4 is shown in Figures 5(a) and 5(b) which illustrate the area of the mould cavity responsible for formation of the frangible ring 26. In this area of the mould cavity features 111 of the core sleeve are positioned very close to features 143 of the cavity block in order to form the thin, continuous membrane of plastic required to join the base and removable portions of the closure at the frangible ring. The mould cavity features 111 and 143 form the upper and lower grooves 28, 29, respectively (Figure 3). It is the separation of these features in the cavity region 44 during injection that determines the wall thickness of the frangible ring section 26 in the moulded product.

For the closure 10, the material thickness in the frangible ring 26 determines the break force required to snap off the removable portion 30 from the base 20. The internal mould dimension “t” representing the minimum separation during injection between the cavity block and core in the cavity region 44 determines the frangible ring wall thickness. To effectively control the dimension “t” in the moulding process, the tool is provided with a core adjustment mechanism which enables fine adjustment of the position of the core in the mould cavity, as described in detail hereinbelow.

A multi-cavity moulding tool 100 is shown in perspective view in Figure 6, with the tool in an open configuration showing the fixed mould portion 102 and the movable mould portion 120. The tool 100 is illustrated in section through two mould cavities, and has provision for a further six mould cavities which are vacant. The tool opens and closes, in use, in the directions indicated by arrow 115, which also defines the orientation of the mould core axes.

The fixed mould portion 102 comprises, at one end, a fixed platen attaching plate 104 which is used to secure the fixed mould portion to a moulding machine. A manifold holder plate 106 is secured to the platen attaching plate, and in turn supports a cavity plate 108. The cavity plate 108 receives cavity inserts 110 with mould cavity forming features directed toward the movable mould portion. An injector 112 carries liquid plastic material from the manifold to the mould cavity through the cavity insert 110.

The movable mould portion 120 is based on core backplate 122 which in use attaches to the moulding machine movable platen. Side rails 124 extend along the sides of the core backplate 122 upon which a core support plate 126, core holder plate 128 and stripper plate 130 are secured. Each mould core has a concentric stripper ring 146 which is received in the stripper plate 130. The mould core forming features project out from the centre of the stripper plate to extend into the mould cavity when the tool is closed, at which time the surface of stripper plate 130 lies adjacent the surface of cavity plate 108.

Between the side rails 124 there is a core holder plate 132 fastened to the core backplate 122. A retaining plate 134 is fixed atop the core holder plate. A bolster plate 136 is affixed to the retaining plate 134, beneath the core support plate 126.

Each mould core in this instance comprises three concentric core parts 140, 142, 144. The elongate central core 140 is machined with features to form the interior of the closure snap-off protrusion. The end of the central core 140 remote from the mould cavity is secured to the core backplate 122 by means of the core base plate 132 and retaining plate 134. The central core 140 extends through the centre of core sleeve 142, which in turn is sheathed by core insert 144 and stripper ring 146. The core insert 144 is machined with features to form the interior of the closure threaded skirt and top panel, and is fixed in the tool portion 120 by means of the plates 126, 128.

Referring to Figure 7 the tool portion 120 is shown in partial section of with some components cut-away to better illustrate the core sleeve 142 and related mechanics. The forming features 143 on the core sleeve are restricted to the cavity region 44 which controls the frangible membrane thickness. Thus, by enabling adjustable fine control of the relative axial position of the core sleeve with respect to the remainder of the core, control of the moulded membrane thickness can be achieved. The mechanism 150 for adjusting the axial position of the core within the tool is described and explained in greater detail below with reference also to Figures 8, 9 and 10. Figure 8 is a side elevation of one mould core in partial section showing also the core sleeve adjustment mechanism 150 with supporting structure partially cut-away. Figure 9 shows the core and adjustment mechanism with supporting structure partially cut-away, and Figure 10 shows the core and adjustment mechanism in isolation.

The elongate core sleeve 142 has its axis parallel to the opening/closing direction of the moulding tool. The core sleeve 142 extends from the mould cavity forming features 143 at one end, through the centre of core insert 144, and through core support plate 126 and bolster plate 136. The distal end of the core sleeve 142 is provided with a flange 152 which in use is received in a cavity formed in bolster plate 136 between retaining plate 134. Although the core sleeve is restrained by a close coaxial relationship with the central core and core insert, the flange base of the core sleeve within the bolster plate cavity affords the core sleeve a small amount of axial movement, as controlled by the adjustment mechanism 150. Compression springs 153 are located within the cavity occupied by flange 152 which act between the bolster plate cavity and the surface of flange 152 facing the mould. The springs 153 provide a suitable axial bias force against the flange surface in a direction away from the mould cavity. This results in a bias on the movable core sleeve towards its fully retracted position.

The adjustable core sleeve 142 can be advanced from its fully retracted position progressively further into the mould cavity by action of a slide wedge 154. The slide wedge 154 extends through an aperture provided in side rail 124, perpendicularly to the core axis, and is supported on the retaining plate 134. A bifurcated end of the slide wedge extends and into the bolster plate cavity on each side of the central core and beneath the flange 152. The bifurcated end of the slide wedge is machined with a small planar taper on its surface facing the flange 152, and the corresponding surfaces of the flange 152 are constructed with a matching planar taper angle.

A wedge block 158 is fixed to the bolster plate 136. A portion of the slide wedge 154 projects out from the side rail 124 and terminates in a dial flange 156. A threaded bolt 160 extends through a hole in the flange 156 and parallel to the slide wedge, toward the core axis. The bolt 160 is threadedly engaged with wedge block 158 which itself is fixed to bolster plate 136. As best seen in Figure 8, the matching tapered surfaces of the slide wedge 154 and sleeve flange 152 bear against one another in a plane 155 that is inclined slightly in a direction toward the slide wedge screw flange 156.

A dial 162 is coupled for rotation with the bolt 160 wherein rotation of the dial, depending on the direction, effects a lengthening or shortening of the distance between screw flange 156 and wedge block 158 by action of the threaded engagement between bolt and wedge block. With a conventional right-handed bolt thread, clockwise rotation of the dial 162 shortens the exposed bolt length, forcing the slide wedge further underneath the sleeve flange 152. By virtue of the tapered bearing surfaces between the slide wedge and sleeve flange, such movement of the slide wedge causes corresponding axial displacement of the core sleeve. This results in the core sleeve forming features advancing a small amount in the direction of the mould cavity, against the bias action of springs 153. Conversely, anti-clockwise rotation of the adjustment dial 162 causes the slide wedge to move in the opposite direction to allow the core sleeve to axially retract by a corresponding amount.

The dial 162, shown particularly in Figure 11, is mounted at the head of bolt 160 adjacent the slide wedge flange 156 and faces outwardly from the side of the tool 100. The dial is calibrated into ten equal rotational intervals marked by numbered indicia 163 corresponding to radial holes 164 formed around the edge of the dial. The holes 164 allow the dial to be locked into place at each rotational interval by means of a pin with pull-ring 168 which can align with the holes through pin block 166 attached to the slide wedge flange 156 adjacent the dial periphery.

Numbered indicia 161, in the centre of the dial, represents the individual mould core to which the adjustment mechanism applies, such as in the typical application of a multiple cavity moulding tool where each core has a separate adjuster. The dial rotational intervals 163 are marked "1" to "10" and can be aligned by rotation of the dial with an indicator mark 165 on the pin block 166 whereupon the pin 168 is aligned with and able to engage a corresponding hole 164 to hold the dial in place.

An alternative scale for the adjustment mechanism could be achieved by allowing the dial any rotational position and providing scale markers on the slide wedge 154 which can be referenced to a fixed point on the side rail 124, for example. An alternate form of locking the dial in position would then be appropriate.

The amount of axial displacement of the core sleeve relative to the degree of rotation of the dial 162 is determined by the pitch of the thread on the bolt 160 and the taper angle of plane 155. Geometrically, if the wedge taper angle is represented by θ and the bolt thread pitch is represented by p (millimetres per rotation) the core sleeve displacement, d (mm), can be determined by $d = p \cdot \tan(\theta)$. For example, with a taper angle of five degrees and a thread pitch of 1.25 millimetres per rotation, the core sleeve will advance or retract by (1.25*tan(5°)) or approximately 110 microns for each complete rotation of the dial 162. Using a dial calibrated in ten equal intervals, each advancement of the dial from one mark to the next will result in axial advancement of the core sleeve by approximately 11 microns.

In the example of the plastic closure 10 with snap-off protrusion 30, moulding tool 100 has adjustable core sleeves 142 to allow the axial position thereof to be finely adjusted with the tool in service. Fine control of the core sleeve position enables fine control over the thickness of material in the frangible ring membrane 26 of the resulting moulded closure. The force required in use of the closure 10 to snap off the protrusion 30 from the base 20 is affected by the thickness of the frangible ring 26 in the manufactured product. Through manipulation of the core adjustment mechanisms it is therefore possible to maintain the snap-off break force of moulded closures within an acceptable range from multiple cavities over an extended period of service of the tool. A process for operation of the tool 100 in such a manner is outlined in the flowchart diagram of Figure 12 and is also discussed briefly below.

The general tool operating process 300 illustrated in Figure 12 begins at step 302 with the commissioning of a new multi-cavity moulding tool and installation for operation in a suitable moulding machine. Each mould core in the tool is equipped with a means for positioning the core sleeve as described hereinabove, incorporating an adjustable dial.

A tool calibration procedure begins with step 303, wherein the tool is operated in the moulding machine to produce moulded products for calibration of the core adjustment mechanisms. A representative sample of moulded products are collected from each mould core over a range of adjustment dial settings. This can be accomplished, for example, by operating the tool through a series of fifty cycles for each dial setting within the calibration range, and randomly selecting ten of the product from each mould cavity for each dial setting.

The selected samples (e.g. ten moulded closures from each tool cavity for each core dial setting) are tested at step 304 to measure functional performance. In the case of the closure with snap-off protrusion, a functional performance measurement may involve the use of a test jig to hold the closure base 20 in place while applying a transverse force to the protrusion 30. The amount for force required to be applied to the protrusion in order to break it away from the base gives a measure of the closure performance, and is ideally within an acceptable break force range. The measured break force data is correlated against the dial settings to determine a relationship between dial setting and measured break force for each tool cavity (step 305). This information is stored as break force calibration data 320.

For operation of the tool, an adjustment dial setting for each cavity is selected (step 306) utilising the break force calibration data 320 with reference to a predetermined acceptable break force range 325 which may be specified by the operator. For example, each adjustment dial might typically be set corresponding to those break force calibration measurements falling closest to the centre of the predetermined break force range.

In the operational procedure of the process 300, at step 310 the tool is continuously cycled using the selected dial settings, producing manufactured product 330. The manufactured product is periodically sampled at 312 by a random selection of product from each mould cavity. The sampled product is tested at 314 to gain a measure of the snap-off break force for closures from each cavity.

As discussed, there are a number of reasons for a manufacturing tool changing in characteristics over extended use. Sometimes this is manifested in, over time, a variation in the relative axial positions of the forming features 111 on the mould cavity and features 143 on the core sleeve (Figure 5(a)). As a result, the measured snap-off break force for closures produced by the tool may also vary over time or during extended operation.

Ideally, the measured snap-off break force for every closure produced by the tool should be within the acceptable break force range. Under this premise, if any of the tool cavities yield closures with break force measurements that are outside the acceptable break force range then the tool operation is paused whilst the the corresponding core sleeve is adjusted by indexing of the dial as indicated by the calibration data (step 316). New samples from the relevant tool cavity should be immediately re-tested once the tool operation has re-commenced to ensure compliance with the break force range.

Similarly, by comparing the measured snap-off break force for closures from the same tool cavity against the calibration data or over different sampling periods, the dial settings can be adjusted at step 316. to ensure closures produced by each tool cavity remain within the predetermined acceptable range 325. For example, if the measured break force on closures from a given cavity rises, from one sampling period to the next, from the centre of the acceptable range to high in the range, the corresponding adjustment dial may be indexed to advance the core sleeve to effect a reduction in the mould cavity in the region 44 (Figure

5(b)). This should result in a reduction in the measured snap-off break force for closures from that cavity once manufacturing operation re-commences.

Advantageously, the functional performance of the manufactured product from the tool can be maintained within an acceptable performance range by periodic sampling, testing, and adjustment of the tool forming features, whilst the tool remains in commission. The adjustment dials for each of the tool cavities are accessible from the sides of the tool whilst installed in a moulding machine, for easy manipulation by an operator.

The present invention is not limited to the manufacture of any particular item. The use of a closure body for illustration is not limiting, and any injection moulded part requiring close tolerance control is within the scope of the present invention.

Many modifications may be made to the described embodiments without departing from the spirit and scope of the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A manufacturing tool for use in an injection moulding machine to produce a moulded product, the manufacturing tool including first and second tool portions which attached to respective fixed and movable platens of the injection moulding machine so as to be relatively moveable along the machine axis between open and closed conditions in use, wherein the first tool portion includes a mould cavity recess and the second tool portion includes a mould core which extends into the cavity recess when the tool is in the closed condition, the cavity recess and core together defining a mould cavity when closed to form the product when polymer material is injected therein, and wherein the product has a critical performance characteristic determined by an axial displacement between features of the cavity recess and core when the tool is in the closed condition, the second tool portion further comprising a precision position mechanism which can be manipulated by an operator with the tool in the injection moulding machine to axially advance or retract an adjustable part of the mould core so as to accurately determine said axial displacement and enable moulding of the product with the critical performance characteristic within a predetermined specification.

2. A manufacturing tool as defined in claim 1, wherein the precision position mechanism comprises a movable slide wedge that supports the adjustable part of the mould core against a spring bias, wherein the movable slide wedge is controllable by a micrometer adjustment that can be locked in known incremental positions.

3. A manufacturing tool as defined in claim 1, wherein the moulded product has a frangible membrane comprising a thinned wall-section the formation of which is defined by said axial displacement, and wherein the critical performance characteristic relates to a force required to rupture the frangible membrane in the moulded product.

4. A manufacturing tool as defined in claim 1 or 2, wherein the adjustable part of the mould core comprises the entire mould core.

5. A manufacturing tool as defined in claim 1 or 2, wherein the adjustable part of the

mould core comprises a sleeve portion of the mould core.

6. A manufacturing tool as defined in claim 1, 2 or 3 wherein said axial dispacement is adjustable by use of the precision position mechanism in increments of 10 microns or less.

7. A manufacturing tool as defined in any of claims 1 to 6, including multiple moulding cavities each of which is individually adjustable by a respective precision position mechanism.

8. A method of operating a manufacturing tool as defined in any of claims 1 to 7, including operating the manufacturing tool in a moulding machine to produce moulded product, measuring a critical performance characteristic of the moulded product, and manipulating the precision position mechanism based on the measured performance characteristic.

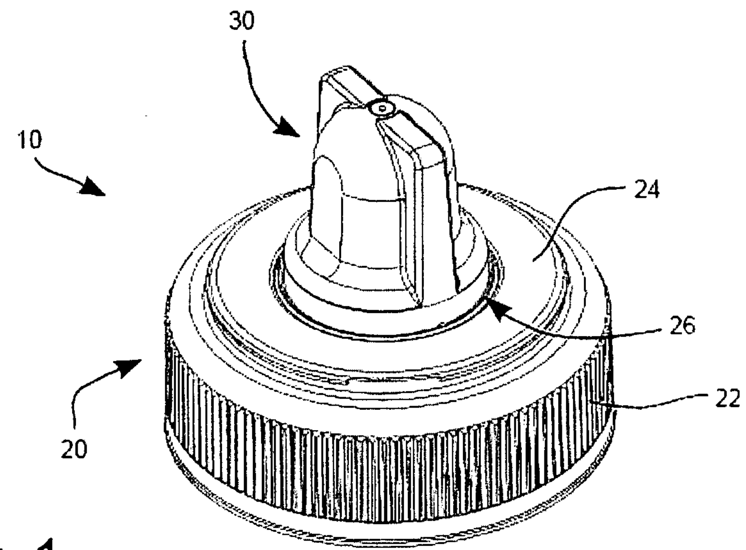


Figure 1

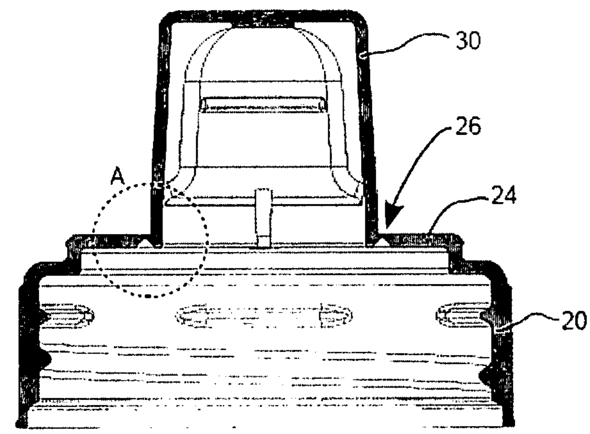


Figure 2

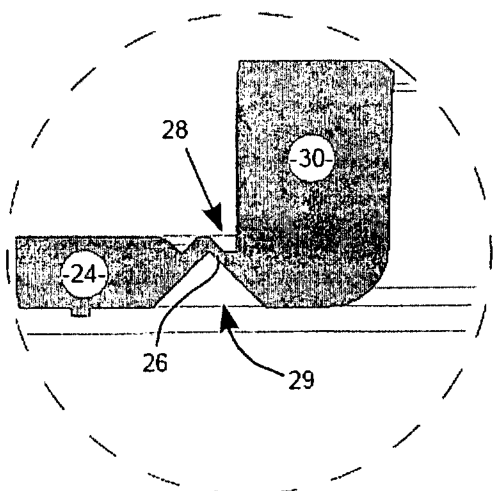
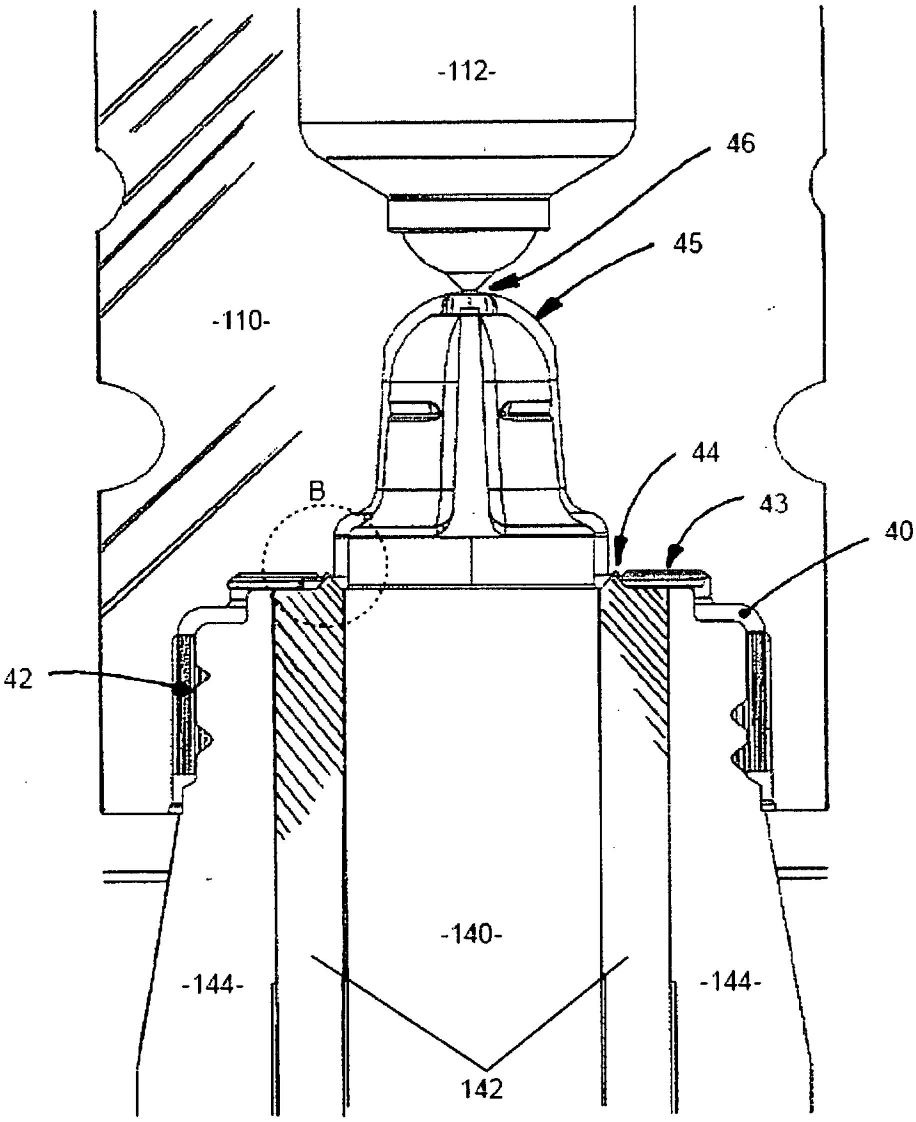


Figure 3



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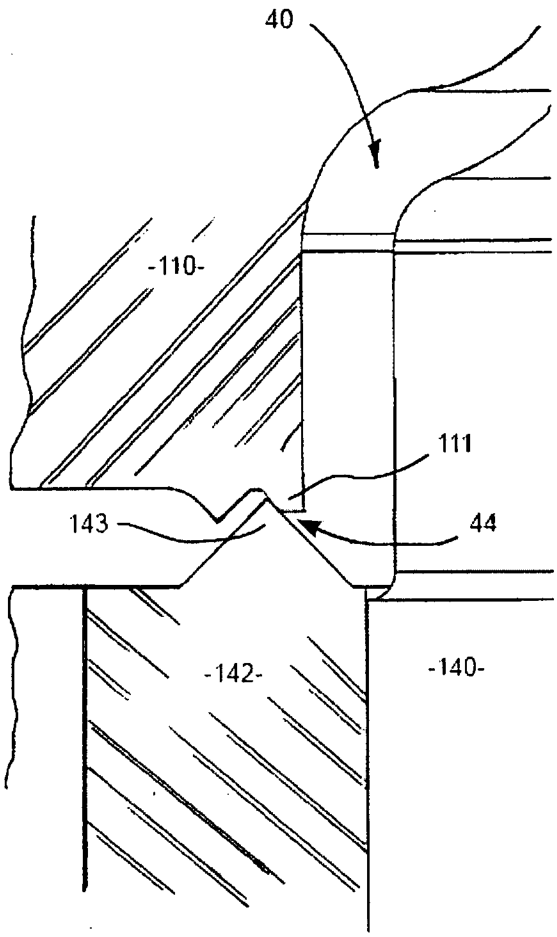


Figure 5(a)

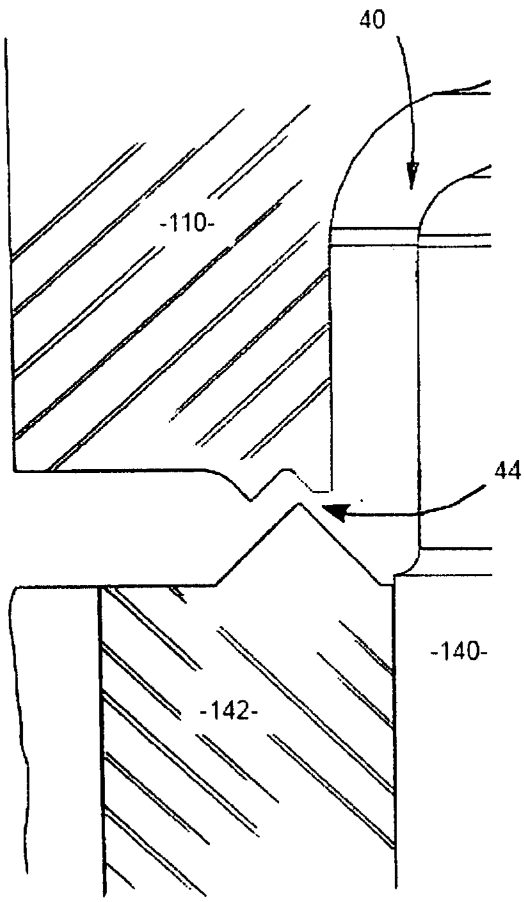
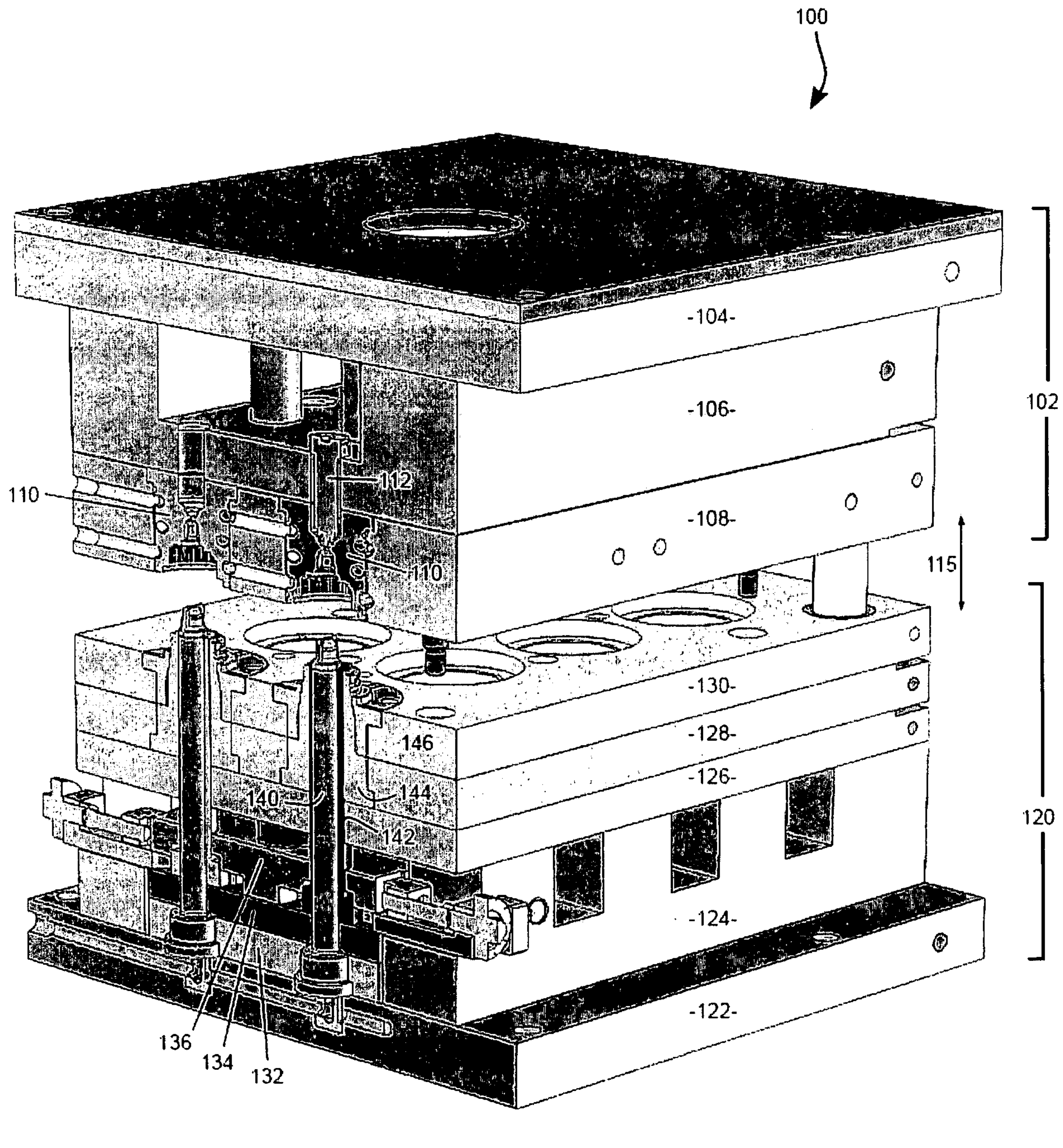


Figure 5(b)

Figure 6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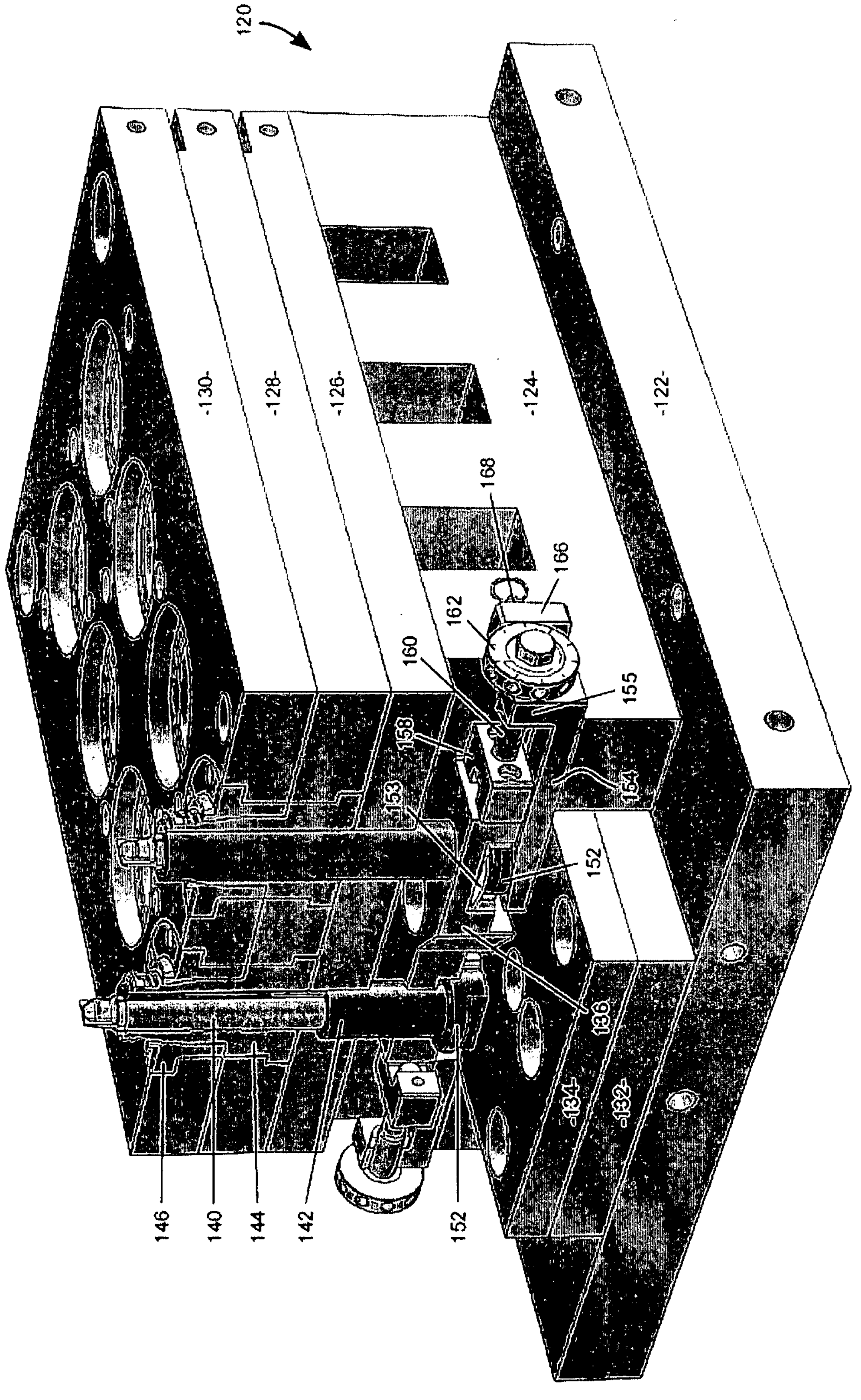
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Figure 7

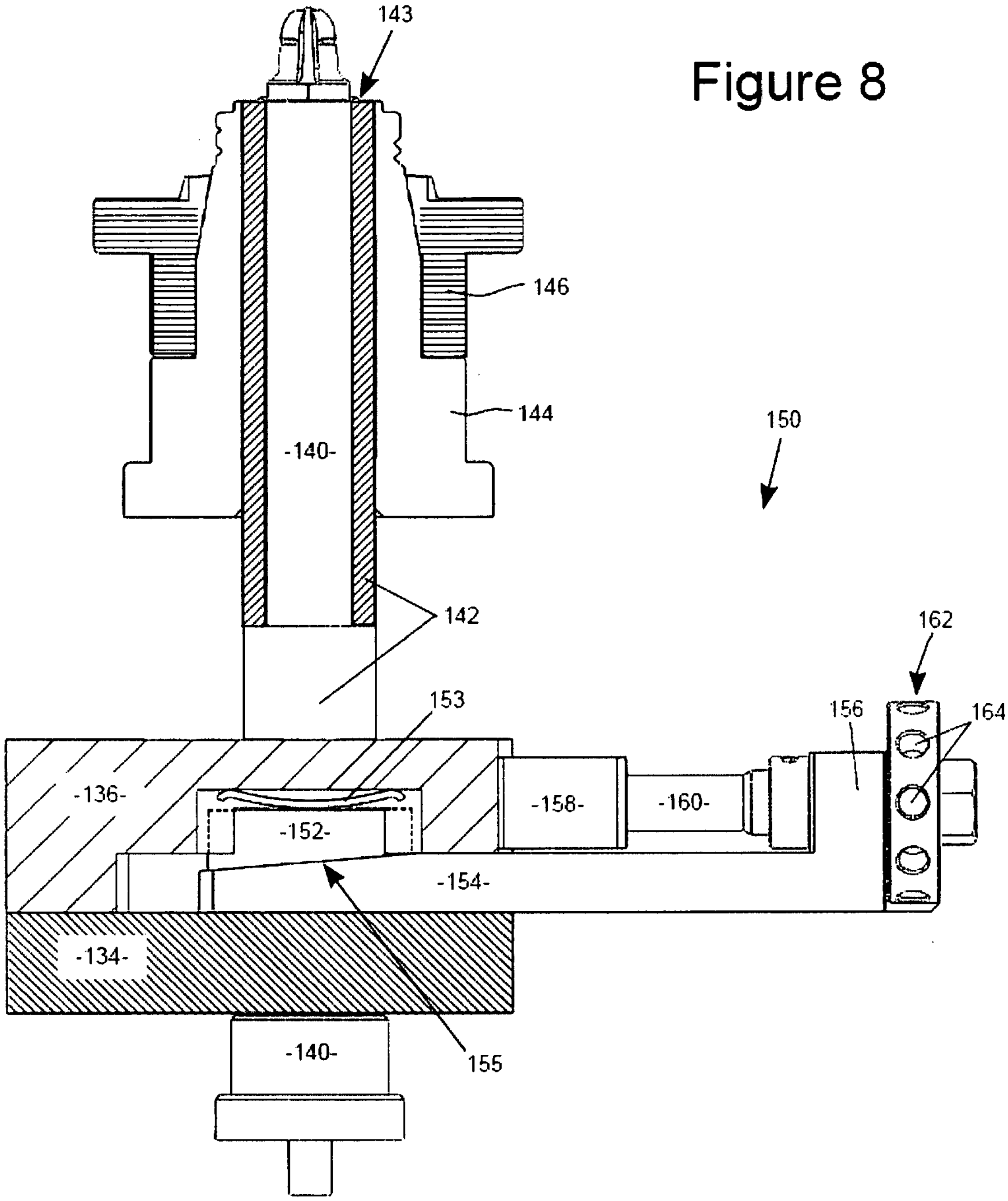
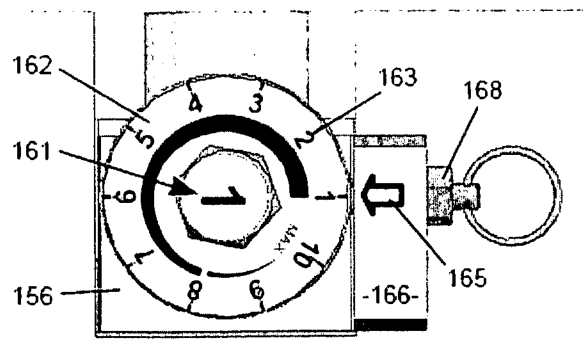


Figure 8



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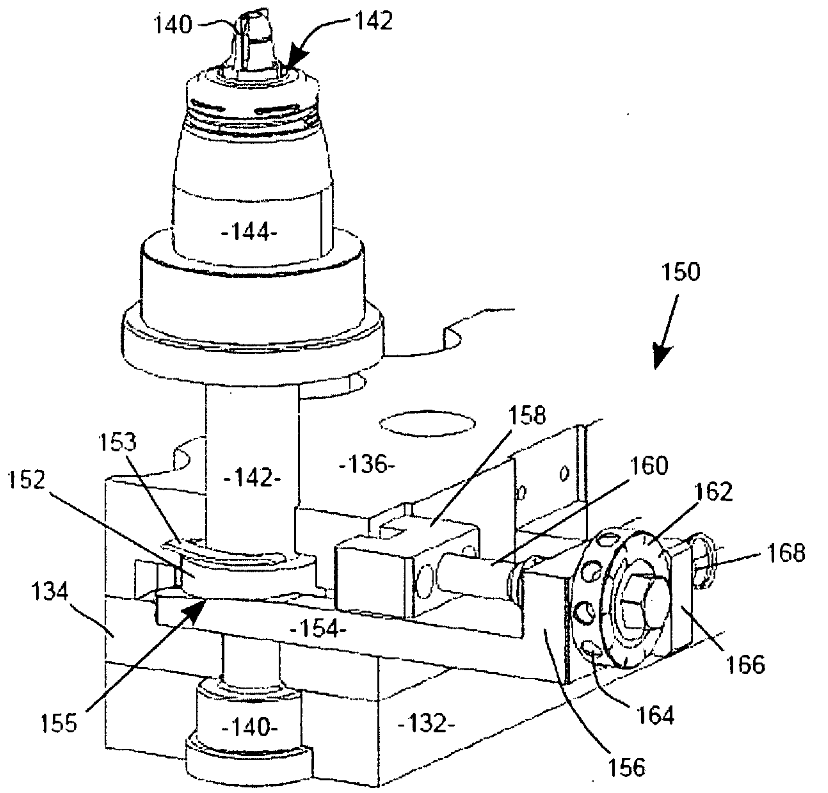

Figure 9

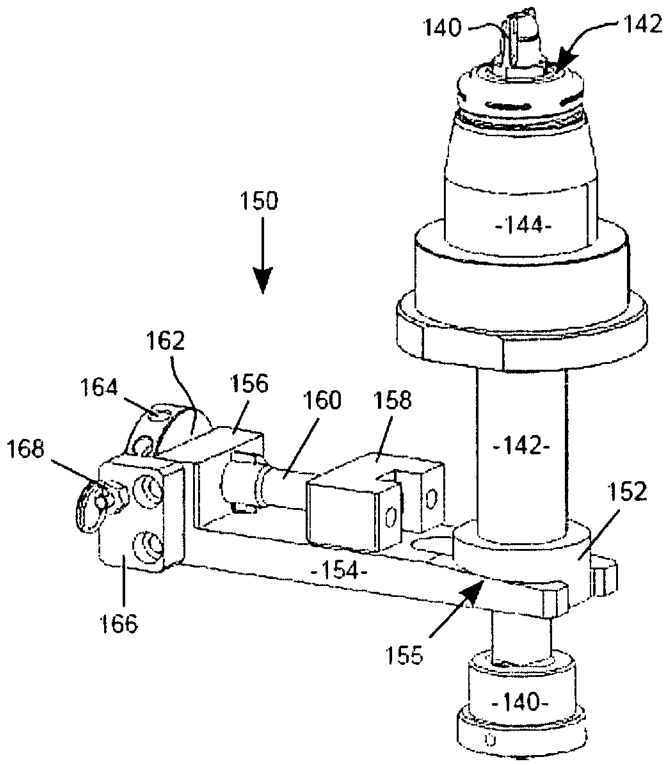

Figure 10

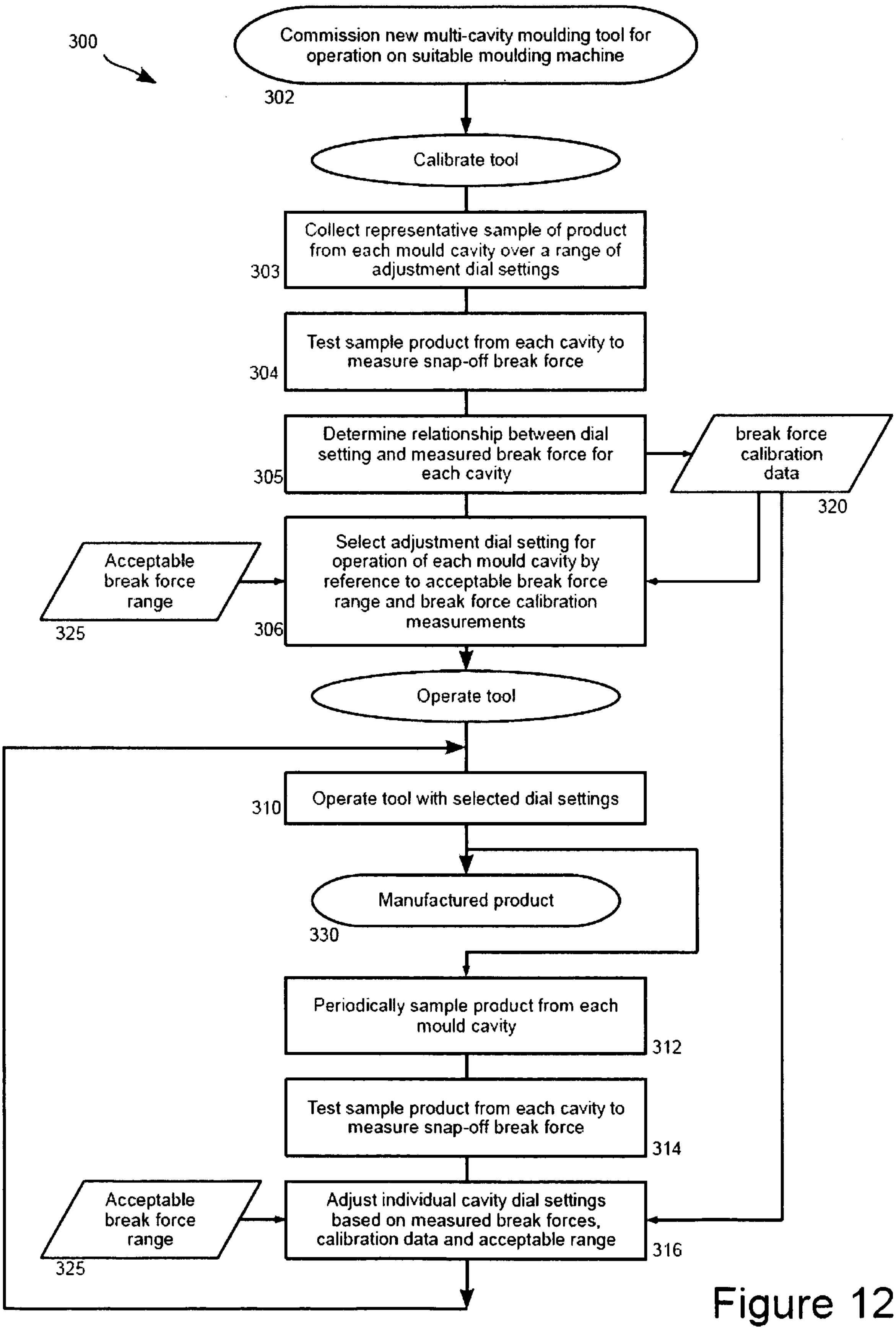
300
Commission new multi-cavity moulding tool for operation on suitable moulding machine
302
Calibrate tool
Collect representative sample of product from each mould cavity over a range of adjustment dial settings
303
Test sample product from each cavity to measure snap-off break force
304
Determine relationship between dial setting and measured break force for each cavity
305
break force calibration data
320
Acceptable break force range
325
Select adjustment dial setting for operation of each mould cavity by reference to acceptable break force range and break force calibration measurements
306
Operate tool
Operate tool with selected dial settings
310
Manufactured product
330
Periodically sample product from each mould cavity
312
Test sample product from each cavity to measure snap-off break force
314
Acceptable break force range
325
Adjust individual cavity dial settings based on measured break forces, calibration data and acceptable range
316

Figure 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2008/001128

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

B29C 45/66 (2006.01) *B29C 45/80* (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI; IPC Marks - B29C 45/03, B29C 45/17, B29C 45/64, B29C 45/66, B29C 45/80; Key Words - MICRO+, +METER+, ADJUST+, POSITION+, GAP+, CLEARANC+, PRECIS+, ACCURAT+;

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6875384 B1 (WHITNEY) 5 April 2005 See Abstract and col. 4 line 40 to col. 5 line 50	1, 4, 8
X	US 7232303 B1 (DOOLEY ET AL.) 19 June 2007 See Abstract, Fig. 6 and col. 6 line 15 – line 46, col. 1 line 31 – 51	1, 4, 5
A	US 4747982 A (NAKATSUKASA ET AL.) 31 May 1988 See Abstract	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search
30 September 2008

Date of mailing of the international search report
03 OCT 2008

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C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent Abstract Accession No. 87-288964/41, Class P53, JP 62-202718 A (KOBE STEEL KK) 7 September 1987 See Abstract	
A	US 2003/0141632 A1 (FULLER ET AL.) 31 July 2003 See Abstract	2
A	Derwent Abstract Accession No. 94-303935/38, Class P53, DE 4310791 A1 (SAECHSISCHE KUNST GMBH) 29 September 1994 See Abstract	
A	Patent Abstracts of Japan, JP 63-035326 (CANON INC) 16 February 1988 See whole abstract	
A	Patent Abstracts of Japan, JP 2001-212859 (TOYO MACH & METAL CO LTD ET AL.) 7 August 2001 See whole abstract	
A	Derwent Abstract Accession No. 98-273734/25, Class A35, M22, DE 29802894 U1 (SICK WERK SOYCK AG) 14 May 1998 See Abstract	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	6875384	NONE			
US	7232303	US	2007141197		
US	4747982	JP	62202718		
US	2003141632	EP	1321272	DE	10161911
DE	4310791	NONE			
JP	63035326	NONE			
JP	2001212859	NONE			
DE	29802894	NONE			

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX