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(54) Title of the Invention: **Compressed injection molding**
Abstract Title: **Controlling the volume of injected resin in injection moulding**

(57) A method of producing an injection moulding comprising injecting a predetermined volume of a molten resin into an internal cavity of a die assembly 64; applying a pre-determined pressure on the resin within the cavity by a moving core 73; measuring a position of the core 76 and adjusting the predetermined volume of resin in subsequent cycles if the position of the moving core is different from a pre-determined position 79. The measured position of the core provides feedback data which is used to accurately control and correct the volume of injected resin. Also disclosed is a method of producing an injection moulding, and apparatus thereof, wherein the moveable core closes an outlet of the incoming resin channel when the volume of the internal cavity is reduced.

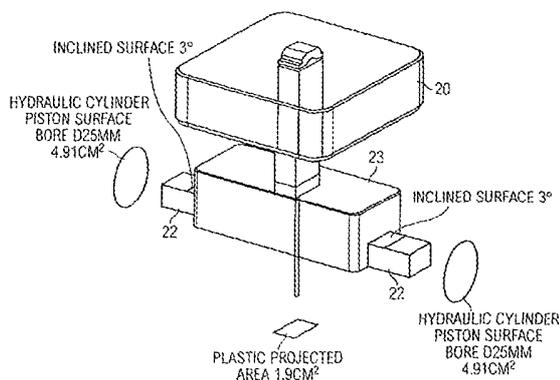


FIG. 8

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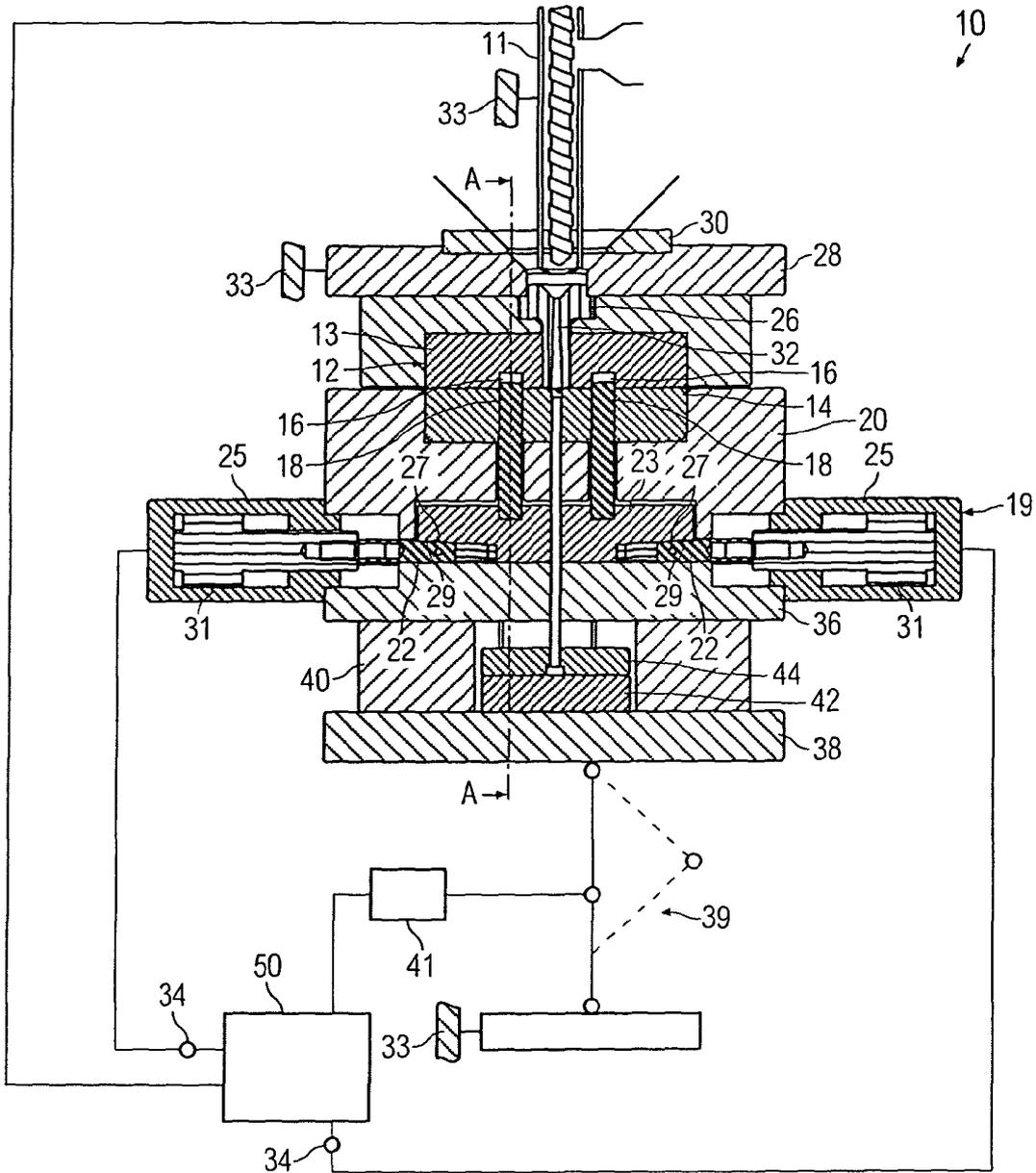


FIG. 1

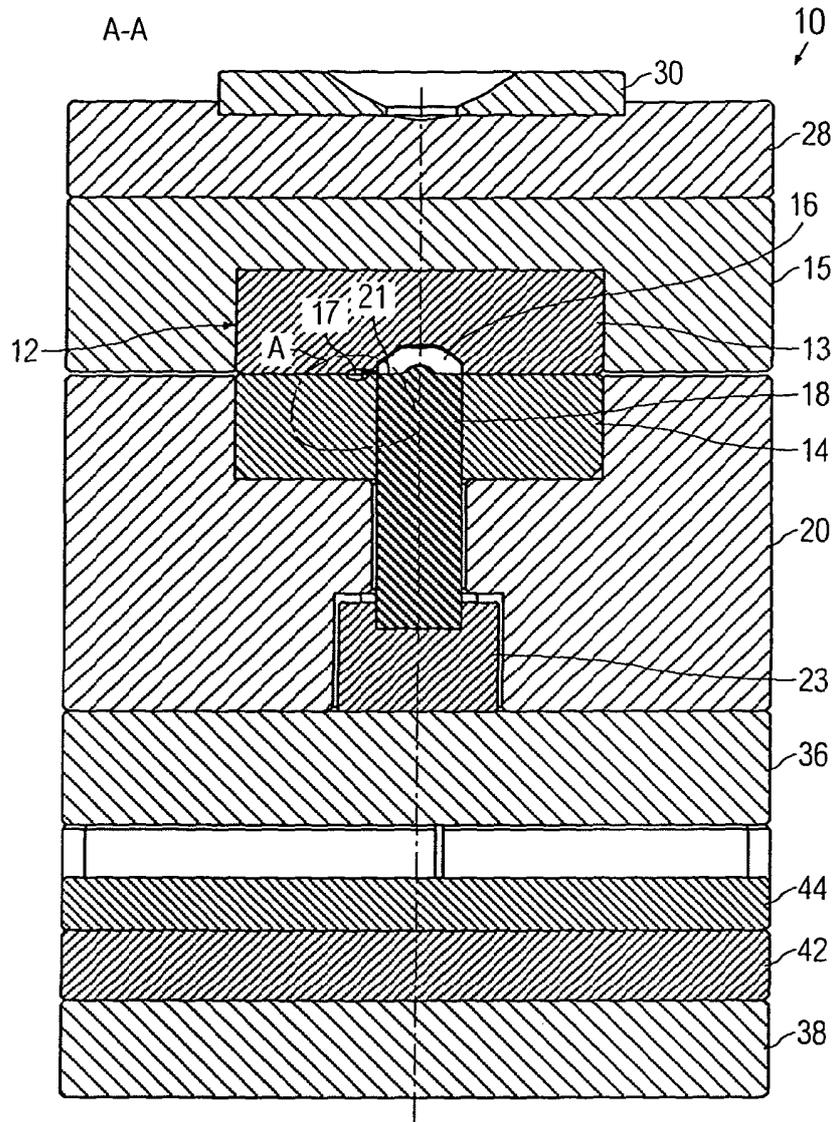


FIG. 2

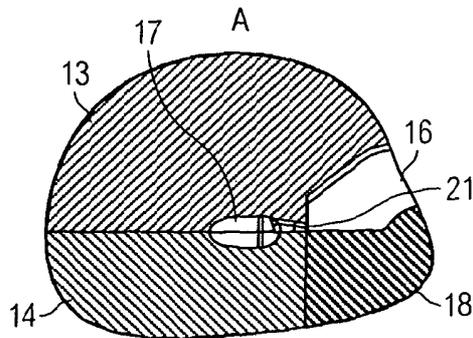


FIG. 3



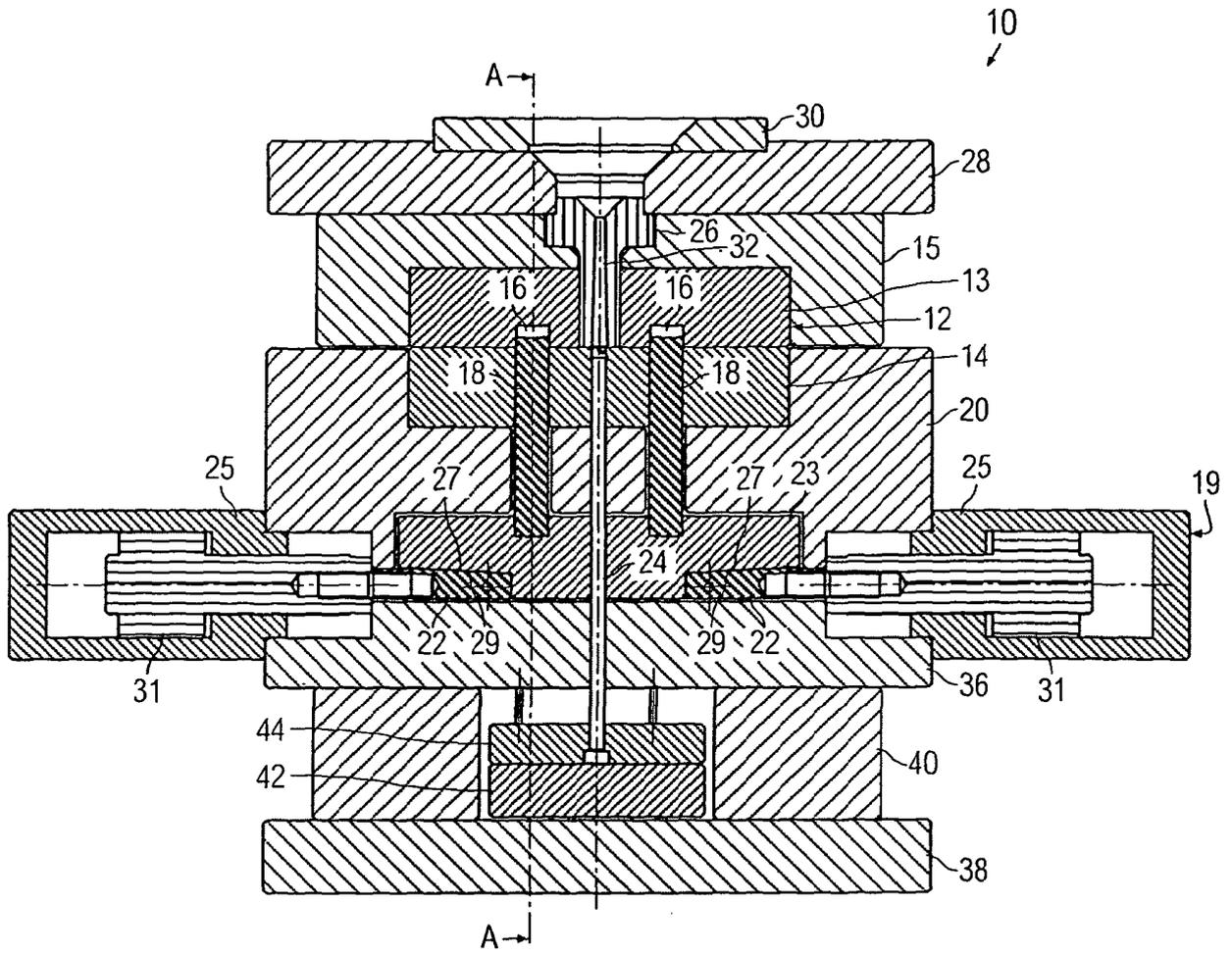


FIG. 4

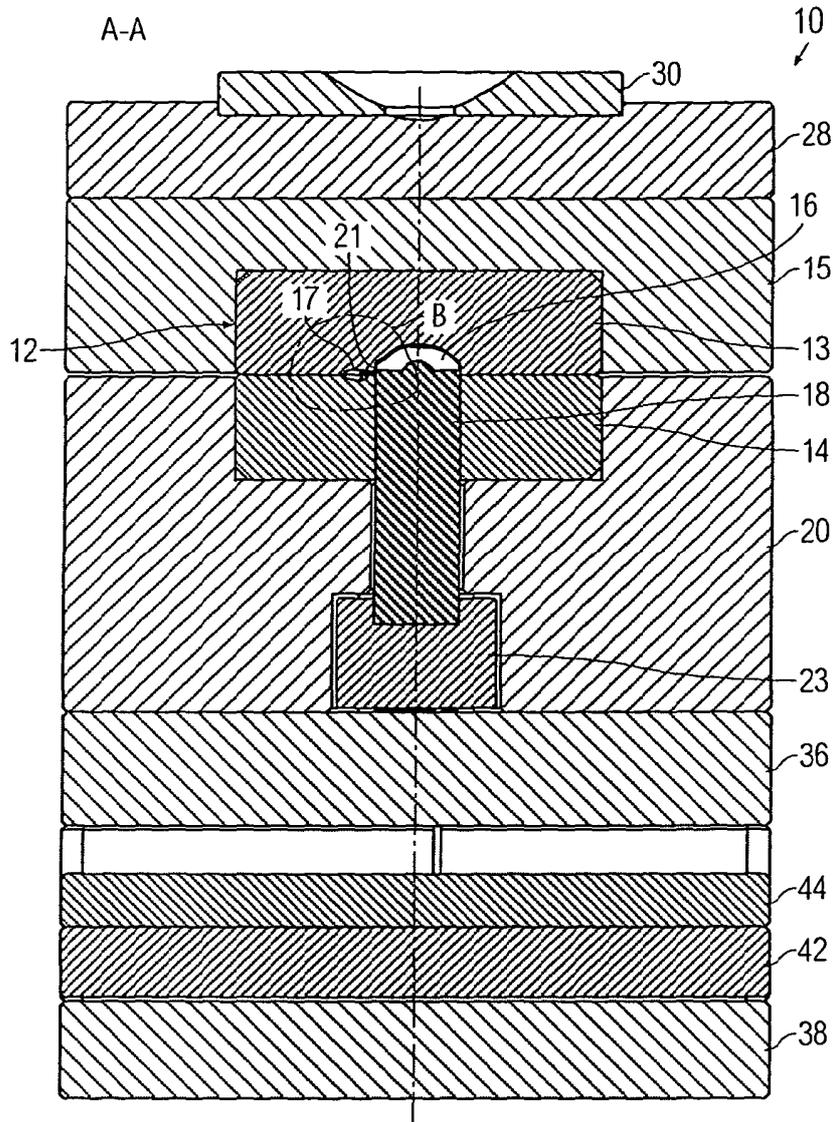


FIG. 5

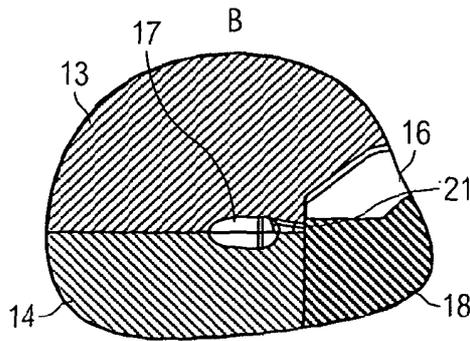


FIG. 6



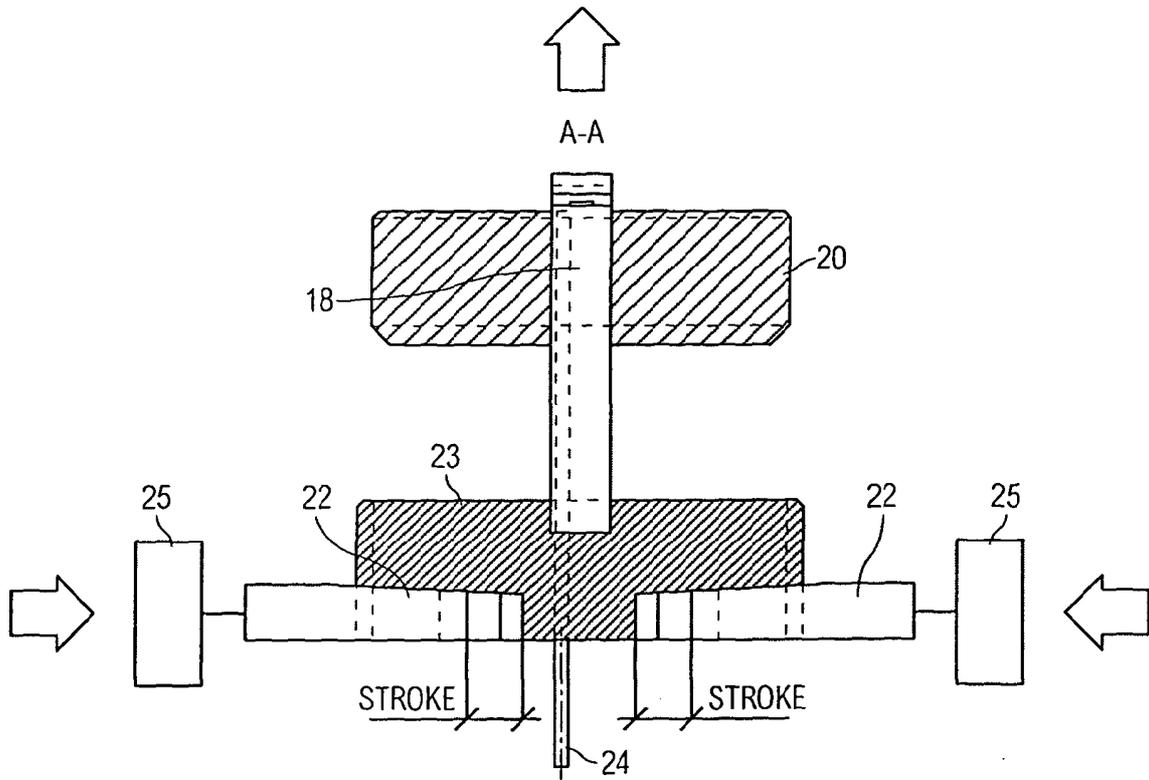


FIG. 7



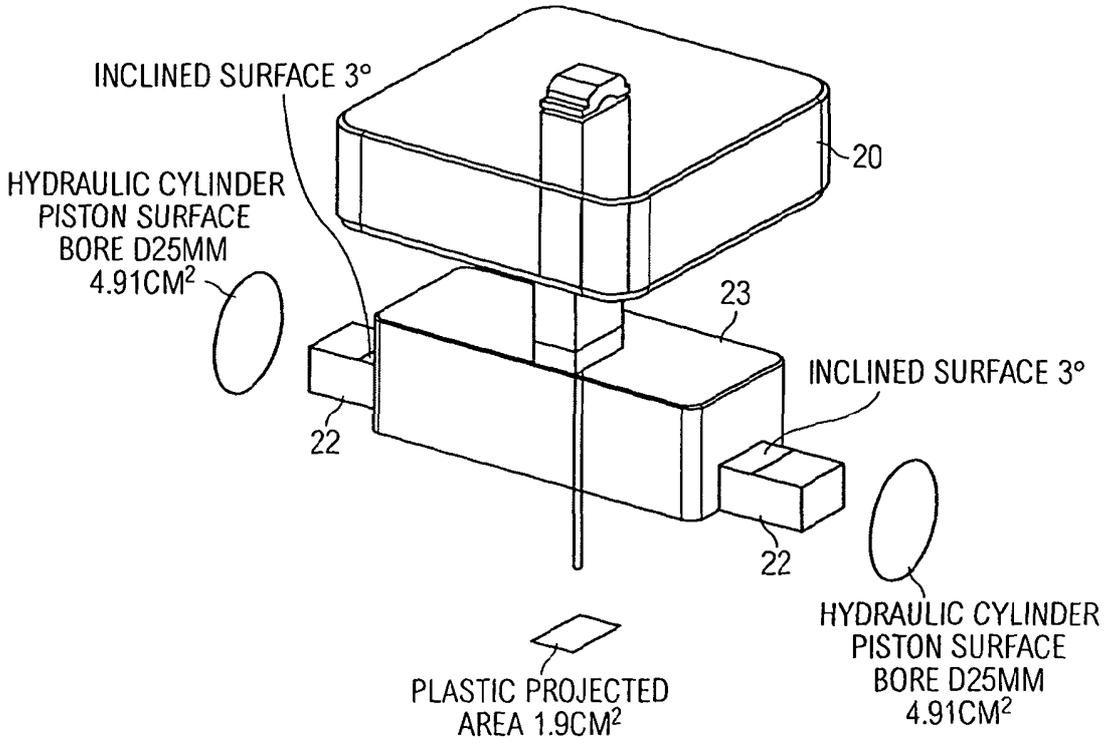


FIG. 8



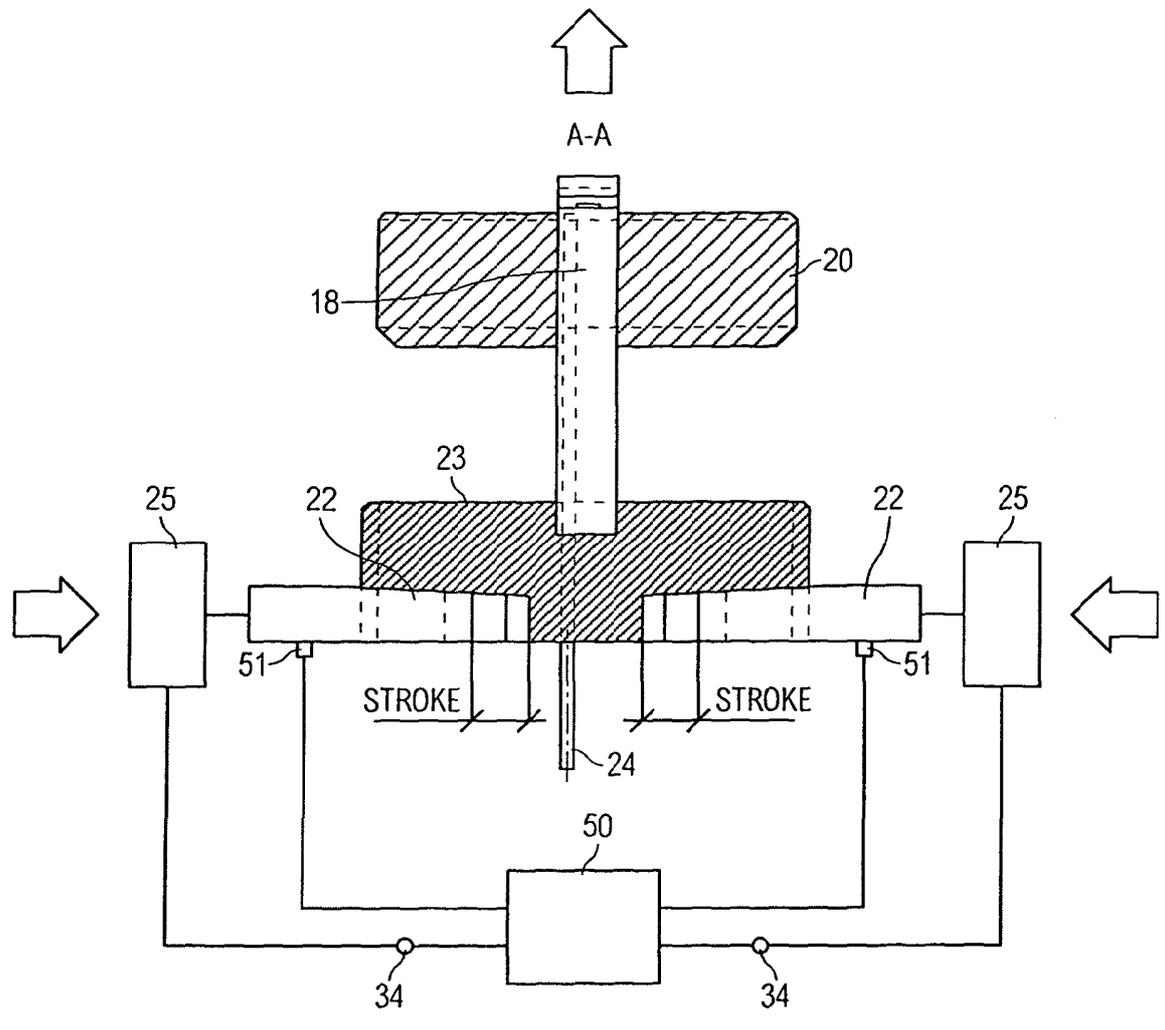


FIG. 9

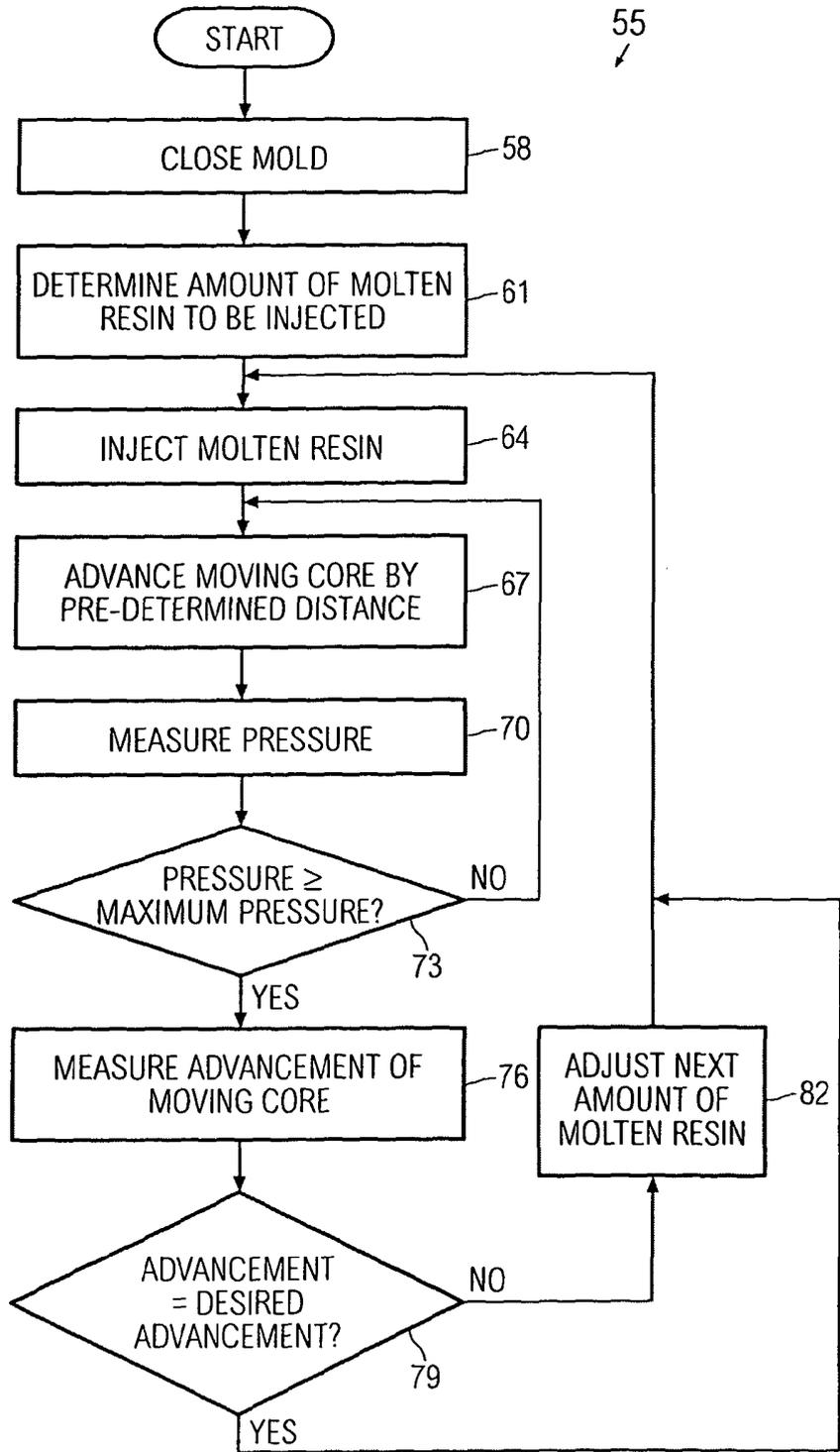


FIG. 10

COMPRESSED INJECTION MOLDING

This application relates to a method and to an apparatus for injection molding.

5

Injection molding is widely used for manufacturing a variety of parts that ranges from small components to entire body panels of cars. Injection molding uses thermoplastic and thermosetting plastic materials to produce plastic parts.

10

The molding process includes a step of feeding the plastic material into a heated barrel, where the plastic material is also mixed. The heated barrel converts the plastic material into a molten or a semi-molten state. After this, the molten plastic material is extruded into a mold cavity such that the plastic material fills essentially the entire mold cavity. The mold often comprises steel or aluminum, which has been shaped using precision-machinery such that the mold cavity forms various features of the desired plastic part. The mold is afterward cooled, wherein the cooling hardens and solidifies the molded plastic to form the desired plastic part.

15

20

It is an object of the application to provide an improved injection molding machine.

25

The application provides a molding apparatus for producing injection molding.

30

The molding apparatus includes a first mold-defining member together with a second mold-defining member, one or more channels, and one or more movable cores.

The first mold-defining member can be provided as a movable member while the second mold-defining member can be provided as a stationary member.

5

In an open position, the first mold-defining member is placed apart or away from the second mold-defining member. In contrast, in a closed position, the first mold-defining member is placed adjacent to the second mold-defining member, such that the first mold-defining member and the second mold-defining member define an internal cavity. The internal cavity is used for receiving molten resin, wherein the internal cavity is used for shaping the molten resin into a pre-determined shape. The molten resin refers to a liquid or semi-liquid state of the resin.

The channel comprises an inlet for receiving molten resin and a channel outlet for delivering the molten resin to the internal cavity.

The movable core is movable between a first position and a second position. The first position can corresponds to a normal cavity volume position while the second position can corresponds to a reduced cavity volume. The movable core in the second position reduces a volume of the internal cavity. In this position, a surface of the movable core also closes the channel outlet channel and is contact with the channel outlet. This allows the movable core to cover the channel outlet for cutting off the delivery of the molten resin to the internal cavity in order to compress the molten resin within the internal cavity.

The movable core is also independently movable with respect to or in reference to the first mold-defining member and with respect to the second mold-defining member.

5 Put differently, the movable core moves independent of the first mold-defining member and of the second mold-defining member.

The movable core is different from a mold ejector pin.

10 The mold ejector pin is used in the open position of the first and the second mold-defining members to remove the shaped resin from the said mold-defining members. In contrast, the movable core is used in the closed position of the said mold-defining members.

15

The movable core has an advantage of providing a simple mechanism to compress the molten resin in the mold cavity.

20 The channel can comprise one or more grooves in the first mold-defining member. The groove can serve as a channel for receiving molten resin and for delivering the molten resin to the internal cavity.

25 Similarly, the channel can comprise one or more grooves in the second mold-defining member. The grooves in the second mold-defining member can also be partly complementary to the groove in the first mold-defining member. The groove provides a simple manner of providing resin channels.

30

A part of the moveable core can be provided in a hollow portion of the first or of the second movable mold-defining member.

A hydraulic transversal wedge mechanism can be provided for longitudinally actuating the movable core. The first and the second mold-defining member forms a mold assembly
5 in which one of the first and the second mold-defining member is provided as a movable member. The moveable core moves in the longitudinal direction of the molding assembly or in the direction of a movable member.

10 By using a small angle, the wedge mechanism can provide a large compressive force on the mold cavity.

The transversal wedge mechanism can include a positional sensor for measuring the position of the transversal
15 wedge mechanism. The measurement can be used to improve operations of the injection-molding machine.

A hydraulic die clamping device can also be provided for longitudinally actuating the first mold-defining member
20 or the second mold-defining member. The hydraulic die clamping device often includes knee lever mechanism with a hydraulic piston, which is easy to implement.

The hydraulic die clamping device can include a pressure
25 sensor for measuring pressure exerted by the actuation of the hydraulic die clamping device.

The application provides a molding machine. The molding machine includes the above-mentioned molding apparatus, a
30 mold injection device, and a machine bed.

Operational, the machine bed provides a support for the molding machine and the mold injection device. The mold

injection device is used for preparing resin for injecting to the molding apparatus. The molding apparatus is used for shaping the resin that it receives from the mold injection device.

5

The molding machine can include a control unit. This control unit has a port for controlling the volume of molten resin injected by the mold injection device. The controlling is done in accordance to a positional data of a moving core of the molding apparatus, when a mold assembly of the molding apparatus is in a closed position. The control unit provides a feedback between the molding apparatus and the mold injection device such that the molding machine can improve its operations.

15

The application provides a method of producing an injection moulding. The moulding relates to an object that is produced by molding. The method comprises a step of injecting a molten resin into an internal cavity of a die assembly. The molten resin flows into the internal cavity via an outlet of a resin channel,

20

A movable core is then advanced into the internal cavity. This is done such that the volume of the internal cavity is reduced and such that a surface of the movable core closes the outlet of the resin channel. The surface of the movable core covers or blocks the outlet of the resin channel in order to cut off the flow of the molten resin into the internal cavity.

25

The blocking of the resin outlet and the reducing of the volume of the internal cavity often compresses the molten resin within the internal cavity.

30

This compression also moves the molten resin away from a separation line or area that is defined by the die assembly. The die assembly has a first mold defining member
5 and a second mold defining member. In a closed position, the first mold defining member and the second mold defining member defines the separation line that may have an area for holding a thin layer of excess resin material. The moving of the resin away from the separation line re-
10 duces or eliminates this formation of excess material. The excess material is also called a burr or flash. Put differently, the end position of the movable core is away from the separation line such that no or little burr exist on the molding.

15

This manner of compressing the molten resin has an advantage of being simple to implement and efficient as essentially no loss of pressure to the channels occurs.

20 The movable core can be advanced such that the volume of the internal cavity is reduced only after the molten resin being injected into the internal cavity. Put differently, the movable core can be advanced while after the molten resin is completed. The movable core can also
25 be advanced while the molten resin is being injected. This provides flexibility in implementation this process.

The advancing of the movable core into the internal cavity often exerts a molding pressure on the molten resin,
30 which is contained within the internal cavity of the die assembly. The molding pressure shapes the molten resin into the desired form.

The application also provides a method of producing an injection moulding. The moulding refers to an object that is an object produced by molding.

5 The volume of molten resin being injected into the internal cavity of the die assembly can be improved by adjusting the volume of the molten resin according to a previous or an earlier end positional data of a movable core of a die or mold assembly.

10

The method includes a step of injecting a predetermined volume of a molten resin into an internal cavity of a die assembly by a mold injection apparatus. The predetermined volume relates a desired volume of the final
15 moulded object.

20

A pre-determined pressure is then applied on the molten resin within the internal cavity by a moving core. This pressure acts to shape the molten resin according the internal shape of the internal cavity.

25

After this, the position of the moving core that corresponds to the application of the pre-determined pressure on the molten resin is measured. This positional data of the moving core provides an indication of the volume of the molten resin in the internal cavity, which is the volume of the desired moulding.

30

When the measured position of the moving core is essentially different from a pre-determined or desired position, this indicates the volume of molten resin injected into the internal cavity is different from the desired volume. For quality and cost reasons, the volume of in-

jected molten resin should be accurate. If the volume of injected molten resin is too high, too much molten resin is used to produce the moulding. This would translate into higher material cost and possibly moulding with excessive thickness. On the other hand, if the volume of injected molten resin is too low, the moulding has walls that are too thin.

The predetermined volume of a molten resin is later adjusted for subsequent steps of mold injection to eliminate this volume difference.

This method provides an easy or accurate way of controlling a volume of the molten resin since the method uses a feedback loop for the control. This is different from other methods that just focus on providing an accurate volume of injected molten resin.

The step of applying the pre-determined pressure on the molten resin can comprise a step of advancing the moving core by a pre-determined distance. The pressure being applied to the molten resin is afterward measured. The advancing of the moving core and the measuring of the pressure are repeated when the measured pressure is less than a pre-determined pressure.

In the following description, details are provided to describe embodiments of the application. It shall be apparent to one skilled in the art, however, that the embodiments may be practiced without such details.

Some parts of the embodiments, which are shown in the Figs. below, have similar parts. The similar parts may

have the same names or similar part numbers. The description of such similar parts also applies by reference to other similar parts, where appropriate, thereby reducing repetition of text without limiting the disclosure.

5

Fig. 1 illustrates a cross-sectional top view of an embodiment of an improved injection molding machine in a first position,

10 Fig. 2 illustrates a side cross-sectional view of the injection molding machine of Fig. 1,

Fig. 3 illustrates an expanded cross-sectional view of a part of the injection molding machine of Fig. 2

15 Fig. 4 illustrates a cross-sectional top view of the injection molding machine of Fig. 1 in a second position,

Fig. 5 illustrates a side cross-sectional view of the injection molding machine of the Fig. 4,

20 Fig. 6 illustrates an expanded cross-sectional view of a part of the injection molding machine of Fig. 5,

Fig. 7 illustrates a schematic drawing of a compression mechanism for the injection molding machine of Fig. 1,

25 Fig. 8 illustrates a perspective view of the compression mechanism of the injection molding apparatus of Fig. 7,

Fig. 9 illustrates an embodiment of the compression mechanism of Fig. 7, and

30 Fig. 10 illustrates a process flow chart for the compression mechanism of Fig. 9.

Fig. 1 shows an injection molding machine 10. The injection molding machine 10 includes a die assembly 12 that operates with a mold injection apparatus 11, which is fixed to a machine bed 33. The term "die" is also known as "mold" or "mould".

The die assembly 12 includes a stationary die 13 and a movable die 14. The movable die 14 is positioned next to the stationary die 13. In a closed position, the movable die 14 and the stationary die 13 define two internal mold cavities 16, as shown in Fig. 1.

The stationary die 13 and the movable die 14 also comprise grooves that form channels 17 when the die assembly 12 is in the closed position. This is illustrated in Figs. 2 and 3. The channels 17 are also known as runners.

As can be seen in Fig. 1, the stationary die 13 is placed next to a first major surface of a cavity plate 15 and it is removably taken up and received by the stationary die receptacle 15. The cavity plate 15 is also called a stationary die receptacle. Both the cavity plate 15 and the stationary die 13 have central openings for taking up a runner insert 26 that is placed into the central portion of the cavity plate 15 and into the central portion of the stationary die 13. The runner insert 26 has a hollow core, which is provided as a channel or a runner 32. The runner 32 is connected to the channels 17. These connections are not shown in the figures.

30

One end of the channels 17 is adapted to receive molten resin from the mold injection apparatus 11 through the runner 32. Another end of the channels 17 is connected to

the respective cavities 16 outlets 21, which terminate at an outlet orifice in the stationary die 13, as can be best seen in Figs. 2 and 3.

5 As can be seen in Fig. 1, a second major surface of the cavity plate 15, which is opposite to the first major surface of the cavity plate 15, is placed next to a first major surface of a clamping plate 28, which is fixed to the machine bed 33. The clamping plate 28 is also called
10 a stationary plate. The cavity plate 15 is attached to the clamping plate 28.

A second major surface of the clamping plate 28, which is opposite to the first major surface of the clamping plate
15 28, is placed next to an injection head insert 30. The clamping plate 28 is attached to the injection head insert 30. The injection head insert 30 has a central opening 47, is aligned with a central opening 45 in the clamping plate 28.

20 Referring to the movable die 14, it has multiple hollow cores in which longitudinally moving cores 18 are inserted. The moving cores 18 are attached to a moving apparatus 19. The moving cores 18 are also inserted inside
25 a core plate 20 that is adapted to keep longitudinal axis of the moving cores 18 essentially horizontal and essentially parallel to each other while allowing the moving cores 18 to move back and forth essentially in the horizontal direction. The core plate 20 is also called a
30 guiding core.

The movable die 14 is placed next to a first major surface of a movable die receptacle that is provided by the

core plate 20. A second major surface of the movable die receptacle 20, which is opposite to the first major surface of the movable die receptacle 20, is attached to the moving apparatus 19.

5

Referring to the moving apparatus 19, it includes wedges 22 and a lifting block 23 together with hydraulic pistons 25. The wedges 22 are located next to the lifting block 23 while the lifting block 23 is in contact with the moving
10 ing cores 18.

The wedges 22 are secured to piston rods 31 of the hydraulic pistons 25, wherein the piston rods 31 are adapted to move the respective wedges 22 towards the
15 lifting block 23 or away from the lifting block 23.

The wedges 22 have inclined surfaces 27 that correspond to inclined surfaces 29 of the lifting block 23. The inclined surfaces 27 and 29 are inclined in relation to the
20 moving direction of the moving cores 18. Put differently, the inclined surfaces 27 and 29 are not perpendicular to the moving direction of the moving cores 18. These inclined surfaces 27 and 29 are also in contact with each other, wherein the inclined surfaces 27 of the wedges 22
25 contact the lifting block 23 via its inclined surfaces 29, as illustrated in Fig. 1.

The inclined surfaces 27 and 29 are also adapted such that the lifting block 23 would be positioned farther
30 from the die assembly 12 when the wedges 22 are positioned away or farther from the lifting block 23. Similarly, the lifting block 23 would be positioned near to

the die assembly 12 when the wedges 22 are positioned toward or nearer to the lifting block 23.

5 The lifting block 23 is guided by the core plate 20 such that the lifting block 23 is movable essentially in the horizontal direction while it slides on its inclined surfaces 29 against the inclined surfaces 27 of the wedges 22. This can be seen from Fig. 1.

10 The hydraulic pistons 25 are attached to an intermediary plate 36 of a die clamping apparatus. The intermediary plate 36 is also called a die clamping movable plate. The die clamping apparatus is not shown in the figures. The intermediary plate 36 is attached to a base clamp plate
15 38 via a support ring 40 and to the movable die receptacle 20. The base clamp plate 38 is also called a main movable plate.

The base clamp plate 38 is also connected to a knee lever
20 mechanism 39 that is actuated by a hydraulic piston 41. The knee lever mechanism 39 is fixed to the machine bed 33.

An ejector pin 24 is attached to a superior ejector plate
25 44. The superior ejector plate 44 is also called an ejector actuation plate. An inferior ejector plate 42, which is secured to the base clamp plate 38, blocks the superior ejector plate 44. The inferior ejector plate 42 is also called a blocking plate. The ejector pin 24 is in-
30 serted in a central hollow core of the intermediary plate 36, in a central hollow core of the lifting block 23, a central hollow core of the movable die receptacle 20, and a central hollow core of the movable die 14.

The mold injection apparatus 11, the hydraulic piston 25, and the hydraulic piston 41 are connected to a control unit 50 via hydraulic lines that include pressure sensors
5 34.

Operationally, the die assembly 12 is movable between an open position and a closed position. In the open position, the movable die 14 is positioned apart or away from the
10 stationary die 13. In contrast, in the closed position, the stationary die 13 is positioned next to the movable die 14 such that the stationary die 13 and the movable die 14 define the internal mold cavities 16, as shown in Fig. 1.

15

The moving cores 18 are movable between a reduced volume position and a normal volume position. The normal volume position is illustrated in Figs. 2 and 3 while the reduced volume position is illustrated in Figs. 5 and 6.

20

When the die assembly 12 is in the closed position and when the moving cores 18 are in the normal volume position, the moving cores 18 do not block the outlets 21 of the channels 17. This is better seen in Fig. 3.

25

When the moving cores 18 shift to the reduced volume position, the moving cores 18 block and cover the outlets 21 of the channels 17 such that any molten resin within the outlet 21 is in contact with the circumferential surface of the moving cores 18. The blocking prevents the
30 molten resin within the channels 17 from flowing out of the runner outlets 21 into the mold cavities 16. This is better seen in Fig. 6. In this reduced volume position,

the moving cores 18 also reduce the volume of the die cavities 16, thereby compressing the molten resin, which is take up therein.

5 In use, the movable die 14 is positioned by the intermediary plate 36, which is moved by the base clamp plate 38. The base clamp plate 38 is in turn moved by the knee lever mechanism 39, which is actuated by the hydraulic piston 41. The control unit 50 controls the hydraulic
10 piston 41.

The intermediary plate 36 can be actuated such that it moves away from the stationary die 13 or towards the stationary die 13. When the intermediary plate 36 moves away
15 from the stationary die 13, the movable die 14 also moves away from the stationary die 13 to enter into the open position of the die assembly 12. Similarly, when the intermediary plate 36 is actuated toward the stationary die 13, the movable die 14 also moves toward the stationary
20 die 13 to assume the closed position of the die assembly 12.

The mold injection apparatus 11 is used for receiving resin pellets. The received resin pellets are intended
25 for kneading and for plasticizing by a screw mechanism of the mold injection apparatus 11 in a manner that is controlled by the control unit 50. The plasticizing process includes a step of including plasticizers into the resin pellets. The plasticizers serve as to impart flexibility,
30 workability, or stretchability to the resin pellets. The mold injection apparatus 11 is also used for heating these resin pellets such that the resin pellets are in a

molten state. The molten state allows the resin to be injected into the mold cavities 16 of the die assembly 12.

The resin pellets includes thermoplastic material or
5 thermosetting material. The thermoplastic material, also known as thermosoftening plastic, refers to a polymer that turns to a liquid when heated and turns to a glassy state when cooled sufficiently. The thermoplastic polymers can be melted and be molded repeatedly. Most thermo-
10 plastics are provided as high-molecular-weight polymers that have chains associate through weak Van der Waals forces as found in polyethylene, through stronger dipole-dipole interactions and hydrogen bonding as found in nylon, or through stacking of aromatic rings as found in
15 polystyrene. The thermoplastic material often has reinforcing fibers produced from ceramic fibers, inorganic fibers, metallic fibers, or organic fibers. In contrast, the thermosetting material, also known as a thermoset plastic, refers to a polymer material that irreversibly
20 cures. The cure may be done through heat that is generally above 200 degree Celsius, through a chemical reaction such as a two-part epoxy, or through irradiation such as electron beam processing.

25 In one example of the resin pellets, the resin pellets are primarily formed from polypropylene and have a length of about 2 to about 100 millimeters. The resin pellets have, in an amount of about 20% to about 80% by weight, reinforcing fibers, which have a length essentially equal
30 to that of the resin pellets and are arranged essentially in parallel. In a case of a mixture of the resin pellets with other pellets not containing reinforcing fibers, the mixture often has reinforcing fibers in an amount of

about 5% to about 70% by weight, preferably about 5% to about 60% by weight.

5 The injection head insert 30 is intended for engaging the mold injection apparatus 11 that provides the molten resin.

10 The molten resin is intended for transmitting from the mold injection apparatus 11 through the runner 32 of the runner insert 26, through the runners 17, and through the runner outlets 17 to the mold cavities 16.

15 The mold cavities 16 are used for receiving the molten resin and for forming the received molten resin into a pre-determined shape. The formed resin solidifies when sufficiently cooled to form moldings or products. In the open position, the stationary die 13 is positioned apart from the movable die 14 such that the finished moldings can be removed. The ejector pins 24 are used for removing
20 the finished moldings by urging the finished moldings out of the open die assembly 12.

The control unit 50 controls the hydraulic pistons 25. The control unit 50 has a sequence control circuit, such
25 as a digital sequencer, which can be programmed to move the moving cores 18. In particular, the hydraulic pistons 25 can position its respective wedges 22 towards the lifting block 23 or away from the lifting block 23.

30 When the wedges 22 are positioned towards the lifting block 23, the wedges 22 exerts a pressure force on the lifting block 23 to move the lifting block 23 together with the moving cores 18 towards the stationary die 13.

The moving cores 18 then assume the reduced volume position. In this position, the hydraulic pistons 25 exert forces that are transmitted via the wedges 22, via the lifting block 23, and via the moving cores 18 to the mol-
5 ten resin in the mold cavities 16 to further compress it.

The machine bed 33 is intended for supporting and for fixing the stationary parts of the injection molding machine 10 and the stationary parts of the mold injection
10 apparatus 11.

In one implementation, inclined surfaces 27 of two wedges 22 are inclined at an angle of about 3 degrees, as illustrated in Figs. 7 and 8. Two piston rods 31 exert a pres-
15 sure on these two wedges 22. The pressure on each wedge 22 extends over a circular area with a diameter of 25 millimeters. This area corresponds to an area of 4.91 cm² (centimeter square). This pressure in turn exerts a force on a molding of a die assembly over a projected area of
20 1.9 cm².

Assuming that each piston rod 31 exerts a pressure of 80 bar on the wedge 22 and assuming no frictional loss, each wedge 22 would then transmit a force of 75538 Newton =
25 [80 x 10 x 4.91 / (tangent of 3 degrees)] onto the moving core 18. This then translates to a total force of 151076 Newton from the two wedges 22 on the molding or to a total pressure of 7951 bar on the molding. This calculated pressure is higher than 900 bars, which is the maximum
30 that most injection machines of the prior art can produce.

One method of using the injection molding machine 10 is described below.

The method includes a step of closing the die assembly 12 such that the movable die 14 presses the stationary die 13 to form the mold cavities 16.

5

The mold injection apparatus 11 receives resin pellets. A screw mechanism of the mold injection apparatus 11 then kneads and plasticize the resin pellets. The resin pellets are also uniformly mixed. During the kneading and the plasticizing process, the resin pellets are heated such that the resin pellets in the mold injection apparatus 11 become molten.

The molten resin is then extruded or is forced into the runners 17 of the die assembly 12. The forcing also pushes the molten resin into the channels 17 that deliver the molten resin into the mold cavities 16.

At the same time or a short time afterwards, as controlled by the control unit 50, the piston rods 31 move the wedges 22 away from the lifting block 23 to allow the moving cores 18 to move to the normal volume position. The pressure of the molten resin in the mold cavities 16 may push the moving cores 18 farther away from the stationary die 13 thereby bringing the moving cores 18 into the normal volume position. The molten resin may completely fill the mold cavities 16 in this state.

After this, the control unit 50 controls the piston rods 31 to bring the moving cores 18 into the reduced volume position. This is accomplished by the piston rods 31 moving the wedges 22 toward the lifting block 23. This in turn pushes the lifting block 23 towards the stationary

die 13. The moving cores 18 together with the lifting block 23 are then positioned nearer to the stationary die 13.

- 5 In the reduced volume position, the moving cores 18 also block the channels 17 and stop the molten resin from entering into the mold cavities 16.

In addition, in this position, the molten resin is moved
10 away from a separation line or area that is defined by the die assembly 12. In the closed position, the movable die 13 is placed directly next to the stationary die 12 such that both dies 12 and 13 defines the said separation line. The separation line often has an area for holding a
15 thin layer of excess resin material, which is also called a burr or flash. The moving of the resin away from the separation line reduces or eliminates the formation of the said excess material on the resin or molding.

20 The blocking of the channels 17 by the moving cores 18 has an advantage of allowing the molten resin to take up essentially the entire pressure of the moving cores 18 without pressure getting lost back into the channels 17. In other words, the exerting forces of the moving cores
25 18 are efficiently transmitted to the molten resin with no or little losses. This is especially beneficial for a molten resin that is rather stiff. This manner of blocking is also very simple to design and easy to implement, since no additional moving parts are used. This is unlike
30 other implements that use additional plungers or valves to block a flow of molten resin.

The reduction of the volume of the mold cavities 16 also urges the mold cavities 16 to be completely filled with the molten resin. Put differently, the molding surface of the mold cavities 16 would have close contact with the molten resin. Mold cavities with small features or mold cavities that are thin may not be easily filled completely with the molten resin. The pressure of the cavity reduction would help to reduce or to remove this incomplete filling. Thus, a more consistent complete filling of the mold cavities 16 is ensured.

After this, the molten resin is cooled. Cooling fluid, such as water or oil, may be transferred to a cooling chamber of the die assembly 12 to cool the molten resin. Such a cooling chamber is not shown in the figures.

When the resin has solidified sufficiently to form the desired molding, the control unit 50 controls the piston rods 31 to bring the moving cores 18 back into the normal volume position. The die clamping movable plate is also actuated to move the die assembly 12 back to the opened position, wherein the stationary die 13 is separated from the movable die 14. The ejector actuation plate is then activated to move the ejector pins 24 to remove the finished moldings out of the die assembly 12.

The finished moldings then drop into a bin or container that is provided under the injection molding machine 10. A robotic arm may also pick up the falling finished moldings for transferring to the bin.

Fig. 9 shows an embodiment of the compression mechanism of Fig. 7. The hydraulic pistons 25 are connected to the

control unit 50 via hydraulic lines that includes pressure sensors 34. The wedges 22 have movement sensors 51, which are also connected to the control unit 50.

5 The pressure sensors 34 are used for measuring pressure exerted by the wedges 22 on the lifting block 23. The movement sensors 51 are used for measuring movements or positions of the wedges 22. Readings of the sensors 34 and 51 are transmitted to the control unit 50, wherein
10 the control unit 50 uses these readings for controlling the hydraulic pistons 25 and for controlling the mold injection apparatus 11.

The pressure readings provide an indication of the pressure exerted on the molten resin within the mold cavity.
15 The pressure is transmitted from the wedges 22 to the moving core 18 and to the molten resin within the mold cavity. In contrast, the movement readings are used to provide an indication of the volume of the molten resin
20 within the mold cavity.

A pre-determined pressure of the wedges 22 corresponds to a molding pressure, wherein the molding pressure refers to a pressure of the molten resin within the mold cavity
25 that is needed to form the molten resin.

One method of using the compression mechanism for the injection molding machine 10 is shown a flow chart 55 of Fig. 10.

30

The flow chart 55 shows a step 58 of closing the die assembly 12. After this, the amount or volume of molten resin for injecting into the mold assembly 12 is deter-

mined, in a step 61. The molten resin of the determined volume is later injected into the closed mold assembly 12, in a step 64.

5 The control unit 50 then advances the moving core 18 by a predetermined distance, in a step 67. The advancement is achieved by controlling the hydraulic pistons 25 to exert pressure on the wedges 22 in which the pressure causes the moving core 18 to advance. The pressure is transmit-
10 ted from the wedges 22 to the lifting block 23 and to the molten resin within the mold cavity.

The pressure sensors 34 later measure the pressure that causes the advancement of the moving core 18, in a step
15 70. This measured pressure value is then transmitted to the control unit 50. Afterward, the measured pressure value is compared with a pre-determined maximum pressure value, in a step 73. If the measured pressure value is not greater than or is equal to the maximum pressure
20 value, the step 67 of advancing the moving core 18 is performed again. The step 67 is repeated until the measured pressure value is greater than or is equal to the maximum pressure value.

25 On the other hand, if the measured pressure value is greater or is equal to the maximum pressure value, the movement sensor 51 then measures the advancement of the moving core 18 corresponding to the maximum pressure value, in a step 76. The measured advancement is later
30 transmitted to the control unit 50.

The measured advancement is afterward compared with a desired advancement value, in a step 79. The measured ad-

vancement provides an indication of the volume of the molten resin in the die assembly 12. If the measured advancement is not essentially the same as a desired advancement, the amount or the volume of the next molten resin for injecting is adjusted, in a step 82. The step 5 64 of injecting the molten resin is then repeated.

The measured advancement provides feedback data which can be used to control accurately the volume of the injected molten resin within the mold cavity. This implementation 10 is different from other implementation that focuses on accurate injecting of molten resin without data from a molding machine.

15 Although the above description contains much specificity, this should not be construed as limiting the scope of the embodiments but merely providing illustration of the foreseeable embodiments. The above stated advantages of the embodiments should not be construed especially as 20 limiting the scope of the embodiments but merely to explain possible achievements if the described embodiments are put into practice. Thus, the scope of the embodiments should be determined by the claims and their equivalents, rather than by the examples given.

Reference numbers

	10	injection molding machine
	11	mold injection apparatus
5	12	die assembly
	13	stationary die
	14	movable die
	15	cavity plate
	16	cavity
10	17	channel
	18	moving core
	19	moving apparatus
	20	core plate
	21	outlet
15	22	wedge
	23	lifting block
	24	ejector pin
	25	hydraulic piston
	26	runner insert
20	27	inclined surface
	28	clamping plate
	29	inclined surface
	30	injection head insert
	31	piston rod
25	32	runner
	33	bed
	34	pressure sensor
	36	intermediary plate
	38	base clamp plate
30	39	knee lever mechanism
	40	support ring
	41	hydraulic piston
	42	inferior ejector plate

	44	superior ejector plate
	45	central opening
	47	central opening
	50	control unit
5	51	movement sensor
	55	flow chart
	58	step
	61	step
	64	step
10	67	step
	70	step
	73	step
	76	step
	79	step
15	82	step

Patent Claim

1. A method of producing an injection moulding comprising
5 injecting a predetermined volume of a molten resin into an internal cavity of a die assembly, applying a pre-determined pressure on the molten resin within the internal cavity by a moving core,
10 measuring a position of the moving core, and adjusting the predetermined volume of a molten resin for a subsequent injecting when the position of the moving core is different from a pre-determined position.
15
2. The method according to claim 1, wherein the application of the pre-determined pressure on the molten resin comprises
20 - advancing the moving core by a pre-determined distance,
 - measuring the pressure being applied to the molten resin, and
 - repeating the advancing of the moving core and the measuring of the pressure when the measured pressure
25 is less than a pre-determined pressure.
3. A method of producing an injection moulding comprising
30 injecting a molten resin into an internal cavity of a die assembly, wherein the molten resin flows into the internal cavity via an outlet of a resin channel and

advancing a movable core into the internal cavity, such that the volume of the internal cavity is reduced and that the movable core closes the outlet of the resin channel.

5

4. The method according to claim 3, wherein only after the molten resin being injected into the internal cavity, the movable core is advanced such that the volume of the internal cavity is reduced.

10

5. The method according to claim 3, wherein the movable core advances while the molten resin is being injected into the internal cavity.

15

6. The method according to one of claims 3 to 5, wherein the volume of molten resin being injected into the internal cavity of the die assembly is adjusted according to positional data of movable core.

20

7. A molding apparatus comprising a first mold-defining member and a second mold-defining member, wherein the first mold-defining member together with the second mold-defining member defines an internal cavity in a closed state of the molding apparatus,

25

at least one channel, the channel comprising an inlet for receiving molten resin and a channel outlet to the internal cavity, and

30

at least one movable core being movable between a first position and a second position, - wherein the at least one movable core in the second position reduces a volume of the internal cavity,

- wherein the at least one movable core in the second position closes the channel outlet, and
 - wherein the at least one movable core is independently movable with respect to the first mold-defining member and with respect to the second mold-defining member.
- 5
8. The molding apparatus according to claim 7, wherein the channel comprises at least one groove in the first mold-defining member.
- 10
9. The molding apparatus according to claim 8, wherein the channel comprises at least one groove in the second mold-defining member, the groove in the second mold-defining member being at least partly complementary to the groove in the first mold-defining member.
- 15
10. The molding apparatus according to one of claims 7 to 9, wherein the moveable core is at least partly provided in the first mold-defining member.
- 20
11. The molding apparatus according to one of claims 7 to 10, wherein the moveable is at least partly provided in the second mold-defining member.
- 25
12. The molding apparatus according to one of claims 7 to 11 further comprising a mechanism for actuating the movable core.
- 30
13. The molding apparatus according to claim 12, wherein

the mechanism comprises a positional sensor.

14. The molding apparatus according to one of claims 7
to 13 further comprising
5 a device for actuating the first mold-defining mem-
ber.
15. The molding apparatus according to claim 14, wherein
the device comprises a pressure sensor.
10
16. A molding machine comprising
a molding apparatus according to one of the
afore-mentioned claims,
a mold injection device for providing molten
15 resin to the molding apparatus, and
a machine bed for supporting the molding appa-
ratus and the mold injection device.
17. The molding machine according to claim 16 further
20 comprises
a control unit, wherein the control unit comprises a
port for controlling the mold injection device ac-
cording to a positional data of the molding appa-
tus.
25

Patent Claim

1. A method of producing an injection moulding comprising

5 injecting a predetermined volume of a molten resin into an internal cavity of a die assembly, wherein the molten resin flows into the internal cavity via an outlet of a resin channel,

10 advancing a movable core into the internal cavity, such that the volume of the internal cavity is reduced,

applying a pre-determined pressure on the molten resin within the internal cavity by the moving core,

15 measuring a position of the moving core, and adjusting the predetermined volume of a molten resin for a subsequent injecting when the position of the moving core is different from a pre-determined position,

20 wherein the advancing of the moveable core is done such that the movable core closes the outlet of the resin channel.

- 
2. The method according to claim 1, wherein

25 the application of the pre-determined pressure on the molten resin comprises

- advancing the moving core by a pre-determined distance,

30 - measuring the pressure being applied to the molten resin, and

- repeating the advancing of the moving core and the measuring of the pressure when the measured pressure is less than a pre-determined pressure.

3. The method according to claim 1, wherein
only after the molten resin being injected into the
internal cavity, the movable core is advanced such
5 that the volume of the internal cavity is reduced.
4. The method according to claim 1, wherein
the movable core advances while the molten resin is
being injected into the internal cavity.
10
5. The method according to one of claims 1 to 4, where-
in
the volume of molten resin being injected into the
internal cavity of the die assembly is adjusted ac-
15 cording to positional data of movable core.
6. A molding machine comprising
a molding apparatus comprising
a first mold-defining member and a second
20 mold-defining member, wherein the first mold-
defining member together with the second mold-
defining member defines an internal cavity in a
closed state of the molding apparatus,
at least one channel, the channel compris-
25 ing an inlet for receiving molten resin and a
channel outlet to the internal cavity,
at least one movable core being movable
between a first position and a second position,
and
30 a mechanism for actuating the movable core,
- wherein the mechanism comprises a positional
sensor,

- wherein the at least one movable core in the second position reduces a volume of the internal cavity, and

5

- wherein the at least one movable core is independently movable with respect to the first mold-defining member and with respect to the second mold-defining member,

a mold injection device for providing molten resin to the molding apparatus,

10

a machine bed for supporting the molding apparatus and the mold injection device, and

a control unit, wherein the control unit comprises a port for controlling the mold injection device according to a positional data of the molding apparatus,

15

- wherein the at least one movable core in the second position closes the channel outlet.

7. The molding machine according to claim 6, wherein
20 the channel comprises at least one groove in the first mold-defining member.

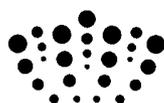
8. The molding machine according to claim 7, wherein
25 the channel comprises at least one groove in the second mold-defining member, the groove in the second mold-defining member being at least partly complementary to the groove in the first mold-defining member.

30

9. The molding machine according to one of claims 6 to 8, wherein the moveable core is at least partly provided in the first mold-defining member.

10. The molding machine according to one of claims 6 to 9, wherein
the moveable core is at least partly provided in the
5 second mold-defining member.
11. The molding machine according to one of claims 6 to 10 further comprising
a device for actuating the first mold-defining mem-
10 ber.
12. The molding machine according to claim 11, wherein
the device comprises a pressure sensor.





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Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 2 16 & 17	JP2001018269 A (MITSUBA CORP et al) see especially WPI abstract accession number: 2001-229478 [24] and figures
X	1, 16 & 17	JP08174616 A (UBE INDUSTRIES) see especially WPI abstract accession number: 1996-366893 [37] and figures

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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

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Worldwide search of patent documents classified in the following areas of the IPC

B29C

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B29C	0045/56	01/01/2006
B29C	0045/76	01/01/2006