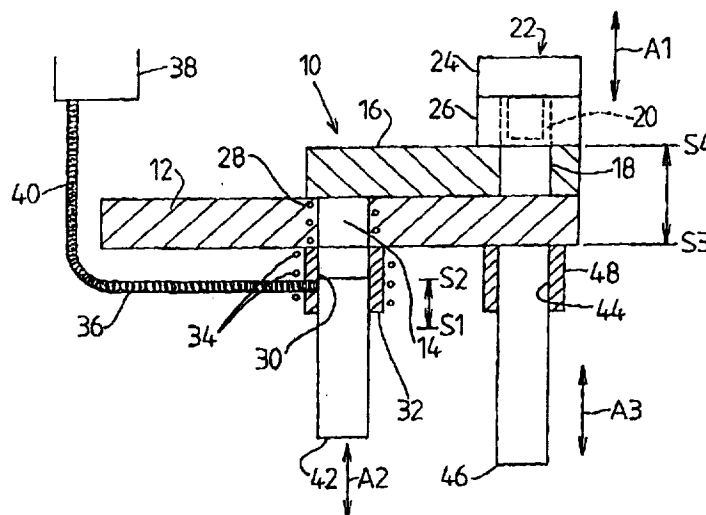




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(21) International Application Number: PCT/US97/15673 (22) International Filing Date: 5 September 1997 (05.09.97) (30) Priority Data: <table border="0"> <tr> <td>96/7509</td> <td>5 September 1996 (05.09.96)</td> <td>ZA</td> </tr> <tr> <td>97/4923</td> <td>4 June 1997 (04.06.97)</td> <td>ZA</td> </tr> </table> (71) Applicant (for AL only): HANDELMAN, Joseph, H. [US/US]; 26 West 61st Street, New York, NY 10023 (US). (71) Applicant (for BF BJ CF CG CI CM GA GH GN KE LR LS ML MR MW NE SD SL SN SZ TD TG UG ZW only): HUMAN SHAFT MOULDING JOINT VENTURE (PROPRIETARY) LIMITED [ZA/ZA]; 90 Rivonia Road, Sandown, Gauteng Province 2196 (ZA). (71) Applicant (for all designated States except AL BF BJ CF CG CI CM GA GH GN KE LR LS ML MR MW NE SD SL SN SZ TD TG UG US ZW): INTERNUNTUM INTERNATIONAL LIMITED [-/-]; Town Mills, Trinity Square, P.O. Box 134, St. Peter Port, Guernsey GYL 3HN (GB). (72) Inventor; and (75) Inventor/Applicant (for US only): HUMAN, Jan, Petrus [ZA/ZA]; 21 Muller Street, Paarl, Western Cape 7646 (ZA).		96/7509	5 September 1996 (05.09.96)	ZA	97/4923	4 June 1997 (04.06.97)	ZA	(74) Agents: HANDELMAN, Joseph, H.; Ladas & Parry, 26 West 61st Street, New York, NY 10023 (US) et al. (81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>With amended claims.</i>
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(54) Title: PRODUCTION OF MOULDED ARTICLES AND APPARATUS FOR PRODUCING MOULDED ARTICLES

**(57) Abstract**

Moulding apparatus is disclosed which comprises transfer element (12) which has a holding cavity (14) therein for receiving a charge of mouldable material. Mouldable material in particulate or molten form is fed into a heated passage (30) by a feed spiral (40) in a tube (36). A plunger (42) displaces molten mouldable material along the passage (30) and into the holding cavity (14). The transfer element (12) is then displaced to a position in which the holding cavity (14) is aligned with an opening (18) in a backing plate (16). The opening (18) is in communication with a mould cavity (20) having the shape of the article to be produced. A second plunger (46) displaces the charge of molten mouldable material from the holding cavity (14) through the opening (18) and into the mould cavity.

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PRODUCTION OF MOULDED ARTICLES AND
APPARATUS FOR PRODUCING MOULDED ARTICLES

FIELD OF THE INVENTION

THIS INVENTION relates to the production of moulded
5 articles and to apparatus for producing moulded articles.

BACKGROUND TO THE INVENTION

A number of different techniques are in commercial use and
by means of which articles are manufactured using synthetic plastics
materials.

10 The most common technique is that of injection moulding.
Injection moulding is capable of producing intricate articles. Because of
the high pressure which is required, an injection moulding machine must
be of very substantial strength. Likewise, the moulds that are used must
also be capable of withstanding high internal pressures.

15 A form of moulding which does not require such high
pressure is known as compression moulding. In this method a shot of
molten synthetic plastics material is fed into the cavity of a female mould
part. A male mould part is then pressed into the female mould part, the
volume of the cavity decreases and the synthetic plastics material is
20 forced to take-up the shape of the space remaining between the two
mould parts. The pressure generated in the cavity is lower than that
used in injection moulding. The technique is widely used for products
such as bottle caps where short cycle times and high production volumes
are required. This technique is limited insofar as the shapes that it can
25 produce are concerned. For example, it cannot make components with
undercuts.

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If a component is to have a constant cross section throughout then it can be extruded. Extrusion involves the use of a die through which the molten synthetic plastics material is forced. This technique can, of course, only be used where the article is of constant cross section throughout. It is thus used for producing tubes, strips and bars.

A further known technique is thermoforming. This technique involves placing a heated and hence softened sheet of synthetic plastics material between two moulds and then closing the moulds to conform the sheet to the shape of the moulds. In some versions of this technique vacuum is applied to the underside of the sheet to assist in drawing it down into the lower mould.

There is a need in the plastics industry for a technique which, whilst being able to mould all the shapes that can be achieved by injection moulding, has the ability to produce articles in larger volumes and of larger size than injection moulding can.

Increasing use is being made in industry of ceramics, of sintered metal and of composite materials filled with carbon and glass fibres and the present invention seeks to provide a new method of producing components using these materials. Injection moulding is not a method that can be used with filled plastics as the fibres can block the so-called pin gates through which the material flows into the mould.

A current method of making components from ceramics uses an injection moulding procedure but this procedure can only make small components.

BRIEF DESCRIPTION OF THE INVENTION

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According to one aspect of the present invention there is provided moulding apparatus comprising a transfer element bounding a holding cavity for mouldable material, a passage leading to said holding cavity, means for displacing mouldable material along said passage and
5 into said holding cavity whilst said transfer element is in a first position, means for displacing said transfer element between said first position and a second position, and a plunger for urging said mouldable material out of said holding cavity and into a moulding cavity whilst said transfer element is in its second position.

10 The apparatus preferably includes heating means for heating said holding cavity and also means for heating said passage.

The mouldable material can be supplied in molten form to said passage. However, it is preferred that the apparatus include means for supplying mouldable material in particulate form to said passage, and
15 that the material be melted in the passage.

In one form the apparatus includes means for reciprocating said transfer element along a rectilinear path between said first and second positions. In this form said transfer element can have at least one bore therein for receiving a reciprocable pin which has a camming
20 surface that is skew to the direction in which the pin reciprocates, said surface bearing on said transfer element as the pin is inserted into the bore to cam said transfer element in one direction between said positions, and means for displacing said transfer element in the other direction between said positions as the pin is withdrawn from said bore.

25 In another form of apparatus said transfer element is a shaft having a transverse bore forming said holding cavity, said shaft being within a sleeve having first, second and third circumferentially

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spaced openings in the walling thereof, the first of said openings forming part of said passage, the second of said openings in use placing the holding cavity in communication with a mould cavity and said third opening permitting said plunger to enter said holding cavity, the second
5 and third openings being diametrically opposed, said sleeve closing-off said holding cavity on the opposite side thereof to said first opening when said shaft is in its first position, and means for turning said shaft to displace it between said first position in which the first opening is in communication with the holding cavity and said second position in which
10 said holding cavity is aligned with said second and third openings.

To enable the mouldable material to remain in the passage for a sufficient time to melt, the volume of said passage can exceed the volume of said holding cavity whereby the passage can contain a sufficient volume of mouldable material to fill the holding cavity a number
15 of times.

Preferably the moulding apparatus includes a plurality of holding cavities in said transfer element, a plurality of passages, a plurality of means for displacing mouldable material along said passages and into said holding cavities, and a plurality of plungers for urging
20 mouldable material out of said holding cavities and into one moulding cavity or into a plurality of moulding cavities. In this form the holding cavities can be of different volumes.

In a specific form of moulding apparatus said transfer element is constituted by a disc mounted for turning about its centre and
25 having a plurality of holding cavities therein, there being a first plurality of reciprocable plungers constituting said means for moving mouldable material along the passages and into said holding cavities whilst said disc is in said first position, and a second plurality of reciprocable

plungers for urging said mouldable material out of said holding cavities and into one moulding cavity or into a plurality of moulding cavities.

According to a further aspect of the present invention there is provided a method of moulding which comprises displacing mouldable
5 material into a holding cavity whilst the holding cavity is in a first position, moving said holding cavity from said first position to a second position, and discharging the mouldable material from the holding cavity into a mould cavity whilst the holding cavity is in said second position.

The method can include the steps of moving a first plunger
10 in a forward stroke along a passage to displace said mouldable material from said passage into said holding cavity, moving the holding cavity to said second position, moving said first plunger in a return stroke, displacing a second plunger in a forward stroke to discharge mouldable material from said holding cavity into said mould cavity, moving said
15 second plunger in a return stroke, and moving the holding cavity back to its first position.

Preferably mouldable material is fed into said passage after said first plunger has performed its return stroke. The mouldable material is preferably fed to said passage in particulate form and the
20 method includes the step of heating the mouldable material in said passage. It is also desirable to heat the mouldable material in said holding cavity.

Preferably the method includes displacing mouldable material into a plurality of holding cavities, and discharging said
25 mouldable material from said holding cavities into one moulding cavity or into a plurality of moulding cavities.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:-

5 Figures 1 and 2 diagrammatically illustrate the operation of a first form of moulding apparatus in accordance with the present invention;

 Figures 3 and 4 illustrate the operation of a second form of apparatus in accordance with the present invention;

 Figure 5 is a diagrammatic pictorial view of moulding apparatus in
10 accordance with the present invention;

 Figure 6 shows components of one of the structures of the apparatus of Figure 5;

 Figure 7 shows some of the components of Figure 6 viewed from the other side;

15 Figure 8 is a pictorial view of a structure in which synthetic plastics material pellets are melted;

 Figure 9 is a pictorial view of the structure of Figure 8 seen from the opposite side;

 Figure 10 is an exploded view of an hydraulically operated
20 mechanism;

 Figure 11 is a further exploded view of the hydraulically operated mechanism;

 Figure 12 is a pictorial view of part of a material feed system;

 Figure 13 is a diagrammatic representation of the apparatus;

25 Figure 14 is a diagrammatic representation of a further form of apparatus; and

 Figure 15 illustrates, to a larger scale, a detail of the apparatus of Figure 14.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring firstly to Figure 1, the apparatus 10 illustrated comprises a transfer element which is in the form of a plate 12 with a holding cavity 14 in it. The apparatus further includes a backing element which is in the form of a plate 16 having an opening 18 therein. The opening 18 leads into a mould cavity 20 bounded by a mould 22 having a male mould part 24 and a female mould part 26. The female mould part 26 is fixed to the plate 16 and the male mould part 24 is displaceable between mould open and mould closed positions as indicated by the double headed arrow A1.

10 Embedded in the plate 12 are heating elements 28 which heat the holding cavity 14. The cavity 14 is in communication with a passage 30 constituted by a sleeve 32 which is surrounded by heating elements 34. A tube 36 leads from an overhead hopper 38 to the passage 30, there being a spiral 40 in the tube 36. In use the spiral 40 is rotated so as to feed mouldable material in particulate form from the hopper 38 to the passage 30. The elements 34 melt the mouldable material and the elements 28 ensure that it remains in molten form whilst in the holding cavity 14.

20 A plunger 42 is displaceable in forward and return strokes as shown by the double headed arrow A2. The length of the plunger's stroke is shown between lines S1 and S2. When the front face of the plunger has moved back to S1, particulate material is fed into the passage 30. As the front face of the plunger moves from S1 to S2, a charge of mouldable material is moved along the passage 30 and into the holding cavity 14.

The apparatus further includes a second passage 44 along which a second plunger 46 moves as shown by the double headed arrow A3. The stroke of the plunger 46 is shown between the lines S3 and S4.

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The passage 44 is constituted by a fixed sleeve 48.

The means for reciprocating the plungers can be hydraulic cylinders or pneumatic cylinders rotatable cams or cams which reciprocate and have inclined cam faces.

5 The sleeves 32 and 48, the plate 16 and the female mould part 22 are fixed and carried by a frame (not shown) of the apparatus.

In the position shown in Figure 1 the plunger 42 is shown in its forward position in which it has moved a charge of mouldable material along the passage 30 and into the holding cavity 14. The force exerted
10 by the plunger 42 is sufficient to pack the holding cavity 14 with molten mouldable material and expel all the air therefrom.

The plunger 46 is in its retracted position at S3. In this position its front face is just clear of the face of the plate 12.

The mould parts 24 and 26 are urged against one another
15 to form the mould cavity 20.

The plate 12 is then displaced to the right from the position shown in Figure 1 to the position shown in Figure 2. The holding cavity 14 moves from the position in which it is aligned with the passage 30 to a position in which it is aligned with the passage 44. The portion of the
20 plate 12 to the left of the cavity 14 closes-off the outlet end of the passage 30. The plunger 42 retracts to the position S1 after the passage 30 has been blocked-off by the plate 12 and the spiral 40 feeds mouldable material along the tube 36 and into the passage 30. The heating elements 34 melt the mouldable material in the passage. This
25 material is preferably a synthetic plastics in particulate form.

Immediately the holding cavity 14 is aligned with the passage 44 and opening 18, the plunger 46 moves in its forward stroke to urge the charge of mouldable material out of the holding cavity 14, through the opening 18 and into the mould cavity 20. The front face of
5 the plunger 42 stops at S4 and forms part of the bounding wall of the cavity 20.

Once the charge of material has solidified in the mould cavity 20, the plunger 46 retracts to the position shown at S3 and the mould parts separate. The plate 12 returns to the position shown in
10 Figure 1 and thereafter the plunger 42 advances so as to re-charge the holding cavity 14 with molten mouldable material and thus start the next cycle.

The passage 30 is of sufficient length to contain, for example, sufficient mouldable material to fill the holding cavity about
15 thirty times. This ensures that the mouldable material is in the passage long enough to melt. There can also be mixing and plastification devices in the passage as well as venting means for ensuring that the mouldable material which reaches the holding cavity has been mixed
homogeneously and is vapour free. Such devices are well known in the
20 injection moulding art and will not be described in more detail herein.

In the moulding apparatus of Figures 3 and 4 the transfer plate is in the form of a rotatable shaft 50 and the backing plate is in the form of a sleeve 52. The shaft 50 has a transverse bore 54 which forms the holding cavity 14.1. The shaft 50 is within the sleeve 52 and the
25 sleeve has three circumferentially spaced openings 56, 58 and 60. In the illustrated form the openings 58 and 60 are diametrically opposed and at right angles to the opening 56.

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Further components which are illustrated in Figures 3 and 4 and which are equivalent to components in Figures 1 and 2 have been designated with the same reference numerals plus the suffix ".1".

5 The plunger 42.1 forces molten mouldable material along the passage 30.1 and into the bore 54.

As soon as the holding cavity constituted by the bore 54 is packed with mouldable material, the shaft 50 is rotated through 90 degrees. This aligns the bore 54 with the openings 58 and 60, the plunger 46.1 then being advanced from its retracted position at S3 to its
10 forward position at S4 thus displacing the charge into the mould cavity. The plunger 46.1 withdraws as soon as the plastics material in the mould has solidified, the shaft 50 is rotated back to its starting position and the cycle is repeated. It is understood that Figures 3 and 4 are only
15 illustrative and that the volume of the bore 54 is greatly exaggerated in relation to the capacity of the mould cavity 20.

The moulding apparatus shown in Figure 5 comprises a series of plates 62, 64, 66, 68 and 70 which are held together by rods 72 which act both as tie rods and guide rods. The plates are shown more widely spaced than they actually are to reveal more of the construction.
20 The rods 72 pass through the plates close to the corners thereof. A structure generally designated 74 is mounted on the plate 68. The plate 66 carries a structure 76 which melts the synthetic plastics material to be moulded, the material reaching the structure 76 from an overhead hopper 78 by way of a number of tubes 80. Only five tubes 80 are shown.
25 However, in this form of apparatus there are eight tubes 80.

The structure 82 feeds molten plastics material from the structure 76 to the structure 74. An operating mechanism for the

structure 82 is designated 84.

A cylinder 86 mounted on the plate 62 serves to rotate one of the components of the structure 74, and the moulds into which the molten synthetic plastics material is forced are mounted on that side of the plate 70 which is hidden in Figure 5.

The structure 74 (see Figures 6 and 7) comprises front and rear steel plates 86 and 88, front and rear intermediate steel plates 90 and 92, and a rotatable disc 94. The plates 90 and 92 and disc 94 can be of "Teflon" (polytetrafluoroethylene) or another synthetic plastics material such as "PEEK" (polyetheretherketone) or a metal or an alloy with a low co-efficient of friction.

The rear plate 88 has a central hole 96 in it and a ring of sixteen through bores 98. It also has openings 100 through which studs can be passed. The front plate 86 has a ring of eight through bores 102 and openings 104 for receiving studs.

The intermediate plate 92 has a ring of sixteen through bores 106, each bore being co-axial with a hollow boss 108. There is a recess 110 in the face of the plate 92, the depth of this recess being half the thickness of the disc 94. A central hole 112 is also provided in the plate 92.

The plate 90 also has a ring of through bores 114 but this ring of bores comprises only eight bores. Bosses 116 protrude from that face of the plate 90 which lies adjacent the plate 86 and are co-axial with the bores 114. A recess 118 (Figure 8) similar to the recess 110 in the plate 92 is provided in the face of the plate 90 opposite to that from which the bosses 116 project.

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The disc 94 has a ring of sixteen bores 120 and also has a central non-circular central bore 122.

The plates 86 and 88 have recesses 124 and 126.

The structure of Figures 6 and 7 is assembled by placing
5 the intermediate plate 92 in the recess 126 of the plate 88 so that the
bosses 108 pass through the bores 98. The bosses 108 project from the
bores 98 on the opposite side of the plate 88 to that on which the plate
92 is positioned. The disc 94 is then inserted into the recess 110 of the
plate 92. At this stage half the thickness of the disc 94 projects from the
10 recess 110. The plates 86 and 90 are assembled in the same way as
the plates 88 and 92, the bosses 116 passing through the bores 102 and
projecting therefrom. Studs, which can either be separate elements or
can be fixed to various plates, are passed through the openings 100 and
104 to clamp the plates 86 and 88 together with the plates 90 and 92
15 and disc 94 between them. The portions of the plates 90 and 92 which
encircle the recesses provided therefor in the disc 94 form rims which
abut one another and the disc 94 is free to rotate in the cavity provided
therefor by the recesses 110 and 118.

The entire structure 74 is then pressed into the recess 128
20 in the plate 68. As seen in Figure 6, the plate 68 has an array of sixteen
through bores 130 which receive the bosses 108. The plate 68 also has
a central opening 132.

The structure 76 (Figures 8 and 9) is in the form of a
cylindrical metal block 134 having a central hole 136 and a ring of eight
25 larger diameter through bores 138 and eight smaller diameter through
bores 140. The bores 138 and 140 alternate with one another.

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Each larger diameter bore 138 is partly plugged at one end by a short bar 142 of copper or other material having external flutes 144. The bars 142 are force fitted into bores 138. As best seen in Figure 8, the bars 142 protrude from one face of the block 134. The flutes 144

5 define passages and permit moulding material to be forced from the rear parts of the bores 138 into the structure 74 as will be described in more detail hereinafter. The projecting bars 142 fit in alternate bosses 108 of the plate 92. Heating elements 146 encircling the outer surface of the block 134 and heating elements 148 encircling the hole 136 are provided

10 for raising the temperature of the block 134.

Turning now to Figures 10 and 11, the structure 82 and mechanism 84 include a first cylinder 150 which has a cylindrical side wall 152 and an end wall 154. Sixteen through bores 156 are provided in a circular array in the end wall 154. The end wall 154 also has a

15 central hole 158.

A piston 160 comprising a piston disc 162 and eight equally spaced plungers 164 protruding from one face thereof fits into the cylinder 150. The plungers 164 pass through alternate bores 156 in the end wall 154. Alternating with the plungers 164 are through bores 166

20 provided in the disc 162. The disc 162 also has a central hole 168. Sealing means (not shown) encircle the disc 162 to seal between it and the cylinder side wall 152.

A second cylinder 170 also comprises a cylindrical side wall (designated 172) and an end wall (designated 174). There is a central

25 hole 176 in the end wall 174 and in addition there is an array of eight equally spaced through bores 178 in the end wall 174.

A second piston 180 comprising a piston disc 182 with eight

equally spaced plungers 184 fits in the cylinder 170. The disc 182 also has a central hole 186. The sealing means between the disc 182 and the side wall 172 of the cylinder 170 have not been shown. The plungers 184 pass through the bores 178 of the end wall 174, through
5 the bores 166 of the disc 162 and through alternate bores 156 of the end wall 154.

A third cylinder 188 is also provided, the cylinder 188 having a cylindrical side wall 190 and an end wall 192. The end wall 192 has a central hole 194 therein. A piston 196 including a disc 198 with a
10 stub shaft 200 protruding from the centre of one face thereof fits into the cylinder 188. The shaft 200 has spiral splines 202. The sealing means between the disc 198 and the wall 190 have not been shown.

A shaft 204 (not shown in Figure 10) passes through the central holes 194, 186, 176, 168, 158, 96 and 112 and enters the bore
15 122 of the disc 94. The end of the shaft 204 is of the same non-circular shape as the bore 122. The shaft 204 has an internally grooved socket 206 which receives the stub shaft 200. The shaft 204 can rotate but is restrained from moving axially.

A cover plate 208 (Figure 10) closes off the cylinder 188.

20 There are further sealing means where the shaft 204 passes through the end walls 154, 174 and 192 of the cylinders 150, 170 and 188. There are also sealing means where the plungers 184 pass through the bores 166 and 178 and where the plungers 164 and 184 pass through the through bores 156 in the end wall 154.

25 Inlets for hydraulic fluid under pressure are provided in the cylindrical side walls 152, 172, 190. This enables hydraulic fluid under

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pressure to be supplied to opposite sides of the piston discs 162, 182, 198 so that the pistons can be reciprocated in their cylinders.

Between the rear face of the block 134 and the front face of the end wall 154 of the cylinder 150 there is a small gap. Bridging this gap are sixteen tubes 210 (Figure 12) each of which has a side entrance 212 for synthetic plastics material pellets. The tube 210 is stepped externally to form a spigot 214. Each entrance 212 has one of the feed tubes 80 connected thereto and each feed tube has a spiral therein for feeding pellets along the tubes to the entrance from the hopper 78 to which the other ends of the tubes are connected. Feed systems of this type are commercially available and will not be described in more detail herein. One such system is known as the "Transitube" system.

The spigots 214 fit into the rear ends of the bores 138.

Turning now to Figure 13, this diagrammatically illustrates the structures 74 and 76 as well as the mechanism 82. It also illustrates a cavity plate 216 and a core plate 218. The Figure is diagrammatic in that certain bores are shown out of position and certain components are shown juxtaposed whereas in fact they are separated by spaces.

The cavity plate 216 has therein a ring of eight cavities 220 each of which has for illustrative purposes the external configuration of a bottle cap. The plate 216 is fixed with the entrances to the cavities 220 in register with the bosses 116 of the plate 90.

The plate 218 is reciprocable towards and away from the plate 216 and carries a ring of eight cores 222 which move into and out of the cavities 220. The cores 222 have the same shape as the inner configuration of a bottle cap. Each includes a pin for forcing a moulded

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bottle cap off the core and, depending on the internal configuration of the cap, may be collapsible.

In use the spirals in the feed tubes 80 are switched on so that pellets of synthetic plastics material are fed to the tubes 210 which
5 bridge between the structures 74 and 76. Simultaneously the heating elements 146, 148 of the block 134 are switched on to raise the temperature of the block to a level sufficient to melt the pellets.

Hydraulic fluid is fed under pressure to the rear face of the piston 160 so that the piston 160 moves along the cylinder 150. The
10 plungers 164 slide through the end plate 154 and into the pellet filled tubes 210 forcing the pellets into the parts of the bores 138 behind the bars 142. Several strokes of the piston 160 are required at start up to fill the bores 138 with plastics material as the bores 138 each have a capacity many times that of the bores 120. The material in the bores
15 138 softens as the block 134 heats up.

Once the bores 138 are full, the next forward stroke of the plungers 164 forces molten plastics material along the flutes 144, through alternate through bores 98 and into the through bores 120 of the disc 94.

At this stage the through bores 120 in the disc 94 are
20 aligned with those through bores 106 in the intermediate plate 92 through which the plungers 164 slide but these bores of the disc 94 are not aligned with the through bores of the plate 90. Thus alternate through bores in the disc 94 are each filled with a charge of plastics material. This charge is equal in volume to the volume of the final product.

25 The plungers 164 are retracted by feeding hydraulic fluid to the other side of the piston 160. The plungers 164 withdraw sufficiently

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far to clear the entrances 212 to the tubes 210 so that the spirals can feed further pellets into the tubes 210. Thus in use each reciprocation of the plungers 164 feeds eight charges of material into eight of the through bores 120 in the disc 94.

5 Whilst both the plungers 164 and 184 are withdrawn, hydraulic fluid is fed to the one side of the piston disc 198. The shaft 200 thus moves in a forward stroke or a rearward stroke. The splines 202 on the shaft cause the shaft 200 to rotate through twenty two and a half degrees. This is sufficient to rotate the disc 94 to a position in which
10 the empty through bores 120 in the disc 94 are aligned with the bores in the plate 92 through which the plungers 164 slide and are closed-off by the plate 90. Simultaneously the filled through bores 120 in the disc 94 are aligned with the bores 114 in the plate 90.

On the next forward stroke of the plungers 164 the empty
15 through bores 120 of the disc 94 are filled with molten material.

The plungers 184 move further in the forward direction than do the plungers 164 as they have to pass through all the plates 86, 88, 90 and 92 and also through the disc 94. The plungers 184 are at this time aligned with those through bores 120 of the disc 94 which were
20 previously filled with molten plastics material. This is because the disc 94 has been rotated to bring the filled bores 120 into alignment with the plungers 184.

The cores 222 are at this time in the cavities 220 and the plate 218 clamped by hydraulic pressure to the plate 216.

25 Hydraulic fluid under pressure is then supplied to the rear face of the piston 180 to force the piston 180 and plungers 184 in a

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forward stroke. The plungers 184 slide through the aligned through bores in the plates 86, 88, 90, 92 and disc 94 until the leading ends of the plungers 184 are flush with the interface between the plate 86 and the plate 92. The charge of molten material is thus forced into the cavity
5 220, put under moulding pressure and moulded to shape. The front faces of the plungers 184 form parts of the walls of the cavities.

The plungers 184 are then withdrawn by feeding hydraulic fluid to the other side of the piston 180. The plungers 184 only have to be withdrawn until their leading ends are just clear of the disc 94. As
10 soon as this stage has been reached the shaft 204 is rotated through 22.5 degrees in the opposite direction by feeding hydraulic fluid to the other side of the piston disc 198. This brings eight further charges of molten synthetic plastics material into alignment with the plungers 184, and eight now empty through bores in the disc 94 into alignment with the
15 plungers 164.

The cycle described is then repeated.

As the plungers 184 withdraw, the cores 222 withdraw into the plate 218, having previously collapsed if this is the type of core used. Simultaneously, the plates 216 and 218 separate to enable the moulded
20 product to be ejected by means of the ejector pins. The plates 216 and 218 then move together and are clamped, the cores 222 move into the cavities 220 and the plungers 184 move in the forward direction once more to force eight further charges of plastics material into the cavities 220.

25 Instead of there being ejector pins carried by the cores 222, the arrangement can be such that the caps remain in the cavities 220 and are ejected by portions of the plungers 184 which move forward at

the end of the moulding cycle.

If an air feed pipe is provided down the centre of each plungers 184 and into the respective cavity, the molten synthetic plastics material can be blown to a hollow shape.

5 It is also possible for each plungers 184 to be hollow over a short part of the length thereof just behind the front face that forms part of the wall of the cavity. The hollow interior of the shaft is connected to the cavity by a multitude of small holes. Pins within the hollow interior of the shaft normally block off these holes. The hollow interior of each shaft
10 is connected to a source of colouring material under pressure. Means are provided for withdrawing the pins from the holes for a brief period at the end of each moulding cycle so that the colouring material can squirt through the holes onto the top surface of the formed cap.

By appropriately arranging the small holes, a design and/or
15 words can be "painted" onto the exterior of the face of the cap in the manner of a dot matrix.

If the material being moulded is a powdered metal eg aluminium that is thereafter to be sintered or a ceramic which is thereafter to be fired, the heating means of the block 134 can be omitted.

20 The disc 94, instead of oscillating back and forth through 22.5 degrees, can rotate stepwise in the same direction.

In a further form of apparatus according to the present invention, as shown in Figures 14 and 15, the transfer element 224 is reciprocable as shown by double-headed arrow A4, in a gap bounded
25 between front and rear plates 226 and 228. The front plate 226 has

-20-

therein an opening 230 forming part of the passage 30 immediately adjacent the element 224 and also has therein an opening 232 for receiving a plunger 234. The rear plate 228 has an opening 236 leading to the female cavity in a mould plate 238. The male mould 240 is
5 mounted on a further mould plate 242. The hydraulic means for clamping the plates 238 and 240 together have not been shown. All the plates 224, 226 and 228 can be of "Teflon" or any other low friction, low surface tension material.

An extruder barrel and screw 244 and 246 form means for
10 feeding molten mouldable material to the holding cavity which is designated 248 and is in the element 224.

The plunger 234 is moved in forward and return strokes by an hydraulic cylinder 250 and is guided for rectilinear movement by a pair of bushes 252 which slide on a guide rod 254.

15 Stops (not shown) limit movement of the plunger 234 between a forward position at S4 in which its front end is flush with the face of the plate 238 and thus forms part of the wall of the mould cavity and a retracted position in which its front end is at S3 and hence clear of the element 224.

20 To enable a moulded cap to be ejected from the mould cavity, the plate 242 moves away from the plate 238 and the plate 238 moves away from the plate 228. A pin (not shown) forming part of the male mould forces the cap off the male mould so that it drops down between the plates 228 and 238.

25 If reference is made to Figure 16, there is shown a pin 256 which has a camming surface 258. The pin is secured to the plate 242

and enters a bore 260 in the element 224. A spring or fluid cylinder (not shown) displaces the element 224 to the position shown in Figure 14. As the mould closes, the pin 256 enters the bore 260 and its camming surface 258 moves the element 224 to the right as viewed in Figure 14.

- 5 The pin 256 thus forms not only the means for displacing the element 224 but also the means for locating the element 224 in exact register with the opening 236 and plunger 234. Two or more pins and bores are provided.

- 10 Cooling means, eg water jackets and a supply of chilled water, can be provided in association with the mould cavity for the purpose of shortening the cycle time.

- Whilst all of the illustrated forms of apparatus have been described as having a single holding cavity, it is desirable to provide a multitude of holding cavities and a multitude of plungers. The plungers
15 can displace plastics material to one moulding cavity or a plurality of moulding cavities.

- In the first form one component having a volume equal to the total of the volumes of the holding cavities can be made. In a second form a plurality of identical or different components can be
20 formed. For example, all the components for one article can be produced in a single cycle. Because each holding cavity is individually supplied with mouldable material, the components can be of different plastics and/or can be of different colours.

- As none of the forms of apparatus described include narrow
25 gates, sprues and runners that block easily, it is believed that a much wider range of materials will be mouldable in the apparatus described that can be moulded with currently available injection moulding machines.

For example, as there are no pin gates that can be blocked, it is believed that synthetic plastics materials with fibres dispersed therein can be moulded. Provided the materials used in the construction of the apparatus are able to withstand the temperatures which must be
5 attained, it is believed that the moulding of glass articles will be possible.

CLAIMS:

1. Moulding apparatus comprising a transfer element bounding a holding cavity for mouldable material, a passage leading to said holding cavity, means for displacing mouldable material along said passage and into said holding cavity whilst said transfer element is in a first position, means for displacing said transfer element between said first position and a second position, and a plunger for urging said mouldable material out of said holding cavity and into a moulding cavity whilst said transfer element is in its second position.
2. Moulding apparatus as claimed in claim 1, and including heating means for heating said holding cavity.
3. Moulding apparatus as claimed in claim 2 and including further heating means for heating said passage.
4. Moulding apparatus as claimed in claim 3, and including means for supplying mouldable material in particulate form to said passage.
5. Moulding apparatus as claimed in any one of claims 1 to 4, wherein said means for displacing mouldable material along said passage is a further plunger.
6. Moulding apparatus as claimed in claim 1, and including means for reciprocating said transfer element along a rectilinear path between said first and second positions.
7. Moulding apparatus as claimed in claim 6, wherein said transfer element has at least one bore therein for receiving a reciprocable

pin which has a camming surface that is skew to the direction in which the pin reciprocates, said surface bearing on said transfer element as the pin is inserted into the bore to cam said transfer element in one direction between said positions, and means for displacing said transfer element in the other direction between said positions as the pin is withdrawn from said bore.

8. Moulding apparatus as claimed in any preceding claim and including a further element which closes-off said holding cavity on the side thereof remote from said passage and which has an opening therein which registers with said holding cavity when said transfer element is in said second position.

9. Moulding apparatus as claimed in claim 1, 2, 3 or 4, wherein said transfer element is a shaft having a transverse bore forming said holding cavity, said shaft being within a sleeve having first, second and third circumferentially spaced openings in the walling thereof, the first of said openings forming said passage, the second of said openings in use placing the holding cavity in communication with a mould cavity and said third opening permitting said plunger to enter said holding cavity, the second and third openings being diametrically opposed, said sleeve closing-off said holding cavity on the opposite side thereof to said first opening when said shaft is in its first position, and means for turning said shaft to displace it between said first position in which the first opening is in communication with the holding cavity and said second position in which said holding cavity is aligned with said second and third openings.

10. Moulding apparatus as claimed in any preceding claim, wherein the volume of said passage exceeds the volume of said holding cavity whereby the passage can contain a sufficient volume of mouldable material to fill the holding cavity a number of times.

11. Moulding apparatus as claimed in claim 1 and including a plurality of holding cavities in said transfer element, a plurality of passages, a plurality of means for displacing mouldable material along said passages and into said holding cavities, and a plurality of plungers for urging mouldable material out of said holding cavities and into one moulding cavity or into a plurality of moulding cavities.
12. Moulding apparatus as claimed in claim 11, wherein the transfer element has holding cavities of different volumes.
13. Moulding apparatus as claimed in claim 1, wherein said transfer element is constituted by a disc mounted for turning about its centre and having a plurality of holding cavities therein, there being a first plurality of reciprocable plungers constituting said means for moving mouldable material along the passages and into said holding cavities whilst said disc is in said first position, and a second plurality of reciprocable plungers for urging said mouldable material out of said holding cavities and into one moulding cavity or into a plurality of moulding cavities.
14. Moulding apparatus as claimed in claim 13, wherein said first plurality of plungers is carried by a first piston which is reciprocable in a first cylinder, means for supplying fluid under pressure to the first cylinder to reciprocate the first piston, and wherein said second plurality of plungers is carried by a second piston reciprocable in a second cylinder which is axially aligned with the first cylinder, there being means for supplying fluid under pressure to the second cylinder for reciprocating the second piston, the plungers of the second plurality passing through said first piston and through an end wall of said first cylinder.
15. Moulding apparatus as claimed in claim 13 or 14, and

including a third piston, a third cylinder and means for supplying fluid under pressure to the third cylinder for reciprocating the third piston in the third cylinder, there being a shaft connected at one end to said disc and at the other end to the third piston, the connection between the shaft and third piston being such that reciprocation of the third piston in the third cylinder causes said shaft to rotate and displace said disc between said first and second positions.

16. Moulding apparatus as claimed in claim 15, wherein said first and second cylinders and the first and second pistons are between said third piston and said disc, said shaft passing through said first and second pistons and through end walls of said first and second cylinders.

17. A method of moulding which comprises displacing mouldable material into a holding cavity, moving said holding cavity from a first position which it is in when said mouldable material is displaced into it to a second position, and discharging the mouldable material from the holding cavity into a mould cavity whilst the holding cavity is in said second position.

18. A method as claimed in claim 17, and including moving a first plunger in a forward stroke along a passage to displace said mouldable material from said passage into said holding cavity, moving the holding cavity to said second position, moving said first plunger in a return stroke, displacing a second plunger in a forward stroke to discharge said mouldable material from said holding cavity into said mould cavity, moving said second plunger in a return stroke, and moving the holding cavity back to its first position.

19. A method as claimed in claim 18 and including feeding mouldable material into said passage after said first plunger has

performed its return stroke.

20. A method as claimed in claim 19 and including the step of heating the mouldable material in said passage.

21. A method as claimed in claim 17 and including heating the mouldable material in said holding cavity.

22. A method as claimed in any one of claims 17 to 21, and including displacing mouldable material into a plurality of holding cavities, and discharging said mouldable material from said holding cavities into one moulding cavity or into a plurality of moulding cavities.

23. A method as claimed in claim 22, and including the step of providing holding cavities of different volumes.

24. A method as claimed in claim 22 or 23 and including the step of feeding mouldable material of different types to the holding cavities.

AMENDED CLAIMS

[received by the International Bureau on 20 February 1998 (20.02.98); original claims 1, 9, 17 and 18 amended; remaining claims unchanged (5 pages)]

1. Moulding apparatus comprising a transfer element bounding a holding cavity for mouldable material, a passage leading to said holding cavity, means for displacing mouldable material along said passage and into said holding cavity whilst said transfer element is in a first position, means for displacing said transfer element between said first position and a second position, a moulding cavity bounded by a wall which defines the shape of the article to be moulded in the moulding cavity, an opening through which said holding cavity communicates with said moulding cavity, and a reciprocable plunger which moves in said holding cavity and urges said mouldable material out of said holding cavity through said opening and into said moulding cavity whilst said transfer element is in its second position, said plunger having a front face which moves between a retracted position and a forward position as the plunger reciprocates, characterized in that said holding cavity is of constant cross section between said opening and the retracted position of said front face and said opening is of the same cross section as said holding cavity, said face of the plunger becoming part of the bounding wall of the moulding cavity when the plunger is in its forward position.
2. Moulding apparatus as claimed in claim 1, and including heating means for heating said holding cavity.
3. Moulding apparatus as claimed in claim 2, and including further heating means for heating said passage.
4. Moulding apparatus as claimed in claim 3, and including means for supplying mouldable material in particulate form to said passage.
5. Moulding apparatus as claimed in any one of claims 1 to 4, wherein said means for displacing mouldable material along said passage is a further plunger.
6. Moulding apparatus as claimed in claim 1, and including means for reciprocating said transfer element along a rectilinear path between said first and second positions.

7. Moulding apparatus as claimed in claim 6, wherein said transfer element has at least one bore therein for receiving a reciprocable pin which has a camming surface that is skew to the direction in which the pin reciprocates, said surface bearing on said transfer element as the pin is inserted into the bore to
5 cam said transfer element in one direction between said positions, and means for displacing said transfer element in the other direction between said positions as the pin is withdrawn from said bore.

8. Moulding apparatus as claimed in any preceding claim and
including a further element which closes-off said holding cavity on the side
10 thereof remote from said passage and which has said opening therein, said opening registering with said holding cavity when said transfer element is in said second position.

9. Moulding apparatus as claimed in claim 1, 2, 3 or 4, wherein said transfer element is a shaft having a transverse bore forming said holding cavity,
15 said shaft being within a sleeve having first, second and third circumferentially spaced openings in the walling thereof, the first of said openings forming said passage, the second of said openings placing the holding cavity in communication with said moulding cavity and said third opening permitting said plunger to enter said holding cavity, the second and third openings being
20 diametrically opposed, said sleeve closing-off said holding cavity on the opposite side thereof to said first opening when said shaft is in its first position, and means for turning said shaft to displace it between said first position in which the first opening is in communication with the holding cavity and said second position in which said holding cavity is aligned with said second and third
25 openings.

10. Moulding apparatus as claimed in any preceding claim, wherein the volume of said passage exceeds the volume of said holding cavity whereby the passage can contain a sufficient volume of mouldable material to fill the holding cavity a number of times.

30 11. Moulding apparatus as claimed in claim 1, and including a plurality

of holding cavities in said transfer element, a plurality of passages, a plurality of means for displacing mouldable material along said passages and into said holding cavities, and a plurality of plungers for urging mouldable material out of said holding cavities and into one moulding cavity or into a plurality of
5 moulding cavities.

12. Moulding apparatus as claimed in claim 11, wherein the transfer element has holding cavities of different volumes.

13. Moulding apparatus as claimed in claim 1, wherein said transfer element is constituted by a disc mounted for turning about its centre and having
10 a plurality of holding cavities therein, there being a first plurality of reciprocable plungers constituting said means for moving mouldable material along the passages and into said holding cavities whilst said disc is in said first position, and a second plurality of reciprocable plungers for urging said mouldable material out of said holding cavities and into one moulding cavity or into a
15 plurality of moulding cavities.

14. Moulding apparatus as claimed in claim 13, wherein said first plurality of plungers is carried by a first piston which is reciprocable in a first cylinder, means for supplying fluid under pressure to the first cylinder to reciprocate the first piston, and wherein said second plurality of plungers is
20 carried by a second piston reciprocable in a second cylinder which is axially aligned with the first cylinder, there being means for supplying fluid under pressure to the second cylinder for reciprocating the second piston, the plungers of the second plurality passing through said first piston and through an end wall of said first cylinder.

25 15. Moulding apparatus as claimed in claim 13 or 14, and including a third piston, a third cylinder and means for supplying fluid under pressure to the third cylinder for reciprocating the third piston in the third cylinder, there being a shaft connected at one end to said disc and at the other end to the third piston, the connection between the shaft and third piston being such that reciprocation of
30 the third piston in the third cylinder causes said shaft to rotate and displace said

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disc between said first and second positions.

16. Moulding apparatus as claimed in claim 15, wherein said first and second cylinders and the first and second pistons are between said third piston and said disc, said shaft passing through said first and second pistons and
5 through end walls of said first and second cylinders.

17. A method of moulding which comprises displacing mouldable material into a holding cavity, moving said holding cavity from a first position which it is in when said mouldable material is displaced into it to a second position, and discharging the mouldable material, whilst the holding cavity is in
10 said second position, from the holding cavity into a moulding cavity through an opening which places said holding cavity in communication with said moulding cavity, characterized in that said holding cavity is of constant cross section and said opening is of the same cross section as the holding cavity.

18. A method as claimed in claim 17, and including moving a first
15 plunger in a forward stroke along a passage to displace said mouldable material from said passage into said holding cavity, moving the holding cavity to said second position, moving said first plunger in a return stroke, displacing a second plunger in a forward stroke to discharge said mouldable material from said holding cavity into said moulding cavity, the moulding cavity being bounded by
20 a wall which defines the shape of the article to be moulded, moving said second plunger in a return stroke, and moving the holding cavity back to its first position, a front face of said second plunger becoming part of the bounding wall of the moulding cavity as the second plunger completes its forward stroke.

19. A method as claimed in claim 18, and including feeding mouldable
25 material into said passage after said first plunger has performed its return stroke.

20. A method as claimed in claim 19, and including the step of heating the mouldable material in said passage.

21. A method as claimed in claim 17, and including heating the mouldable material in said holding cavity.

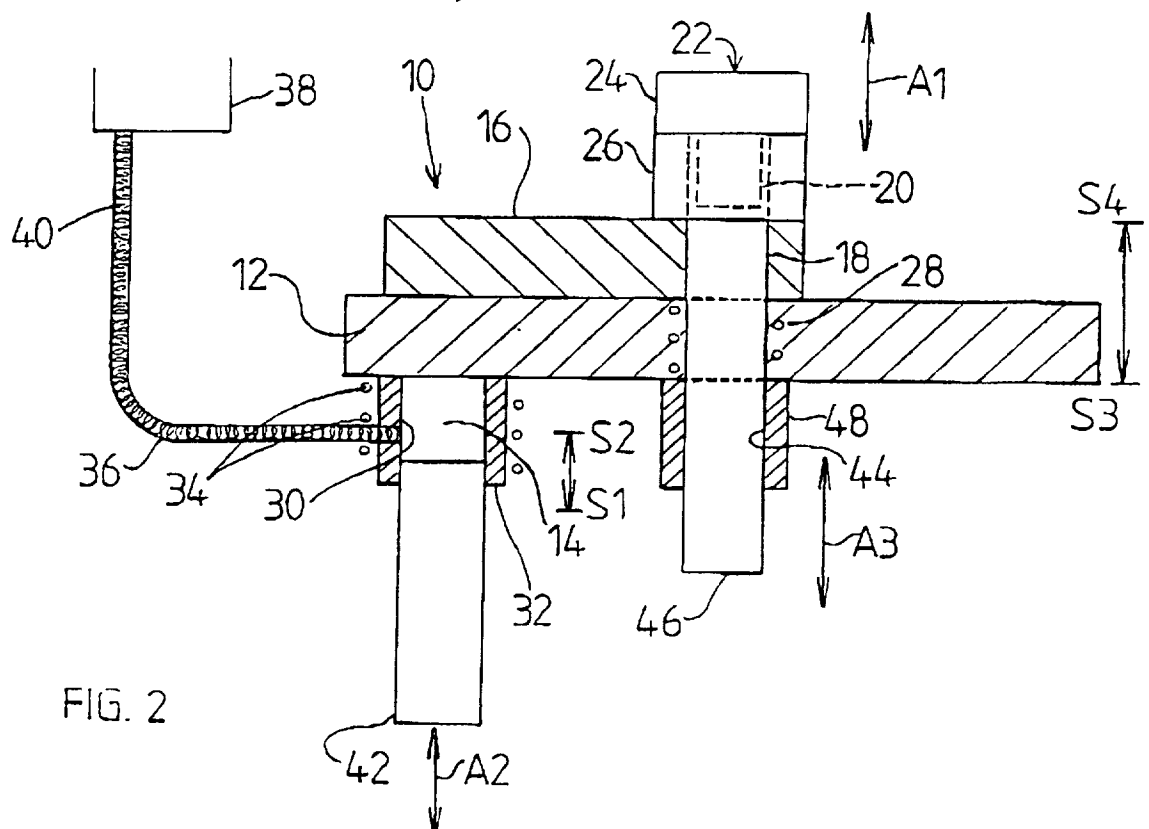
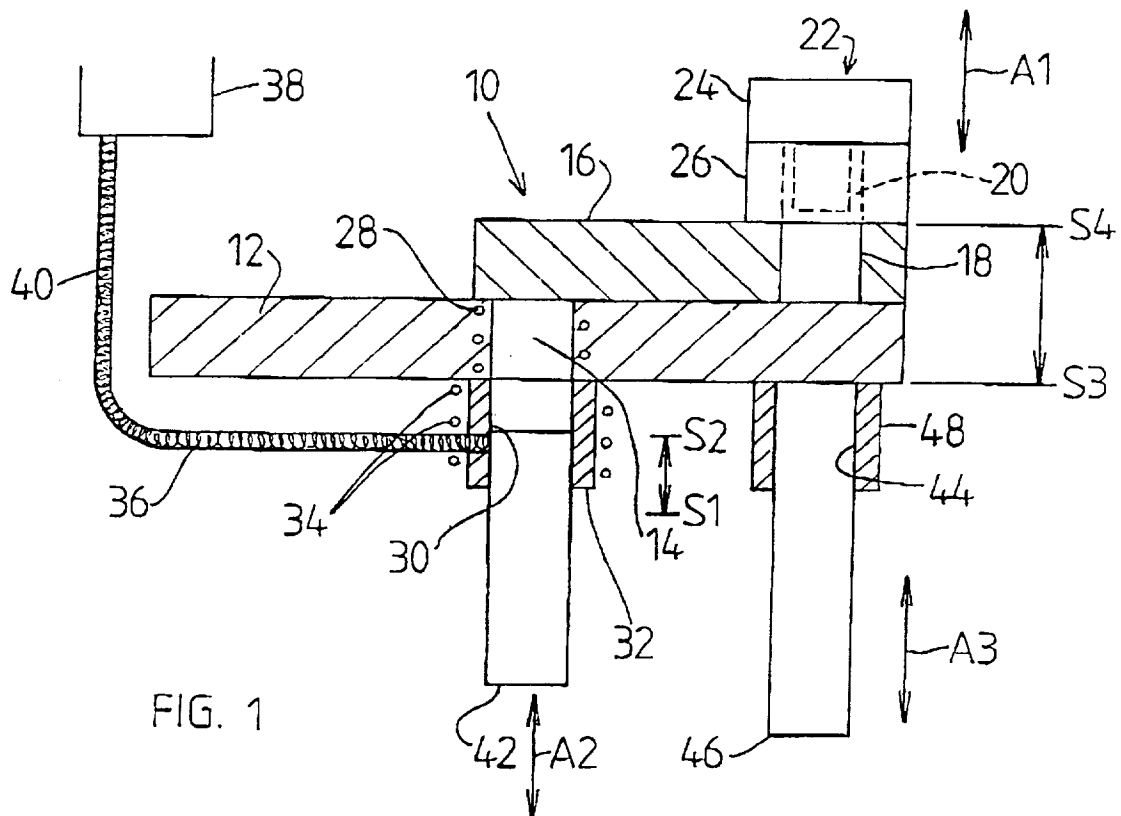
30 22. A method as claimed in any one of claims 17 to 21, and including

-32-

displacing mouldable material into a plurality of holding cavities, and discharging said mouldable material from said holding cavities into one moulding cavity or into a plurality of moulding cavities.

23. A method as claimed in claim 22, and including the step of
- 5 providing holding cavities of different volumes.
24. A method as claimed in claim 22 or 23, and including the step of feeding mouldable material of different types to the holding cavities.

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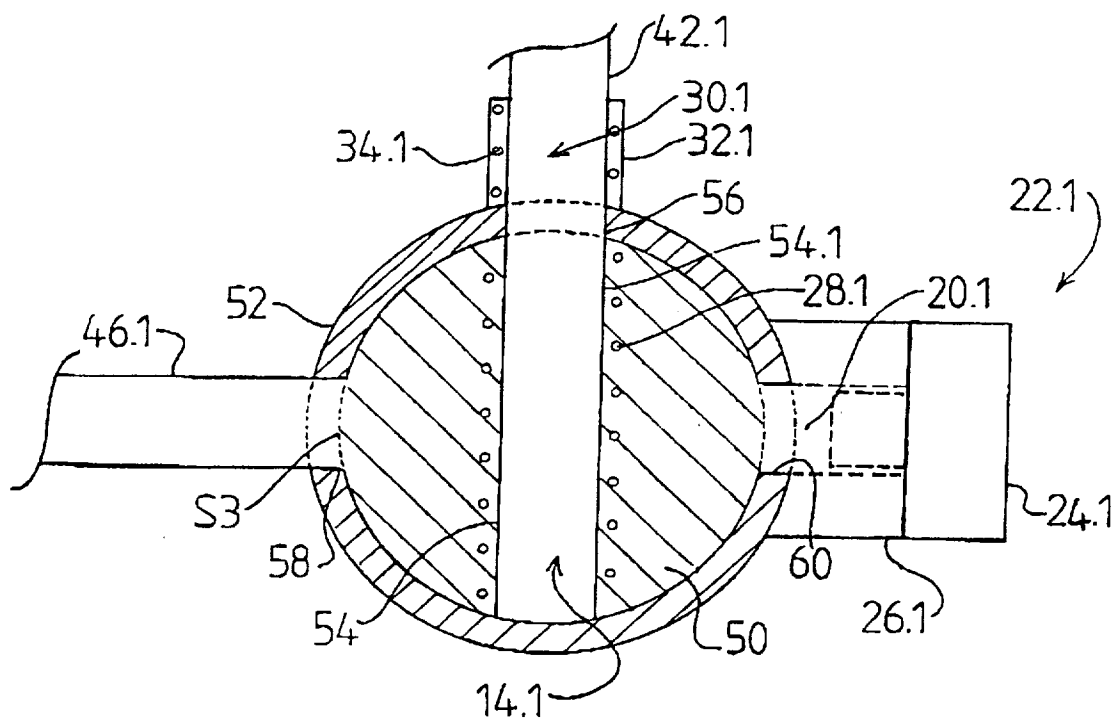


FIG. 3

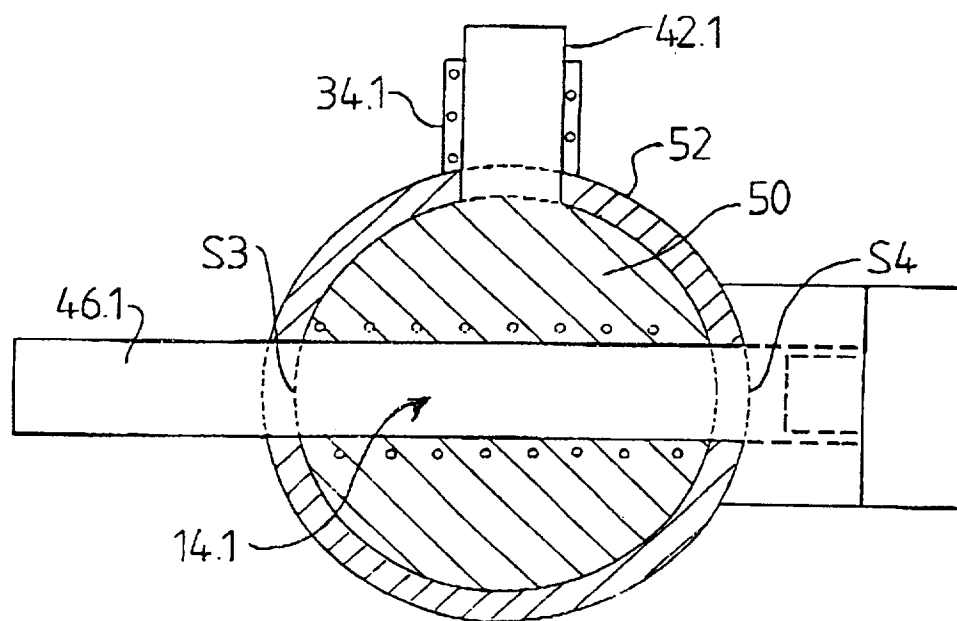


FIG. 4

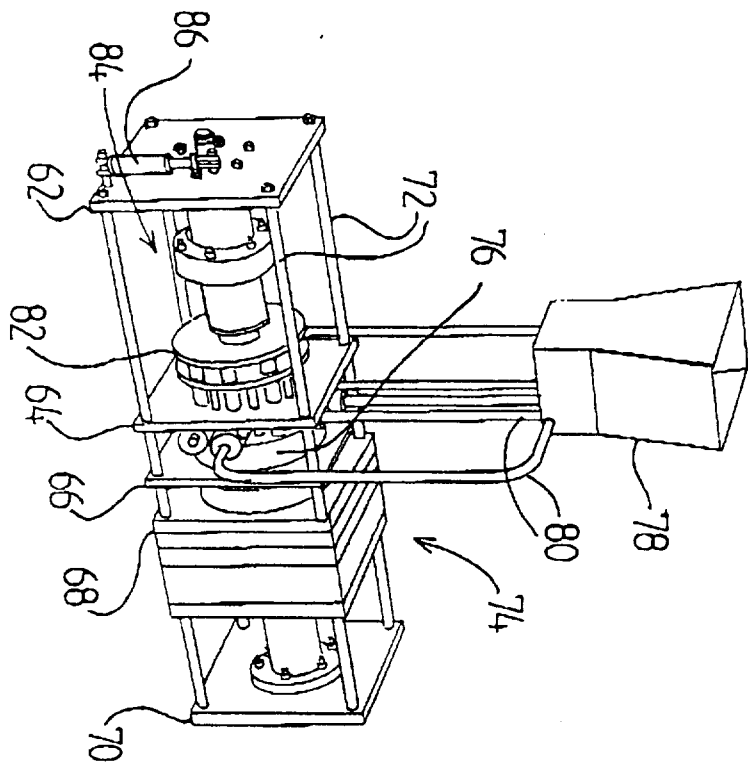


FIG. 5

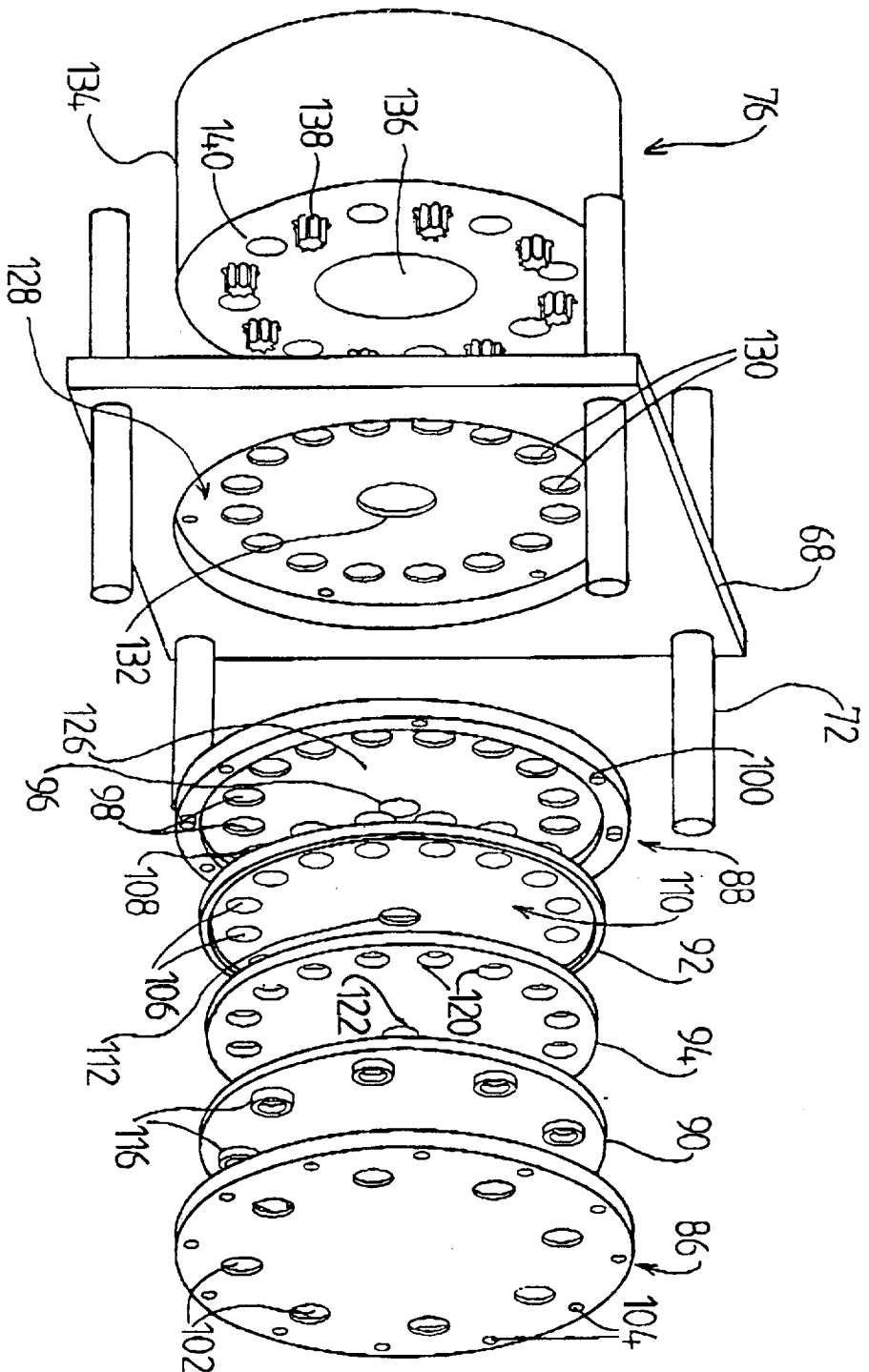


FIG. 6

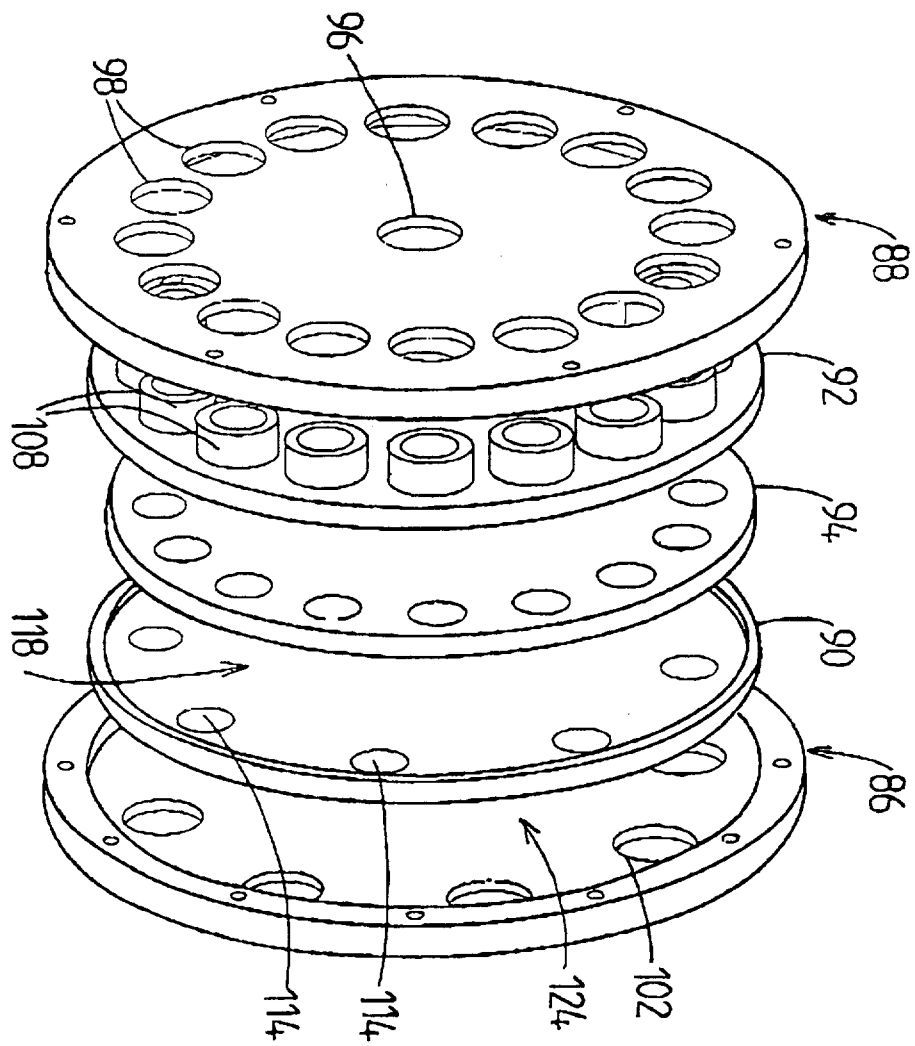


FIG. 7

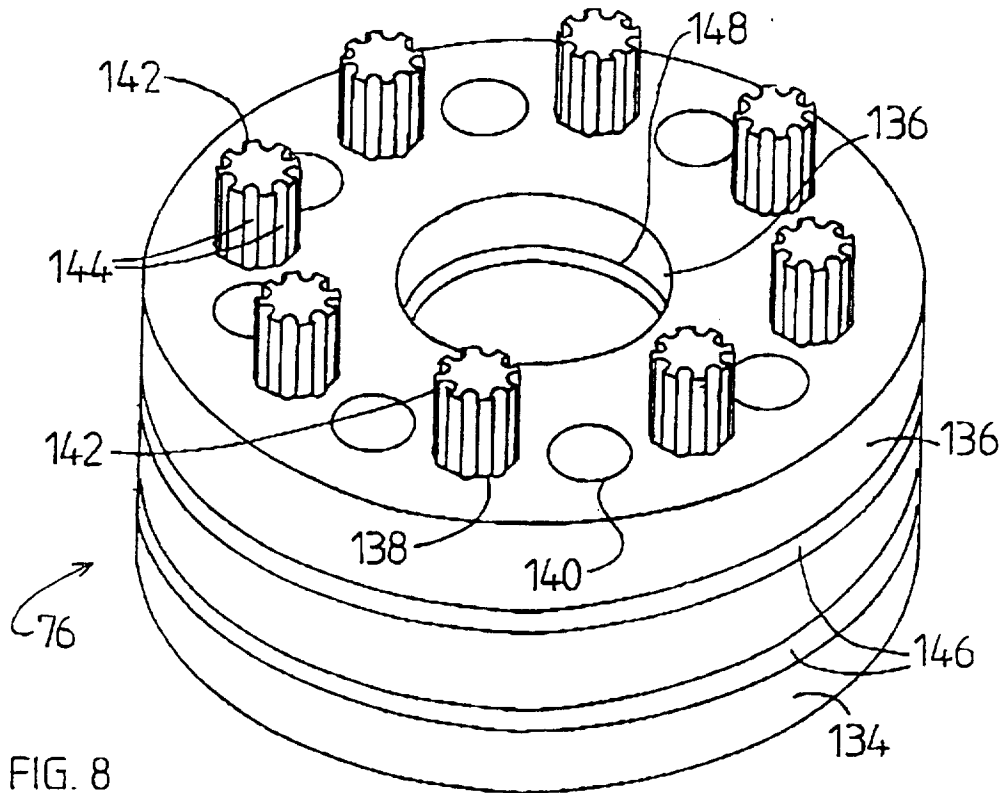


FIG. 8

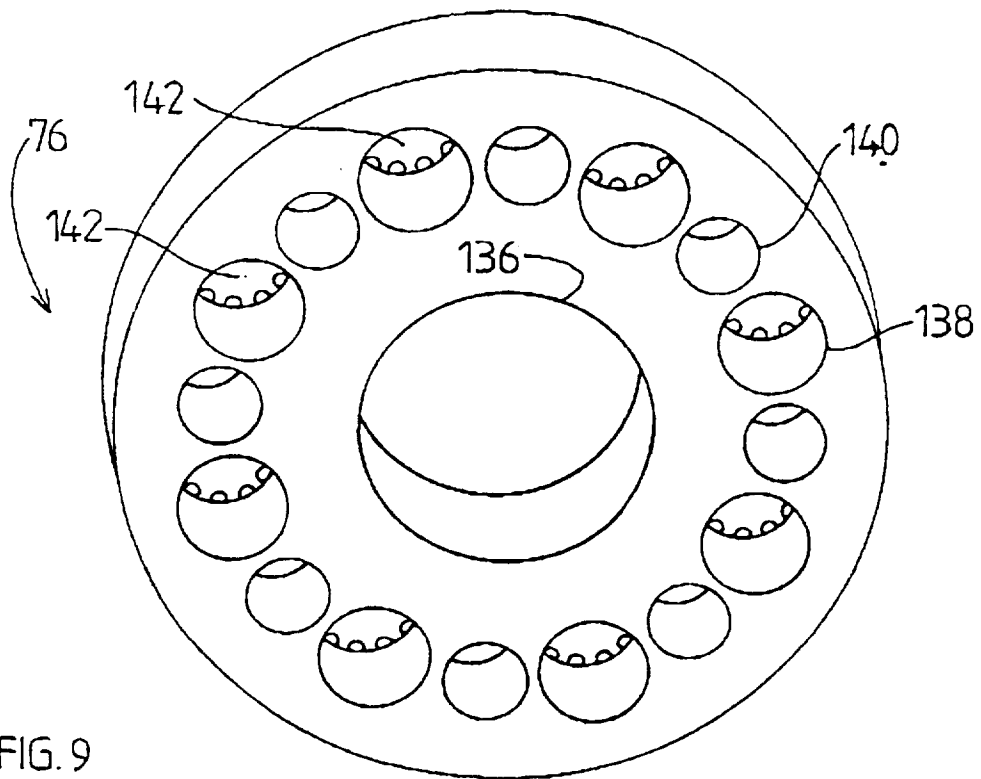


FIG. 9

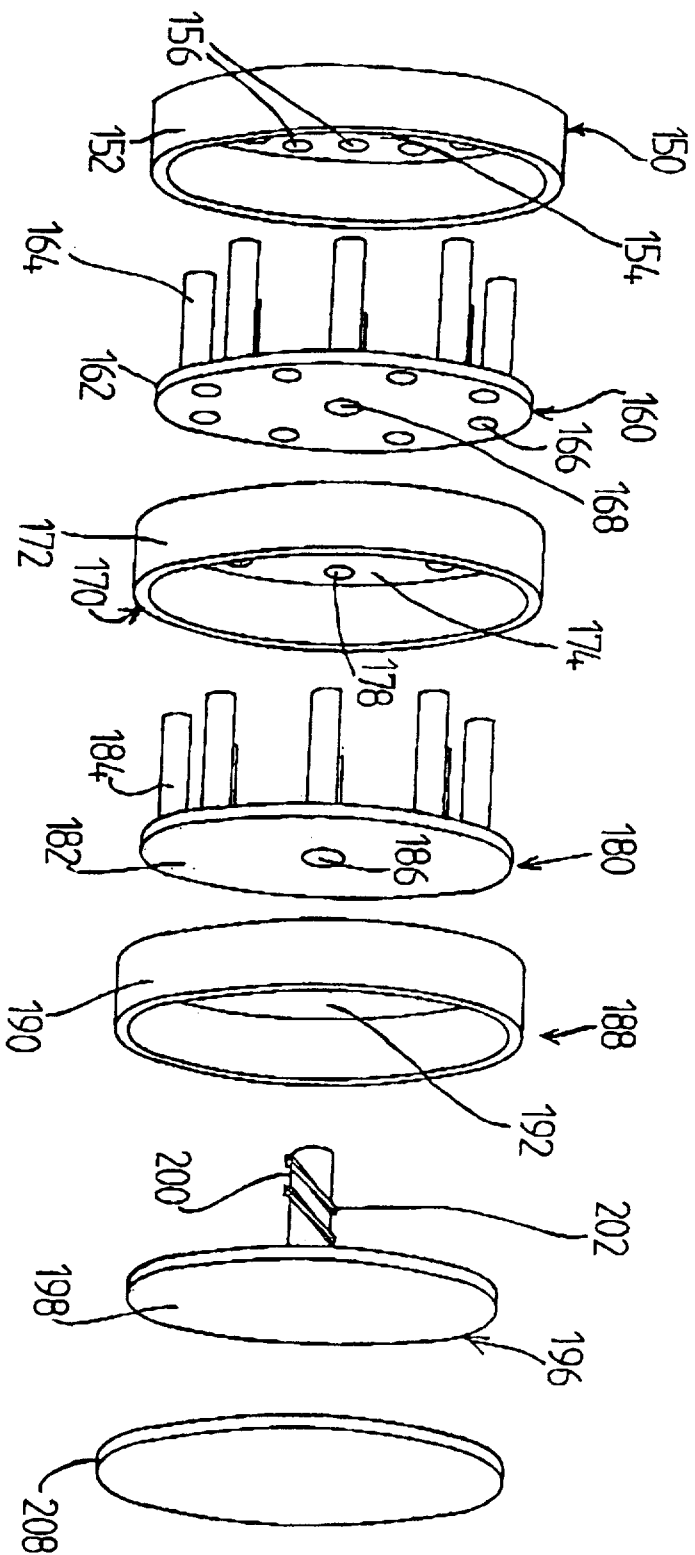


FIG. 10

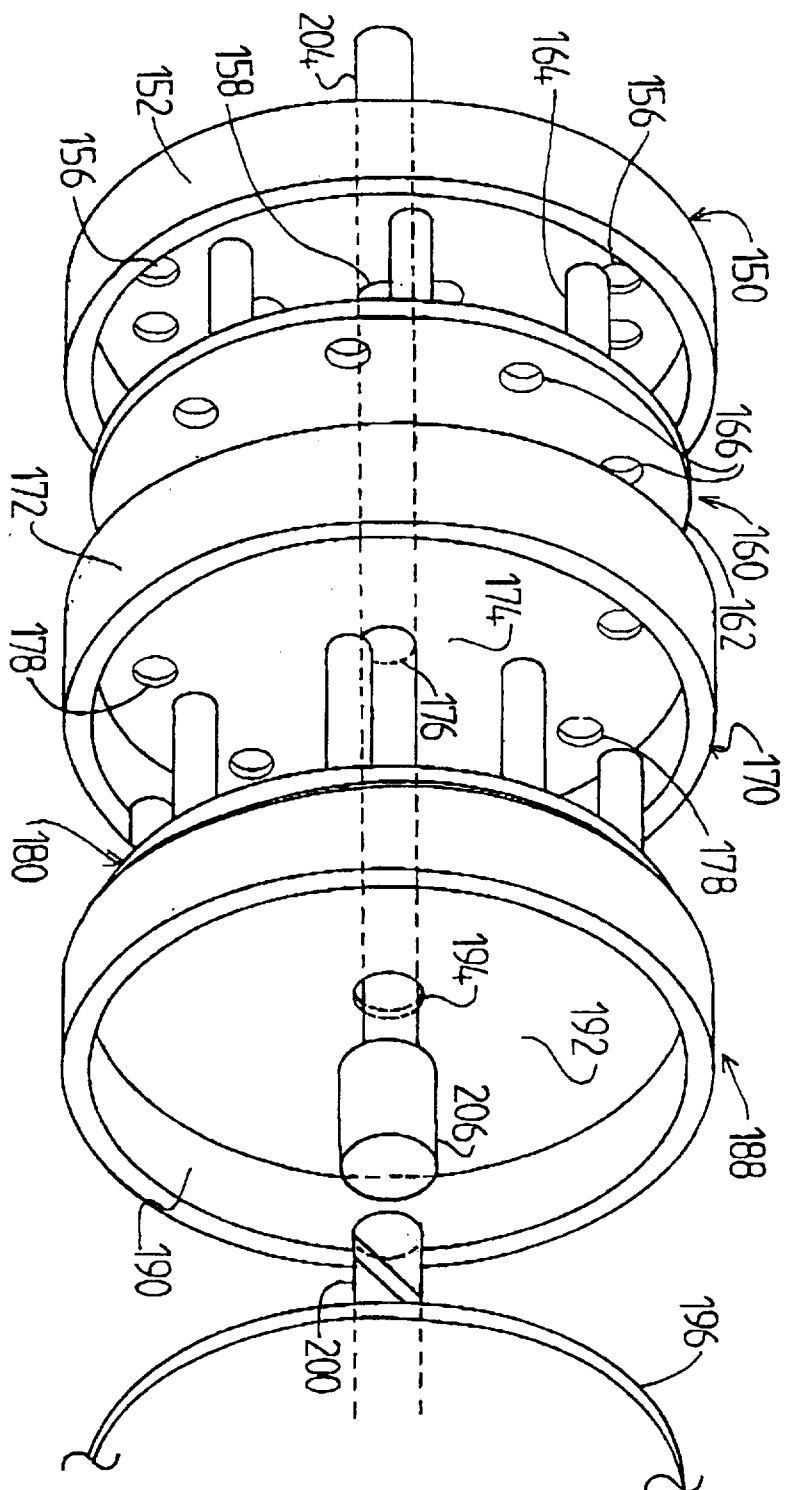


FIG. 11

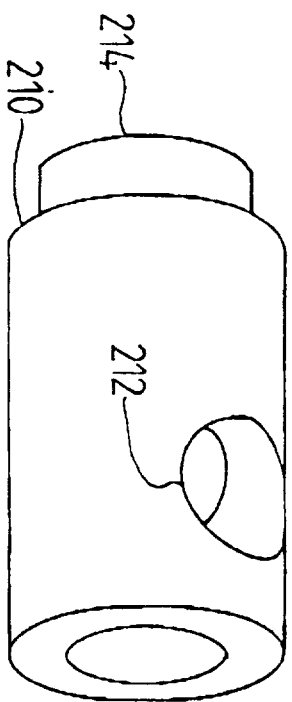
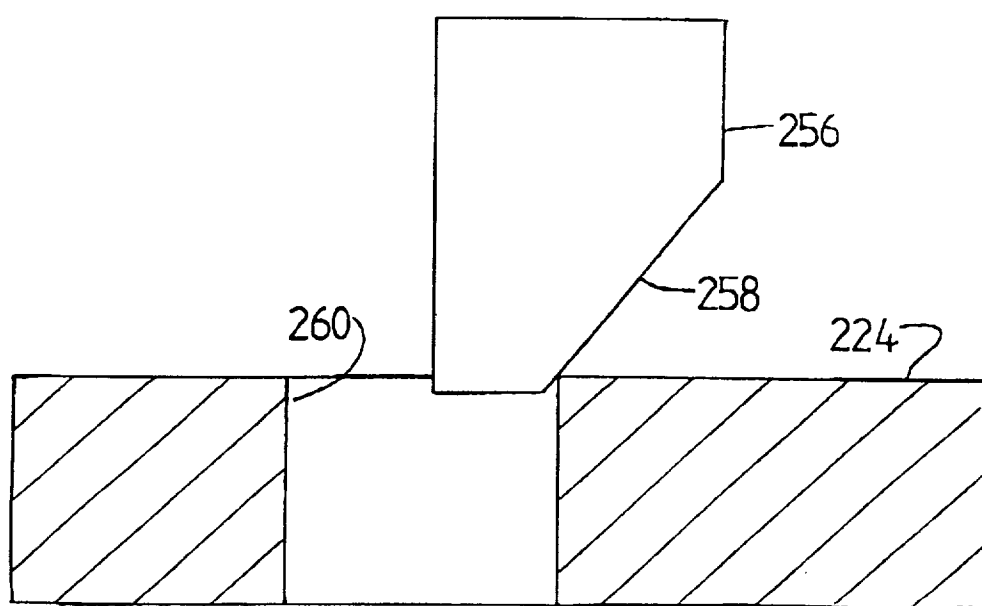
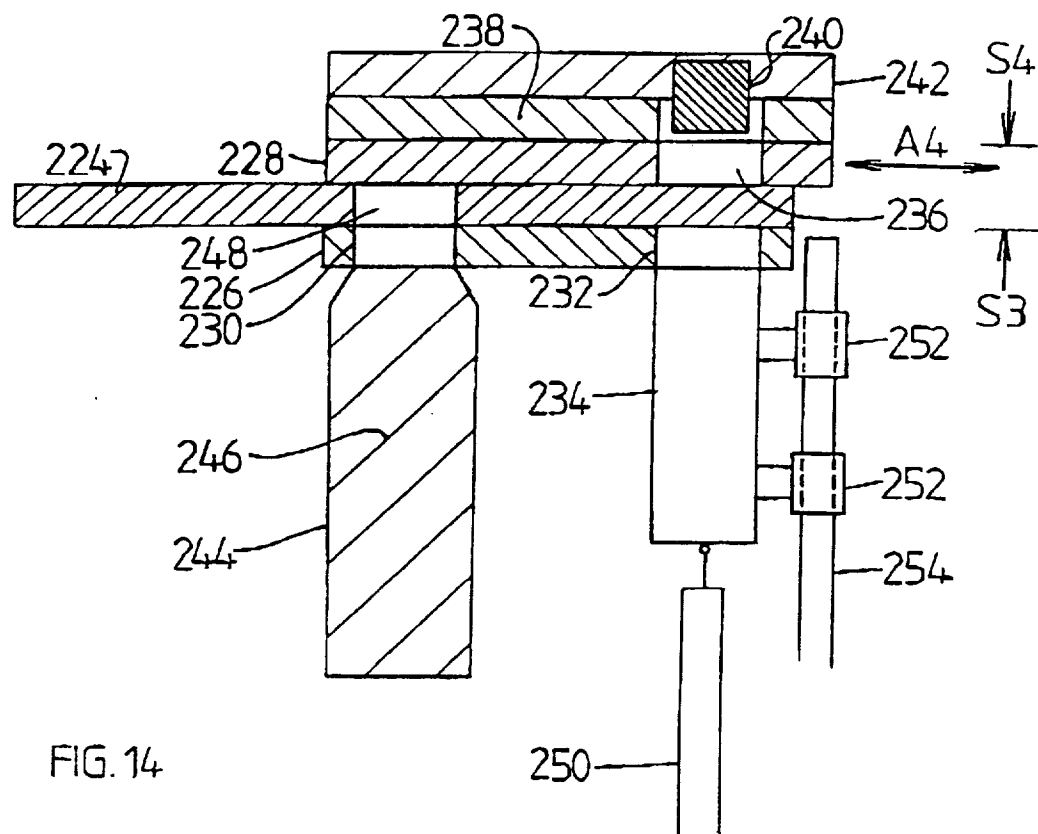


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15673

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B29C 31/04, 45/02

US CL :264/328.4, 328.11; 425/256, 258, 449, 544

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)

U.S. : 264/328.4, 328.11; 425/256, 258, 449, 544

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2,479,383 A (MACMILLIN) 16 August 1949, figures 1-4, column 1, lines 36-45, and column 3, line 30 to column 4, line 40.	1, 2, 10, 11, 17, 21, 22 ----- 6, 7
Y	US 1,460,287 A (STEVENSON) 26 June 1923, figures 1-12.	6, 7
A	US 3,075,286 A (MCVICKER et al) 29 January 1963, figures 1-7.	1, 17
A	SU 1,231,542 A (ALEKSEEV) 15 May 1986, figures 1-4.	1, 17
A	SU 551,123 A (AS UKR MATERIAL PRO) 23 June 1977, figure 1 and abstract.	1, 17

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*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
A document defining the general state of the art which is not considered to be of particular relevance	*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
E earlier document published on or after the international filing date	*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
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*A* document member of the same patent family
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	

Date of the actual completion of the international search

18 NOVEMBER 1997

Date of mailing of the international search report

23 DEC 1997

Name and mailing address of the ISA/US
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ROBERT B. DAVIS

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15673

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 1,253,567 A (VEB MASCHINENFABRIK HEIDENAU) 02 November 1967, figure.	1, 17