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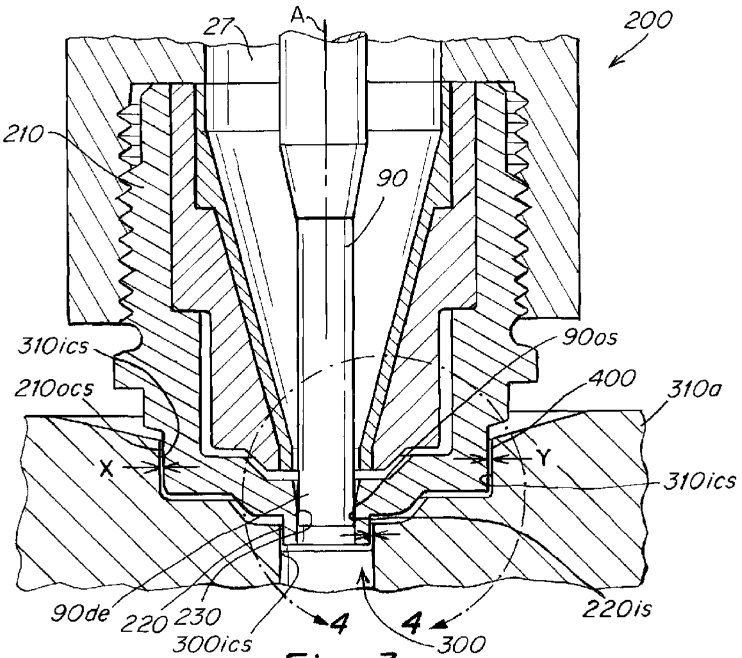

Fig. 3

(57) Abstract: An assembly (200) for routing an injection fluid (23) to a mold cavity (80) comprising: a distal nozzle tip (210) comprising a distal projection (220), a mold (310a, 310b) having a cavity entrance aperture (300) having an inner circumferential surface (300ics), the distal nozzle tip (210) being mounted such that the distal projection (220) is disposed in a stationary position wherein an outer circumferential surface (220ocs) is disposed adjacent the inner circumferential surface (300ics) forming a gap (Z) having a width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

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[Continued on next page]

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DOUBLE SEAL VALVE PIN TIP WITH VENT

RELATED APPLICATIONS

[001] This application claims the benefit of priority to U.S. Provisional Application Serial No. 62/490,078 filed April 26, 2017.

[002] The disclosures of all of the following are incorporated by reference in their entirety as if fully set forth herein: U.S. Patent No. 5,894,025, U.S. Patent No. 6,062,840, U.S. Patent No. 6,294,122, U.S. Patent No. 6,309,208, U.S. Patent No. 6,287,107, U.S. Patent No. 6,343,921, U.S. Patent No. 6,343,922, U.S. Patent No. 6,254,377, U.S. Patent No. 6,261,075, U.S. Patent No. 6,361,300 (7006), U.S. Patent No. 6,419,870, U.S. Patent No. 6,464,909 (7031), U.S. Patent No. 6,599,116, U.S. Patent No. 7,234,929 (7075US1), U.S. Patent No. 7,419,625 (7075US2), U.S. Patent No. 7,569,169 (7075US3), U.S. Patent No. 8297836 (7087) U.S. Patent Application Serial No. 10/214,118, filed August 8, 2002 (7006), U.S. Patent No. 7,029,268 (7077US1), U.S. Patent No. 7,270,537 (7077US2), U.S. Patent No. 7,597,828 (7077US3), U.S. Patent Application Serial No. 09/699,856 filed October 30, 2000 (7056), U.S. Patent Application Serial No. 10/269,927 filed October 11, 2002 (7031), U.S. Application Serial No. 09/503,832 filed February, 15, 2000 (7053), U.S. Application Serial No. 09/656,846 filed September 7, 2000 (7060), U.S. Application Serial No. 10/006,504 filed December 3, 2001, (7068), US Patent 9,011,736 (7100US1), U.S. Patent No. 9,005,509 (7100US3), U.S. Application Serial No. 10/101,278 filed March, 19, 2002 (7070) and PCT Application No. PCT/US11/062099 (7100WO0) and PCT Application No. PCT/US11/062096 (7100WO1), U.S. Patent No. 8,562,336, U.S. Patent No. 8,091,202 (7097US1) and U.S. Patent No. 8,282,388 (7097US2), U.S. Patent No. 9,724,861 (7129US4), U.S. Patent No. 9662820 (7129US3), U.S. Patent No. 9492960 (7135US1), Publication No. WO2015006261 (7135WO0), Publication No. WO2014209857 (7134WO0), Publication No. WO2015105777 (7143), Publication No. WO2016153632 (7149WO2), International publication no. WO2016153704 (7149WO4), U.S. Patent No. 9205587 (7117US0), U.S. Application Serial No. 15/432,175 (7117US2) filed February 14, 2017, U.S. Patent No. 9144929 (7118US0), U.S. Publication No. 20170341283 (7118US3), International Application PCT/US17/043029 (7165WO0) filed

July 20, 2017, International Application PCT/US17/043100 (7165WO1), filed July 20, 2017, International Application PCT/US17/036542 (7163WO0) filed June 8, 2017, International Application PCT/US18/017422 filed February 8, 2018 (7172WO0), International application PCT/US18/021907 filed March 12, 2018 (7173WO0) and U.S. Application Serial No. 15/648588 filed July 13, 2017 (7129US7).

BACKGROUND OF THE INVENTION

[003] Injection molding systems having nozzle inserts and configurations that form circumferential gaps and pockets with the flow channel of the nozzle that do not provide a fluid seal or air venting have been used in systems such as shown in PCT/US15/10270 and PCT/US2016/022452. Such prior art systems typically use a valve pin 80 having a distal tip end surface that is tapered and driven into forcible engagement with a surface of a mold body 310gs, Fig. 2, for purposes of closing off a gate 300 in order to stop flow of injection fluid at the beginning and end of an injection cycle.

SUMMARY OF THE INVENTION

[004] In accordance with the invention there is provided an assembly (200) for routing an injection fluid (23) to a mold cavity (80) in an injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b), the assembly (200) comprising:

a distal nozzle tip (210) comprising a distal projection (220) having an outer circumferential surface (220ocs) and a central bore (230) that communicates with the fluid delivery channel (27) and having an inner surface (220is) adapted to receive a distal end (90de) of the valve pin (90),

a mold (310a, 310b) having a cavity entrance aperture (300) forming a gate through which the injection fluid (23) is routed into the cavity (80), the cavity entrance aperture (300) having an inner circumferential surface (300ics), the distal nozzle tip (210) being mounted such that the distal projection (220) is disposed in a stationary position within the mold body aperture (300) wherein the outer circumferential surface (220ocs) of the distal nozzle tip (210) is disposed adjacent the inner circumferential surface (300ics) forming a gap (Z) having a width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

[005] The mold (310a, 310b) can have an upstream inner circumferential surface (310ics) disposed upstream of the downstream inner circumferential surface (300ics) and the distal nozzle tip (210) can have an upstream outer circumferential surface (210ocs), the distal nozzle tip (210) being mounted such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

[006] The size or width of the gap (Z) is preferably selected to prevent flow of injection fluid upstream (AU1) through the gap (Z).

[007] The size or width of the gap (X) is preferably selected to prevent flow of injection fluid upstream (AU2) through the gap (X).

[008] The gap (Z) preferably ranges between about 0.015 mm and about 0.05 mm and the gap (X) preferably ranges between 0.00 and about 0.015 mm.

[009] The distal nozzle tip (210) is typically stationarily mounted to a nozzle body (50) that houses the fluid delivery channel 27, the nozzle body (50) being stationarily mounted relative to the mold body aperture (300) in an arrangement such that the distal projection (220) is stationarily mounted relative to the mold body aperture (300).

[0010] The distal nozzle tip (210) is preferably mounted relative to the mold (310a, 310b) such that air (AU1, AU2) contained within the cavity (80) or the flow passage (27) is ventable to an air space or ambient air (AS) disposed around the assembly (200).

[0011] The nozzle body (50) is typically mounted relative to the heated manifold (30) such that the fluid delivery channel (27) receives the injection fluid from a fluid distribution channel (30d) of the manifold (30) for delivery downstream through the central bore (230) of the distal projection (220).

[0012] The distal end (90de) of the valve pin 90 preferably has an outer circumferential surface (90os) adapted to be slidably driven into engagement with and along a complementary inner surface (220is) of the distal projection (220) when the pin (80) is driven in the upstream downstream path of travel (UD), injection fluid (23) being prevented from flowing through the central bore (230) when the outer circumferential surface (90os) is engaged with the complementary inner surface (220is).

[0013] The outer circumferential surface (90os) and the complementary inner surface (220is) are preferably generally cylindrical in configuration.

[0014] In another aspect of the invention there is provided a method comprising forming an article in the mold cavity (80) of an injection molding apparatus (10) having an assembly as described above.

[0015] In another aspect of the invention there is provided a method of performing an injection molding cycle comprising injecting an injection fluid (23) from an injection molding machine (20) downstream to a heated manifold (30) and further downstream to a fluid delivery channel (27) of a nozzle body (50),

mounting a distal nozzle tip (210) to the nozzle body (50), the distal nozzle tip (27) comprising a distal projection (220) having a central bore (230) communicating with the fluid delivery channel (27) and having an inner surface (230is) adapted to slidably receive and engage an outer surface (90os) of a distal end (90de) of the valve pin (90),

mounting the distal nozzle tip (210) to a mold (310a, 310b) having a mold body aperture (300) having an inner circumferential surface (300ics), the mold body aperture (300) forming a fluid flow gate into the mold cavity (80),

mounting the nozzle body (50) in an arrangement such that the distal projection (220) is disposed in a stationary position within the mold body aperture (300) such that an outer circumferential surface (220ocs) of the distal projection (220) forms a gap (Z) having a size or width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

[0016] In such a method the mold (310a, 310b) preferably an upstream inner circumferential surface (310ics) and the distal nozzle tip (210) has an upstream outer circumferential surface (210ocs), the method further comprising: mounting the nozzle body (50) such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

[0017] In another aspect of the invention there is provided an assembly (200) for routing an injection fluid (23) to a mold cavity (80) in an injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b), the assembly (200) comprising:

a distal nozzle tip (210) having an upstream outer circumferential surface (210ocs) and a central bore (230) that communicates with the fluid delivery channel (27),

a mold (310a, 310b) having an upstream inner circumferential surface (310ics) disposed upstream of a cavity entrance aperture (300),

the distal nozzle tip (210) being mounted such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

[0018] The distal nozzle tip (210) preferably includes a distal projection (220) having an inner surface (220is) adapted to receive a distal end (90de) of the valve pin (90) and the mold (310a, 310b) includes a cavity entrance aperture (300) adapted to receive the distal projection (220) and forming a gate through which the injection fluid (23) is routed into the cavity (80).

[0019] The distal projection (220) preferably has an outer circumferential surface (220ocs) and the cavity entrance aperture (300) has an inner circumferential surface (300ics), the distal nozzle tip (210) being mounted such that the distal projection (220) is disposed in a stationary position within the mold body aperture (300) wherein the outer circumferential surface (220ocs) is disposed adjacent the inner circumferential surface (300ics) forming a gap (Z) having a width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

[0020] The size or width of the gap (Z) is preferably selected to prevent flow of injection fluid upstream (AU1) through the gap (Z).

[0021] The size or width of the gap (X) is preferably selected to prevent flow of injection fluid upstream (AU2) through the gap (X).

[0022] The gap (Z) preferably ranges between about 0.015 mm and about 0.05 mm and the gap (X) ranges between 0.00 and about 0.015 mm.

[0023] The distal nozzle tip (210) is typically stationarily mounted to a nozzle body (50) that houses the fluid delivery channel 27, the nozzle body (50) being stationarily mounted relative to the mold body aperture (300) in an arrangement such that the distal projection (220) is stationarily mounted relative to the mold body aperture (300).

[0024] The nozzle body (50) is preferably mounted relative to the heated manifold (30) such that the fluid delivery channel (27) receives the injection fluid from a fluid distribution channel (30d) of the manifold (30) for delivery downstream through the central bore (230) of the distal projection (220).

[0025] The distal end (90de) of the valve pin 90 preferably has an outer circumferential surface (90os) adapted to be slidably driven into engagement with and along a complementary inner surface (220is) of the distal projection (220) when the pin (80) is driven in the upstream downstream path of travel (UD), injection fluid (23) being prevented from flowing through the central bore (230) when the outer circumferential surface (90os) is engaged with the complementary inner surface (220is).

[0026] The outer circumferential surface (90os) and the complementary inner surface (220is) are typically generally cylindrical in configuration.

[0027] In another aspect of the invention there is provided a method of performing an injection molding cycle comprising forming an article in the mold cavity (80) of an injection molding apparatus (10) having any assembly as described above.

[0028] In another aspect of the invention there is provided an injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b) and an assembly (200) comprising:

a distal nozzle tip (210) comprising a distal projection (220) having an outer circumferential surface (220ocs) and a central bore (230) that communicates with the fluid delivery channel (27) and having an inner surface (220is) adapted to receive a distal end (90de) of the valve pin (90),

a mold (310a, 310b) having a cavity entrance aperture (300) forming a gate through which the injection fluid (23) is routed into the cavity (80), the cavity entrance aperture (300) having an inner circumferential surface (300ics),

the distal nozzle tip (210) being mounted such that the distal projection (220) is disposed in a stationary position within the mold body aperture (300) wherein the outer circumferential surface (220ocs) of the distal nozzle tip (210) is disposed adjacent the inner circumferential surface (300ics) forming a gap (Z) having a width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

[0029] In another aspect of the invention there is provided an injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b), and an assembly (200) comprising:

a distal nozzle tip (210) having an upstream outer circumferential surface (210ocs) and a central bore (230) that communicates with the fluid delivery channel (27),

a mold (310a, 310b) having an upstream inner circumferential surface (310ics), the distal nozzle tip (210) being mounted such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

Brief Description Of The Drawings

[0030] Fig. 1 is a cross-sectional view of an injection molding machine, hotrunner or heated manifold, nozzle, mold body and nozzle with conventional nozzle tip, tapered valve pin and complementary mold aperture that mates with the tapered tip end of the valve pin.

[0031] Fig. 2 is an enlarged fragmentary view of the tip of the nozzle and complementary mold aperture components of the Fig. 1 system.

[0032] Fig. 3 is a view similar to Fig. 2 showing a nozzle with distal end nozzle inserts and valve pin configurations according one embodiment of the invention.

[0033] Fig. 4 is an enlarged detail view of the area enclosed by arrows 4-4 of Fig. 3.

[0034] Fig. 5 is a cross sectional plan view taken along lines 5-5 of Fig. 4.

[0035] Fig. 6 is an exploded perspective view of the Figs. 4, 5 components.

[0036] Fig. 7A is sectional view similar to Fig. 4 showing additional components including the mold components and showing the distal end of a cylindrically configured valve pin in a gate closed disposition or position.

[0037] Fig. 7B is a section view similar to Fig. 7A showing the valve pin in a gate open upstream position.

[0038] Fig. 8 is a sectional schematic view of a pair of nozzles gated to a single mold cavity, the nozzles having a configuration similar to the nozzles of Figs. 4 and 7A, 7B and being arranged in a sequential valve gate configuration where one nozzle is selected to be first opened during the course of an injection and the other downstream nozzle is initially closed and later opened after injection fluid travels from the exit of the first nozzle through the mold cavity past the exit of the other downstream nozzle.

[0039] schematic cross-sectional view of the distal end of a preferred embodiment of an assembly according to the invention.

DETAILED DESCRIPTION

[0040] Fig. 1 shows an injection molding system 10 comprised of a top clamp plate 13, an actuator 15 that reciprocally drives an interconnected valve pin 90 in an upstream-downstream path UD between gate open and gate closed positions as shown in Figs. 3A, 3B. The valve pin 90 is preferably arranged such that the valve pin is mounted within a guide aperture 90a that extends through a hotrunner or heated manifold 30 and further extends through a fluid material 23 flow channel 30c that is disposed within the heated manifold 30. The nozzle 50 sealably interconnects the manifold flow channel 30c with a central nozzle flow channel 27. The apparatus 10 typically includes a controller 16 that controls the upstream-downstream UD movement of the valve pin 90 during the course of an injection cycle according to a predetermined algorithm or program that receives a signal indicative of axial position of the valve pin 90 from a position sensor 92, the algorithm or program using the position signal to instruct the actuator to controllably drive the valve pin to any desired one or more axial positions during the course of an injection cycle.

[0041] As shown in Fig. 1, a heating device such as a controllably heatable electrical coil mechanism is mounted around the outer circumferential surface of the nozzle body 50 of a valve 200.

[0042] The injection machine 20 injects fluid material 23 under pressure in a downstream direction D into the fluid distribution channels 30d of the heated manifold 30. The fluid material 23 is routed further downstream through downstream manifold channel 30c and further downstream into and through the nozzle channel 27 eventually to and through the central bore 230 of the nozzle tip 210 and further downstream through the mold body aperture or gate 300 into mold cavity 80. As described below, some portion of the fluid material 23 travelling downstream through nozzle channel 300 is routed through lateral nozzle apertures 50 and gaps X, Y, Z during the course of downstream flow to and through the gate 300.

[0043] The apparatus 10 includes a mold body 310a, 310b that forms a cavity 80 the fluid flow entrance to which is aperture or gate 300 with which the travel or drive axis A of the nozzle 50 and valve pin 90 is typically coaxially aligned.

[0044] As shown in Fig. 2, the apparatus 10 includes a nozzle assembly (200) that routs the injection fluid material (23) to the mold cavity (80). The nozzle assembly (200) comprises a nozzle tip (210) disposed and typically screwably attached to or at the distalmost end of the nozzle body 50. The assembly comprises a distal projection (220) having a downstream central bore (230) that communicates with the upstream fluid delivery channel (27). The central bore 230 has an inner surface (230is) adapted to slidably receive a complementary in shape outer surface (90os) of a distal end (90de) of the valve pin (90).

[0045] The mold body aperture (300) if formed to have an inner circumferential surface (300ics) having a circumferential size that can receive the distal projection 220. The mold body aperture (300) acts as a fluid flow passage or gate into the mold cavity (80) for injection fluid 23 flowing downstream through the main nozzle flow channel 27. The distal nozzle tip 210 is typically fixedly or stationarily mounted or attached to the nozzle body 50 which in turn is stationarily or fixedly attached or mounted to the manifold 30 which in turn is fixedly or stationarily mounted relative to the mold 310a, 310b resulting in the distal projection 220 being mounted or disposed in a stationary position within the mold body aperture 300 such that an outer circumferential surface 220ocs of the distal projection 220 abuts, faces or is adjacent the inner circumferential surface (300ics) of the mold body aperture (300).

[0046] The outer circumferential surface 220ocs and the inner circumferential surface 300ics are configured to form an air gap Z between the outer circumferential surface 220ocs and the inner circumferential surface 300ics of a size sufficient to enable air to travel upstream AU1 through the gap Z upon mounting of the distal projection 220 within the mold body aperture 300 and downstream movement D of the distal end 90de of the valve pin 90 through the central bore 230 of the distal projection 220.

[0047] The gap (Z) between the outer circumferential surface (220ocs) and the inner circumferential surface 300ics is preferably at least 0.015 mm and typically ranges from about 0.015 mm to about 0.050 mm, more preferably from about 0.015 mm to about 0.025 mm and most preferably from about 0.015 mm to about 0.020 mm.

[0048] The nozzle body 50 is mounted relative to the heated manifold 30 such that the fluid delivery channel (27) receives the injection fluid from a fluid distribution channel (30d) of the manifold (30) for delivery downstream through the central bore (230) of the distal projection (220).

[0049] The mold body 310a, 310b is configured to have an upstream inner circumferential surface (310ics) that is formed to be of such a size and configuration as to be capable of receiving the distal nozzle tip (210) where the upstream inner circumferential surface 310ics of the mold body and the upstream outer circumferential surface (210ocs) abut, are adjacent to or face each other leaving an air gap X of preferably 0.015 mm or less (typically from about 0.015 mm to about 0.007 mm) between the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs).

[0050] In an alternative embodiment some portion of the circumferential surface 210ocs of the nozzle insert 210 can be configured as a flat 400 or other recess formed on the surface 210ocs that forms a larger than 0.05 mm gap or space between the surface 210ocs and the inner surface 310ics of the mold body 310a such that air can more readily vent upstream through an enlarged space or vent Y greater than 0.025 mm.

[0051] As shown in Figs. 3-6, the flat or recess 400 has a width W which is typically a relatively small portion of the overall circumference of the outer circumferential surface 210ocs.

[0052] As shown in Figs. 3-6 the distal nozzle tip (210) comprises a distal projection (220) having an outer circumferential surface (220ocs) and an inner surface (220is) adapted to slidably receive and engage the outer circumferential surface 90os of the distal end (90de) of the valve pin (90) such that fluid flow 23 through the passage 230 and gate 300 can be stopped.

[0053] The mold (310a, 310b) is formed to include an upstream inner circumferential surface (310ics) for receiving an upstream outer circumferential surface (210ocs) of the distal nozzle tip (210). The nozzle tip 210 is mounted and arranged to form a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220). The size or width of the gap (X) preferably is selected to prevent flow of injection fluid upstream (AU2) through the gap (X).

[0054] Similarly, the size or width of the gap (Z) is selected to prevent flow of injection fluid upstream (AU1) through the gap (Z). As shown, the outer circumferential surface (90os) and the complementary inner surface (220is) of the distal end projection are generally cylindrical in configuration.

[0055] The valve pin 90 is typically controllably drivable by the actuator 15 and the controller 16 upstream and downstream UD along the axis A between a first start of injection cycle closed position, Fig. 7A where the tip end 1142 of the valve pin 90 obstructs the gate 300 to prevent the injection fluid 23 from flowing into the cavity 80 and a full open position, Fig. 7B, where the injection fluid material flows freely without restriction from the tip end 1142 of the pin 90 through the gate at a maximum pressure, the pressure of the injection fluid associated with the nozzle varying between zero at the beginning of the injection cycle when the valve pin 90 is in the first closed position and the maximum pressure.

[0056] The controller 16 typically includes instructions that instruct the actuator 15 to controllably drive the axial UD position of the valve pin 90 between one or more selected positions that vary the pressure or rate of flow of the injection fluid 23 through the gate 300.

[0057] The controller 16 can include a set of instructions that instruct the actuator to controllably drive the valve pin to be disposed or held in a position intermediate the closed position and the full open position for a selected period of time during the course of an injection cycle such that the pressure or rate of flow of the injection fluid 23 is held at a single selected reduced pressure relative to the maximum pressure for the selected period of time.

[0058] Alternatively the controller 16 can include a set of instructions that instruct the

[0059] Figs. 7A, 7B show a system where the valve pin 90 has a cylindrically configured tip end 1155, the tips end of the pin 90 can be positioned at various times and positions between a starting closed position as in Fig. 7A and various upstream opened positions, RP wherein RP represents a path of selectable length over the course of which the velocity of upstream withdrawal of the pin 90 from the gate closed position Fig. 7A to an open position is reduced via a controllable flow restrictor or electric actuator) relative to a maximum velocity of upstream movement that the valve pin would normally have over the uncontrolled velocity path FOV when the hydraulic pressure or electric actuator speed is normally at full pressure or electric power and pin velocity is at its maximum. Thus, the controller 16 can be programmed to drive the valve pin 90 at reduced velocity over any portion or all of the stroke length or travel path of the pin 90 upstream or downstream as well as over any portion or all of the duration of the injection cycle. Thus, the controller 16 can be programmed to drive the valve pin 90 upstream beginning from a gate closed position, Fig. 7A, at a reduced velocity for a selected period of time or over a select length of travel. Or the controller 16 can included instructions that instruct the valve pin to be driven at a reduced velocity relative to maximum when being driven downstream beginning from a fully unrestricted intermediate gate open position COP2, Fig. 7B, or from a maximum upstream position EOS downstream toward and to the gate closed position, Fig. 7A.

[0060] The outer surface 90os of the tip end 1155 of the valve pin 90 and the interior surface 230is of the bore 230 can be configured or adapted to cooperate with each other to restrict and vary the rate of flow of fluid material 1153, Figs. 3A, 3B over the course of travel of the tip end of the valve pin through the restricted velocity path RP. Most typically as shown in Figs. 7A, 7B, the outside circumferential surface 90os of the tip end 1155 of the pin 90 is cylindrical in configuration and the inner surface 230is has a complementary cylindrical surface 1254 with which the tip end surface 90os mates to close the gate 300 when the pin 90 is in the downstream gate closed position. Thus the outside radial surface 90os of the tip end 1155 of the pin 90 can create a restricted flow channel 1154 over the length of travel of the tip end 1155 through and along restricted flow path RP that restricts or reduces the volume or rate of flow of fluid material 1153 relative to the rate of flow when the pin 90 is at a full gate open position, namely when the tip end 1155 of the pin 90 has travelled to or beyond the length of the restricted flow path RP which can be any selected path and is typically between about 4 mm and 200mm.

[0061] In one embodiment, as the tip end 1155 of the pin 90 continues to travel upstream from the gate closed GC position through the length of the RP path, the rate of material fluid flow 1153 through restriction gap 1154 through the bore 230 and gate 300 into the cavity 30 can continue to gradually increase from 0 at gate closed GC position to a maximum flow rate when the tip end 1155 of the pin reaches a position FOP (full open position). In one embodiment at the expiration of the predetermined amount of time when the pin tip 1155 reaches the COP, FOP (full open) position Figs. 7A, 7B, the pin 90 is immediately driven by the hydraulic system at maximum velocity FOV (full open velocity).

[0062] In alternative embodiments, when the predetermined time for driving the pin at reduced velocity has expired and the tip 1155 has reached the end of restricted flow path RP2, the tip 1155 may not necessarily be in a position where the fluid flow 1155 is not still being restricted. In such alternative embodiments, the fluid flow 1153 can still be restricted to less than maximum flow when the pin has reached the changeover position COP2 where the pin 90 is driven at a higher, typically maximum, upstream velocity FOV. In the alternative examples shown in Fig. 7B, when the pin has travelled the predetermined path length at reduced velocity and the tip end 1155 has reached the changeover point COP, the tip end 1155 of the pin 90 (and its radial surface 90os) no longer restricts the rate of flow of fluid material 1153 through the gap 1154 because the gap 1154 has increased to a size that no longer restricts injection fluid flow 1153 below the maximum flow rate of flow. Thus in Fig. 7B the maximum fluid flow rate for injection material 1153 is reached at the upstream position COP of the tip end 1142. In another example shown in Fig. 7B the pin 90 can be driven at a reduced velocity over a shorter path RP2 that is less than the entire length of the restricted mold material flow path RP and switched over at the end COP2 of the shorter restricted path RP2 to a higher or maximum velocity FOV.

[0063] In another alternative embodiment, shown in Fig. 7B, the pin 90 can be driven and instructed to be driven at reduced or less than maximum velocity over a longer path length RP3 having an upstream portion UR where the flow of injection fluid mold material is not restricted but flows at a maximum rate through the bore 230 and gate 300 for the given injection mold system. In this Fig. 7B example the velocity or drive rate of the pin 90 is not changed over until the tip end of the pin 90 or actuator 15 has reached the changeover position COP3. As in other embodiments, a position sensor 92 senses either that the valve pin 90 or an associated component has travelled the path length RP3 or reached the end COP3 of the selected path length and the controller 16 receives and processes such information and instructs the drive system to drive the pin 90 at a higher, typically maximum velocity upstream. In another alternative embodiment, the pin 90 can be driven at reduced or less than maximum velocity throughout the entirety of the travel path of the pin during an injection cycle from the gate closed position GC up to the end-of-stroke EOS position, the controller 16 being programmed to instruct the drive system for the actuator to be driven at one or more reduced velocities for the time or path length of an entire closed GC to fully open EOS cycle.

[0064] The invention includes configurations where a valve pin 90 is driven downstream starting from a fully upstream, gate open position COP, COP2, EOS at one or more reduced downstream velocities over at least the latter portion of the downstream path of travel of the pin toward the gate where the tip end 1155 of the pin 90 restricts flow of the injection fluid through the bore 230 and gate 300 such as shown in Figs. 7A and 7B. Like reduced upstream velocity, reduced downstream velocity drive of a valve pin 90 through particularly through the restricted flow paths RP can serve to lessen the degree of downward force exerted by the distal tip end surface 1142 of the pin 90 on the injection fluid 1153 that is forcibly pushed through the bore 230 and gate 300 and into the cavity 80 when the tip end of the valve pin travels downstream to a position where the distal tip end surface 1142 closes the gate 300 and bore 230. Such reduced force exerted on the injection fluid 1153 at the very end portion of travel RP of the injection cycle at the entrance 300 to the cavity of the mold thus reduces the likelihood of a blemish or artifact being formed on the part that is formed within the cavity at the gate area 300.

[0065] As shown in Fig. 8, nozzle assemblies 200u, 200d can be employed in a sequentially gated arrangement with one assembly 200u being selected as a first valve to inject fluid 1153 into a cavity 80 at a position upstream from a second assembly 200d disposed at a gate position downstream from the gate position of the first assembly 200u. In a typical sequential injection process, the valve pin 90u of the first selected valve 200u is first opened to allow fluid 1153 to flow downstream past the gate position 300d of the downstream valve 200d before the downstream valve pin 90d is opened. Typically as the fluid 1153 flows past the downstream gate 300d a flow front FF of fluid 1153 travels upstream toward the downstream gate 300d forcing air within the cavity 80d to vent through the air gaps Z, X, Y of the downstream valve 200d. Such venting serves to obviate the formation of air pockets and defects in the final molded product. The same sort of venting of air through the Z, X, Y gaps of valve 200u occurs when the valve pin 90u is first opened as a result of air that may reside in either the upstream gate 300u or within the nozzle passage 27u being forced downstream by the downstream movement of the tip end 90de into the gate area 300u. Again, the purging of air through vents Z, X, y minimizes and obviates formation of defects in the molded part or product that is ultimately formed within the cavity 80.

[0066] As above described, the size or width of the vent passages Z, X, Y is selected such that injection fluid does not flow upstream through the gaps Z, X, Y.

What is claimed is:

1. An assembly (200) for routing an injection fluid (23) to a mold cavity (80) in an injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b), the assembly (200) comprising:

a distal nozzle tip (210) comprising a distal projection (220) having an outer circumferential surface (220ocs) and a central bore (230) that communicates with the fluid delivery channel (27) and having an inner surface (220is) adapted to receive a distal end (90de) of the valve pin (90),

a mold (310a, 310b) having a cavity entrance aperture (300) forming a gate through which the injection fluid (23) is routed into the cavity (80), the cavity entrance aperture (300) having a downstream inner circumferential surface (300ics),

the distal nozzle tip (210) being mounted such that the distal projection (220) is disposed in a stationary position within the cavity entrance aperture (300) wherein the outer circumferential surface (220ocs) of the distal nozzle tip (210) is disposed adjacent the downstream inner circumferential surface (300ics) forming a gap (Z) having a width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

2. An assembly according to claim 1 wherein the mold (310a, 310b) has an upstream inner circumferential surface (310ics) disposed upstream of the downstream inner circumferential surface (300ics) and the distal nozzle tip (210) has an upstream outer circumferential surface (210ocs), the distal nozzle tip (210) being mounted such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

3. An assembly according to any of the foregoing claims wherein the size or width of the gap (Z) is selected to prevent flow of injection fluid upstream (AU1) through the gap (Z).

4. An assembly according to any of the foregoing claims wherein the size or width of the gap (X) is selected to prevent flow of injection fluid upstream (AU2) through the gap (X).

5. An assembly according to any of the foregoing claims wherein the gap (Z) ranges between about 0.015 mm and about 0.05 mm and the gap (X) ranges between 0.00 and about 0.015 mm.

6. An assembly according to any of the foregoing claims wherein the distal nozzle tip (210) is stationarily mounted to a nozzle body (50) that houses the fluid delivery channel 27, the nozzle body (50) being stationarily mounted relative to the mold body aperture (300) in an arrangement such that the distal projection (220) is stationarily mounted relative to the mold body aperture (300).

7. An assembly (200) according to any of the foregoing claims wherein the distal nozzle tip (210) is mounted relative to the mold (310a, 310b) such that air (AU1, AU2) contained within the cavity (80) or the flow passage (27) is ventable to an air space or ambient air (AS) disposed around the assembly (200).

8. An assembly according to any of the foregoing claims wherein the distal end (90de) of the valve pin 90 has an outer circumferential surface (90os) adapted to be slidably driven into engagement with and along a complementary inner surface (220is) of the distal projection (220) when the pin (80) is driven in the upstream downstream path of travel (UD), injection fluid (23) being prevented from flowing through the central bore (230) when the outer circumferential surface (90os) is engaged with the complementary inner surface (220is).

9. An assembly according to any of the foregoing claims wherein the outer circumferential surface (90os) and the complementary inner surface (220is) are generally cylindrical in configuration.

10. A method of performing an injection molding cycle comprising forming an article in the mold cavity (80) of an injection molding apparatus (10) having an assembly according to any of the foregoing claims.

11. A method of performing an injection molding cycle comprising injecting an injection fluid (23) from an injection molding machine (20) downstream to a heated manifold (30) and further downstream to a fluid delivery channel (27) of a nozzle body (50),

mounting a distal nozzle tip (210) to the nozzle body (50), the distal nozzle tip (27) comprising a distal projection (220) having a central bore (230) communicating with the fluid delivery channel (27) and having an inner surface (230is) adapted to slidably receive and engage an outer surface (90os) of a distal end (90de) of the valve pin (90),

mounting the distal nozzle tip (210) to a mold (310a, 310b) having a mold body aperture (300) having an inner circumferential surface (300ics), the mold body aperture (300) forming a fluid flow gate into the mold cavity (80),

mounting the nozzle body (50) in an arrangement such that the distal projection (220) is disposed in a stationary position within the mold body aperture (300) such that an outer circumferential surface (220ocs) of the distal projection (220) forms a gap (Z) having a size or width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

12. The method of claim 11 wherein the mold (310a, 310b) has an upstream inner circumferential surface (310ics) and the distal nozzle tip (210) has an upstream outer circumferential surface (210ocs), the method further comprising:
mounting the nozzle body (50) such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily

disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

13. An assembly (200) for routing an injection fluid (23) to a mold cavity (80) in an injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b), the assembly (200) comprising:

a distal nozzle tip (210) having an upstream outer circumferential surface (210ocs) and a central bore (230) that communicates with the fluid delivery channel (27),

the mold (310a, 310b) having an upstream inner circumferential surface (310ics) disposed upstream of a cavity entrance aperture (300),

the distal nozzle tip (210) being mounted such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

14. An assembly according to claim 13 wherein the distal nozzle tip (210) includes a distal projection (220) having an inner surface (220is) adapted to receive a distal end (90de) of the valve pin (90) and the cavity entrance aperture (300) is adapted to receive the distal projection (220) forming a gate through which the injection fluid (23) is routed into the cavity (80).

15. An assembly according to claims 13-14 wherein the distal projection (220) has an outer circumferential surface (220ocs) and the cavity entrance aperture (300) has an inner circumferential surface (300ics),

the distal nozzle tip (210) being mounted such that the distal projection (220) is disposed in a stationary position within the mold body aperture (300) wherein the outer circumferential surface (220ocs) is disposed adjacent the inner circumferential surface (300ics) forming a gap (Z) having a width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

16. An assembly according to any of the foregoing claims 13-15 wherein the size or width of the gap (Z) is selected to prevent flow of injection fluid upstream (AU1) through the gap (Z).

17. An assembly according to any of the foregoing claims 13-16 wherein the size or width of the gap (X) is selected to prevent flow of injection fluid upstream (AU2) through the gap (X).

18. An assembly according to any of the foregoing claims 13-17 wherein the gap (Z) ranges between about 0.015 mm and about 0.05 mm and the gap (X) ranges between 0.00 and about 0.015 mm.

19. An assembly according to any of the foregoing claims 13-18 wherein the distal nozzle tip (210) is stationarily mounted to a nozzle body (50) that houses the fluid delivery channel 27, the nozzle body (50) being stationarily mounted relative to the mold body aperture (300) in an arrangement such that the distal projection (220) is stationarily mounted relative to the mold body aperture (300).

20. An assembly according to any of the foregoing claims 13-19 wherein the distal nozzle tip (210) is mounted relative to the mold (310a, 310b) such that air (AU1, AU2)

contained within the cavity (80) or the flow passage (27) is ventable to an air space or ambient air (AS) disposed around the assembly (200).

21. An assembly according to any of the foregoing claims 13-20 wherein the distal end (90de) of the valve pin 90 has an outer circumferential surface (90os) adapted to be slidably driven into engagement with and along a complementary inner surface (220is) of the distal projection (220) when the pin (80) is driven in the upstream downstream path of travel (UD), injection fluid (23) being prevented from flowing through the central bore (230) when the outer circumferential surface (90os) is engaged with the complementary inner surface (220is).

22. An assembly according to any of the foregoing claims 13-21 wherein the outer circumferential surface (90os) and the complementary inner surface (220is) are generally cylindrical in configuration.

23. A method of performing an injection molding cycle comprising forming an article in the mold cavity (80) of an injection molding apparatus (10) having an assembly according to any of the foregoing claims 13-21.

24. An injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b) and an assembly (200) comprising:

a distal nozzle tip (210) comprising a distal projection (220) having an outer circumferential surface (220ocs) and a central bore (230) that communicates with the fluid delivery channel (27) and having an inner surface (220is) adapted to receive a distal end (90de) of the valve pin (90), a mold (310a, 310b) having a cavity entrance aperture (300) forming a gate through which the injection fluid (23) is routed into the cavity (80), the cavity entrance aperture (300) having an inner circumferential surface (300ics),

the distal nozzle tip (210) being mounted such that the distal projection (220) is disposed in a stationary position within the mold body aperture (300) wherein the outer circumferential surface (220ocs) of the distal nozzle tip (210) is disposed adjacent the inner circumferential surface (300ics) forming a gap (Z) having a width sufficient to enable air or gas to flow upstream (AU1) through the gap (Z) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

25. An injection molding apparatus (10) comprised of an injection molding machine (20), a heated manifold (30) that receives the injection fluid (23), and a valve pin (90) drivable along an upstream and downstream path of travel (UD) through a fluid delivery channel (27) leading to a cavity (80) of a mold (310a, 310b), and an assembly (200) comprising:

a distal nozzle tip (210) having an upstream outer circumferential surface (210ocs) and a central bore (230) that communicates with the fluid delivery channel (27),

a mold (310a, 310b) having an upstream inner circumferential surface (310ics),

the distal nozzle tip (210) being mounted such that the upstream inner circumferential surface (310ics) and the upstream outer circumferential surface (210ocs) are stationarily disposed adjacent to each other forming a gap (X) having a width sufficient to enable air or gas to flow upstream (AU2) through the gap (X) upon downstream movement (D) of the distal end (90de) of the valve pin (90) through the central bore (230) of the distal projection (220).

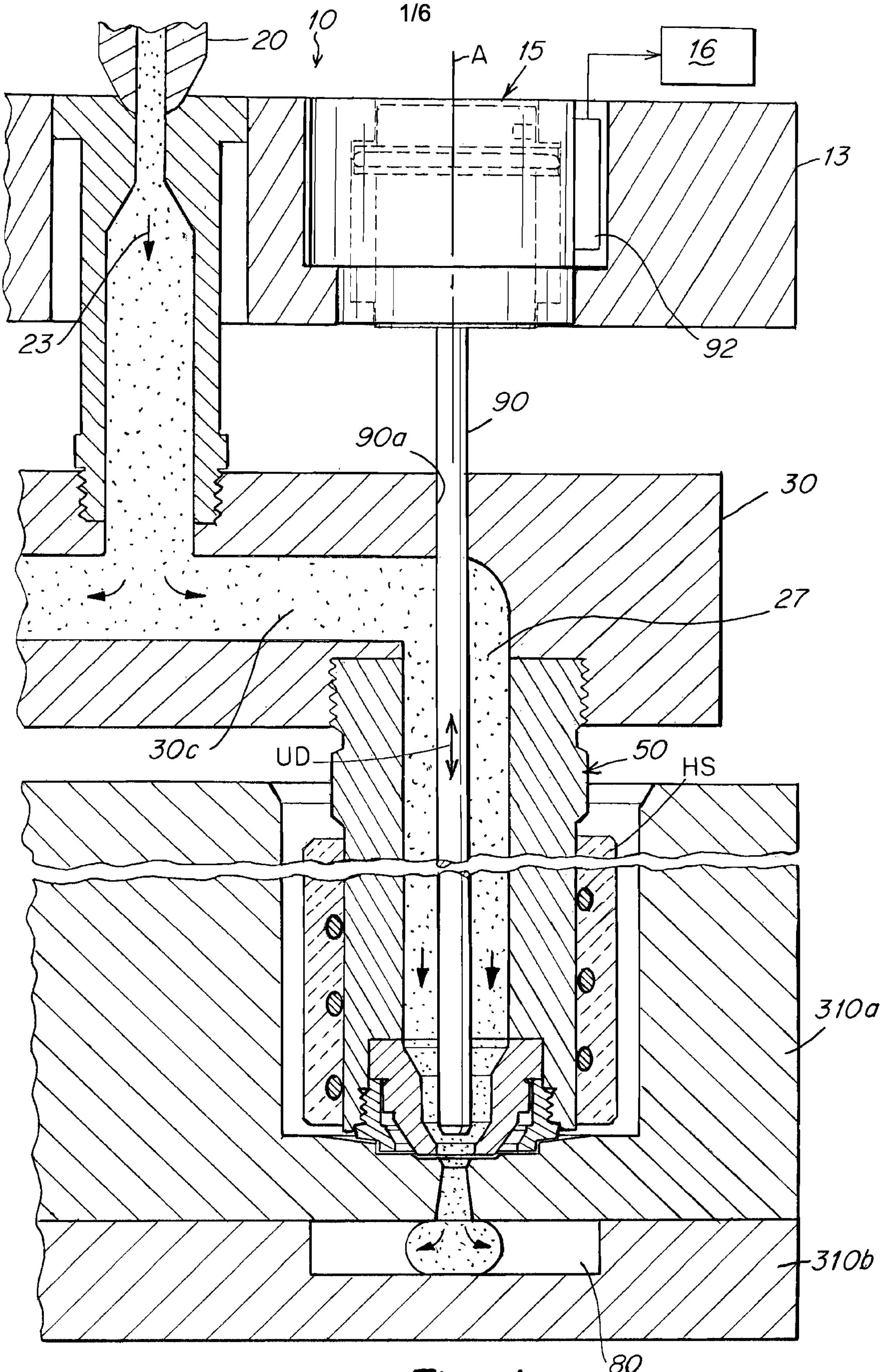


Fig. 1
PRIOR ART

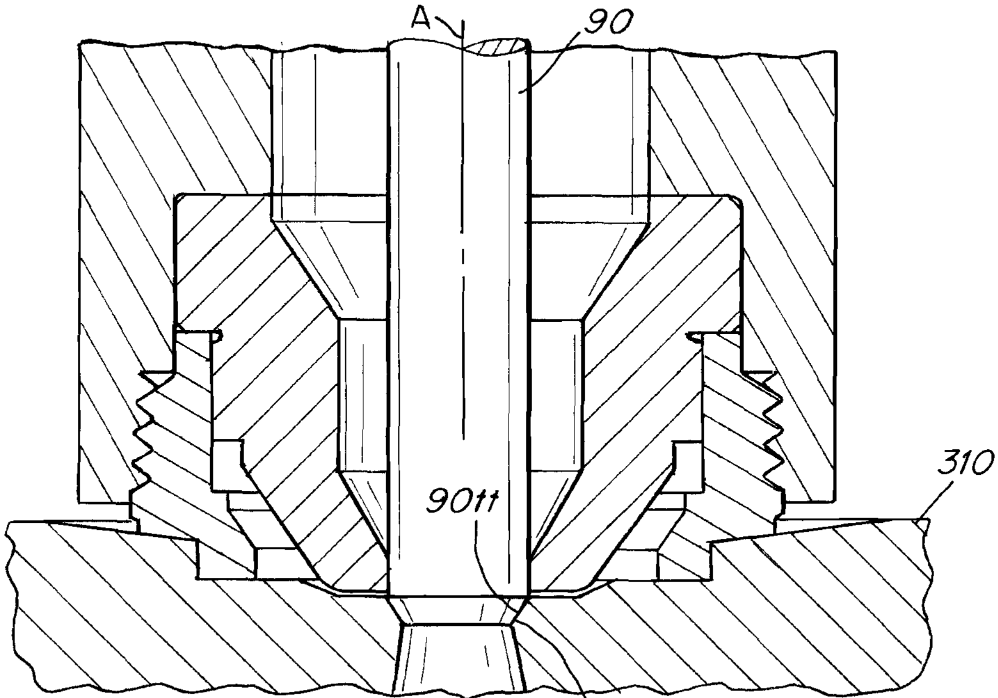


Fig. 2
PRIOR ART

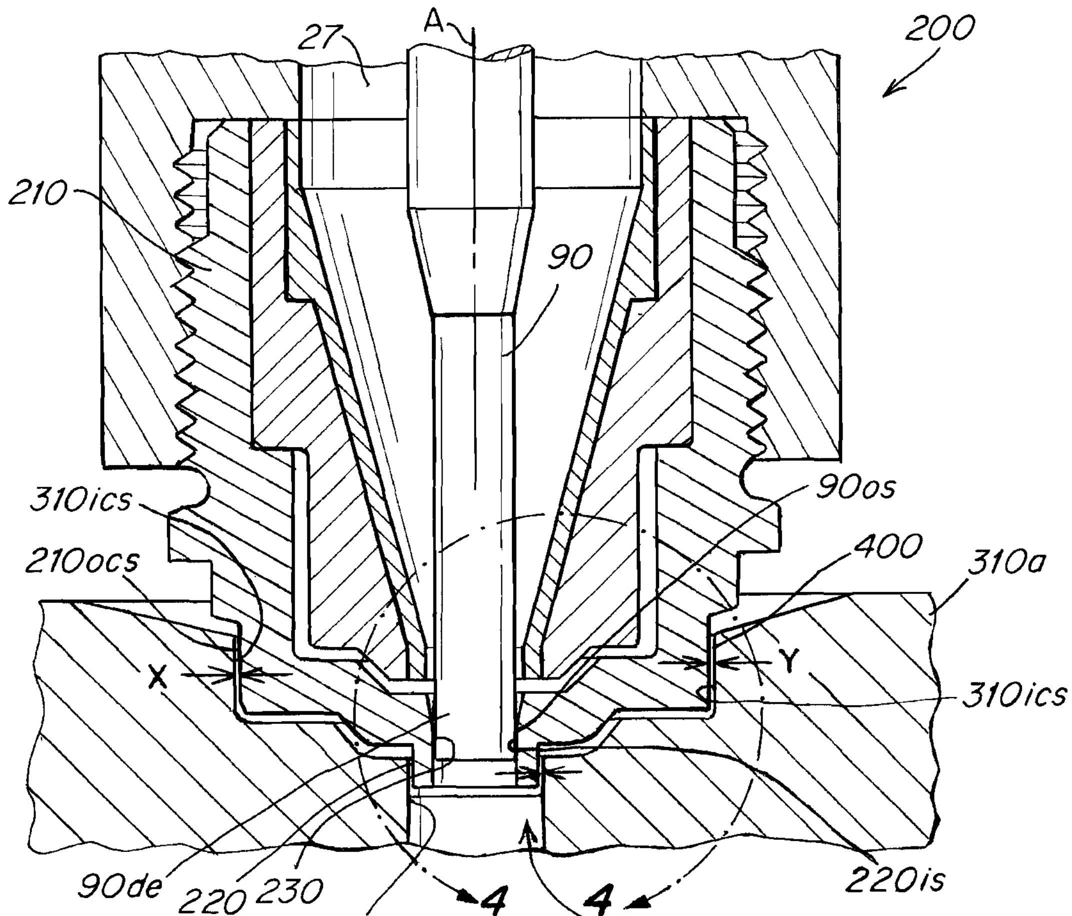
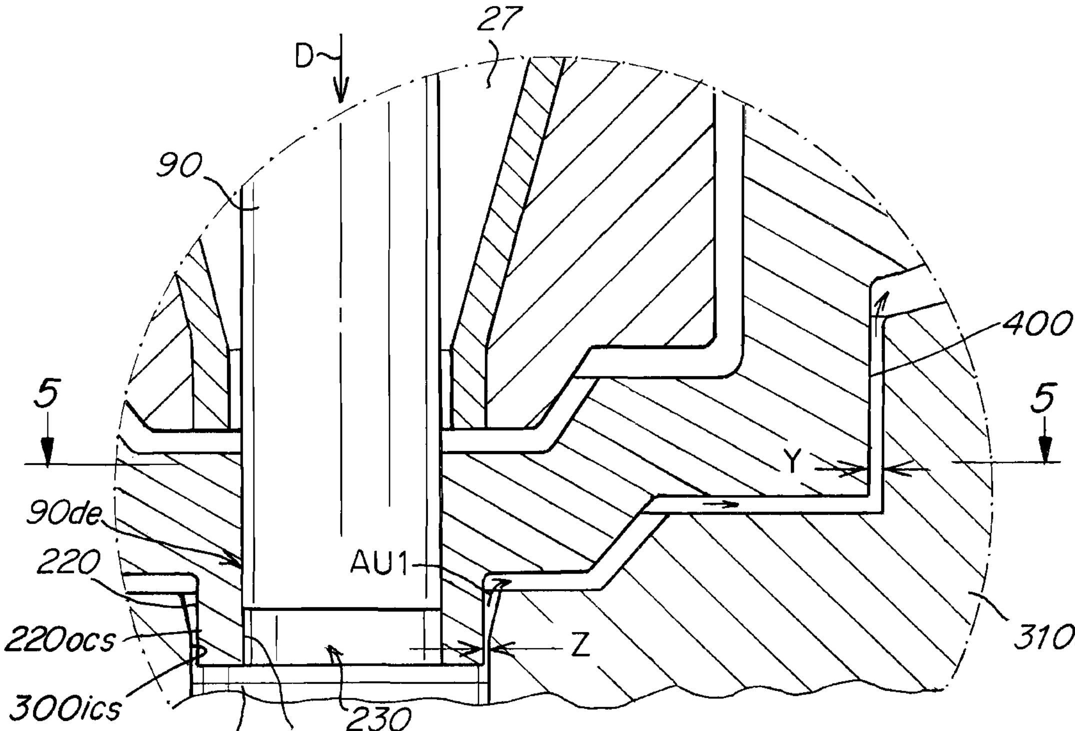
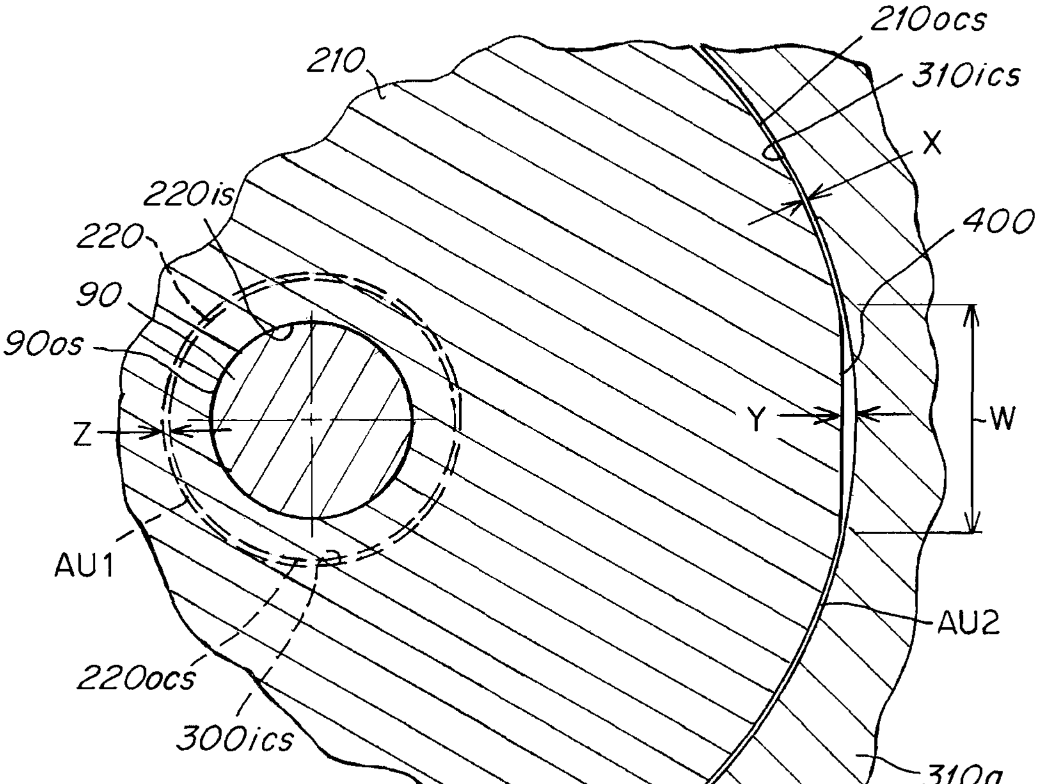


Fig. 3



D
27
90
400
5
5
Y
90de
220
AU1
Z
220ocs
310a
300ics
230
300
220is

Fig. 4



210ocs
210
310ics
X
220is
400
220
90
90os
Y
W
Z
AU1
AU2
220ocs
300ics
310a

Fig. 5

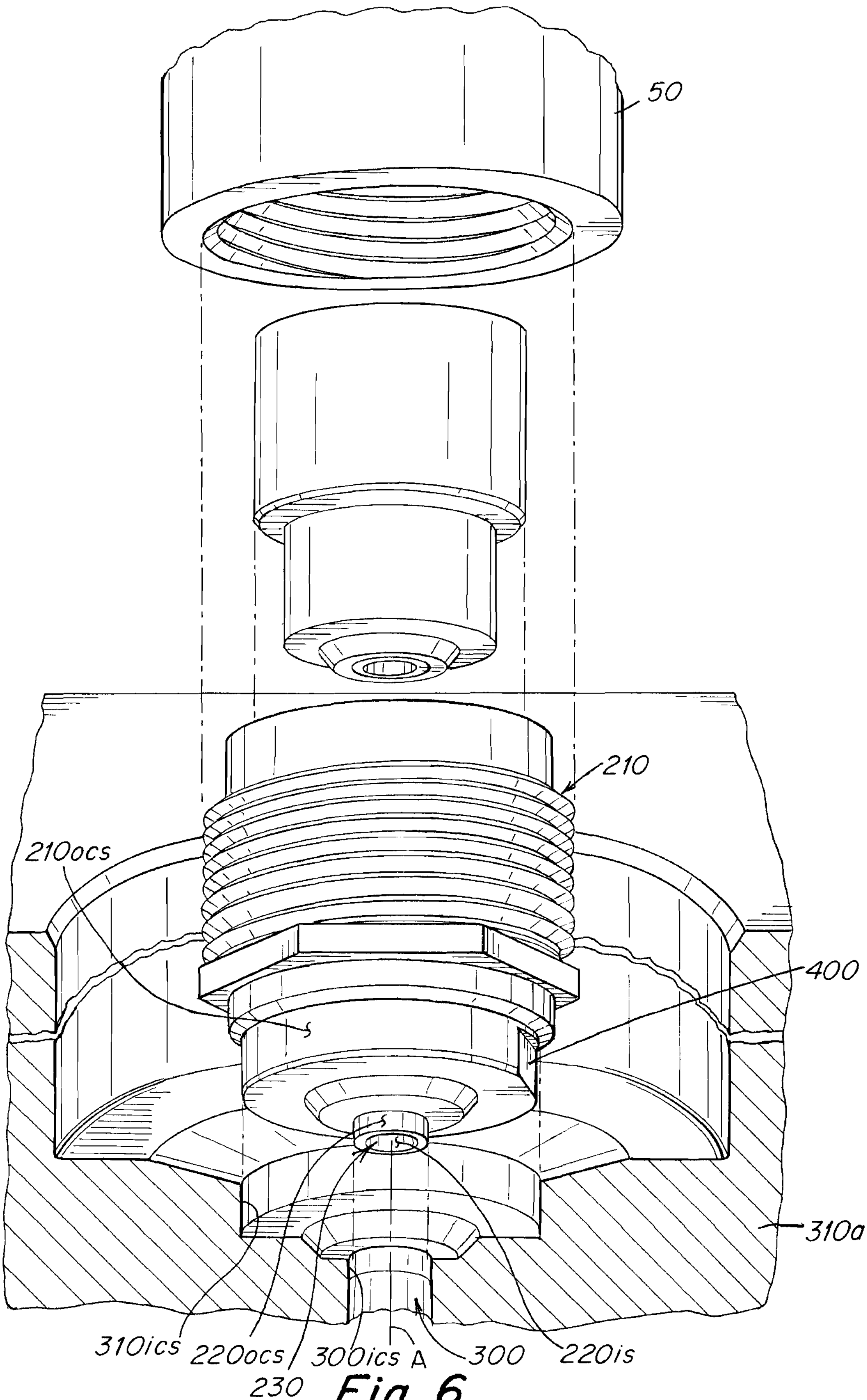
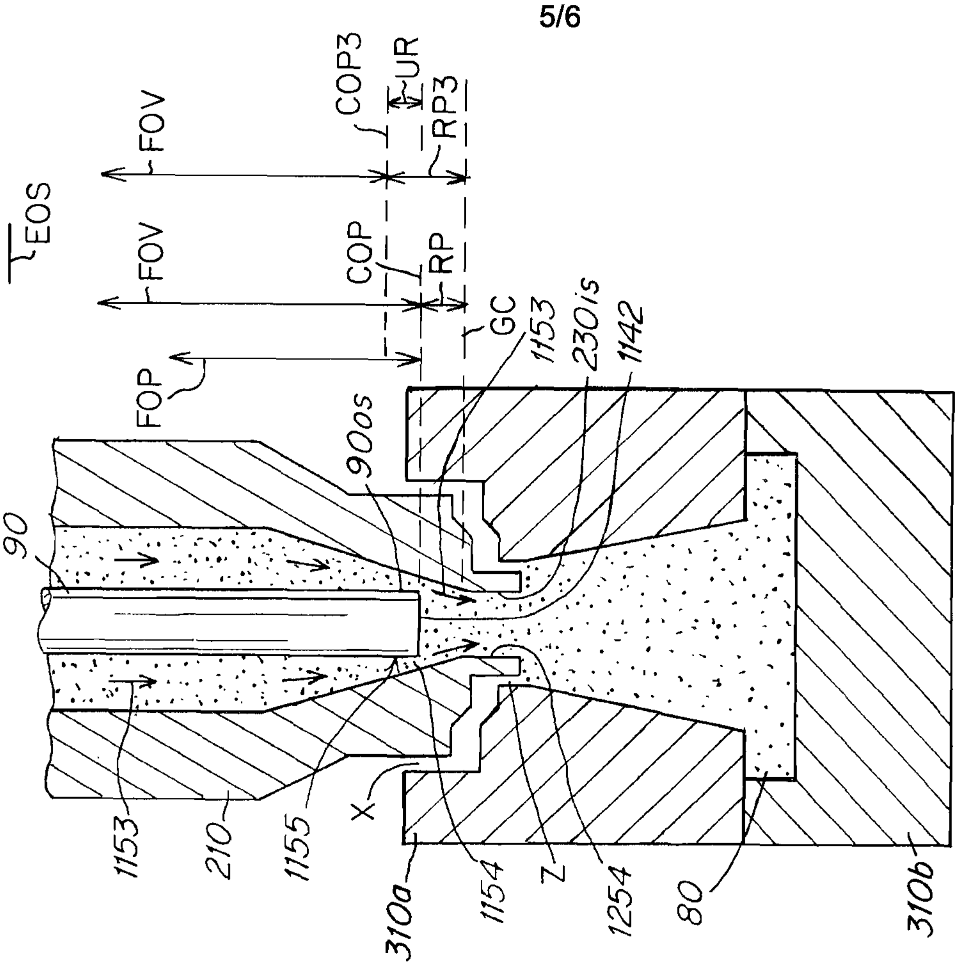


Fig. 6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FOV
COP3
UR
RP3
COP
RP
GC
FOP
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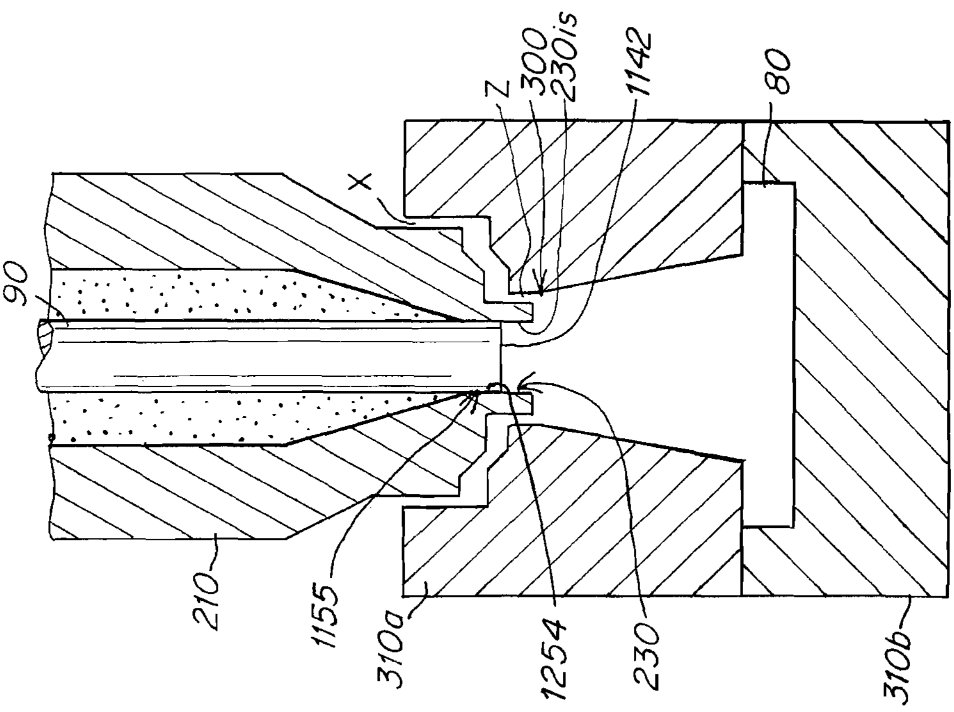
1153
210
1155
X
310a
1154
Z
1254
80
310b

Fig. 7B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230is
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80
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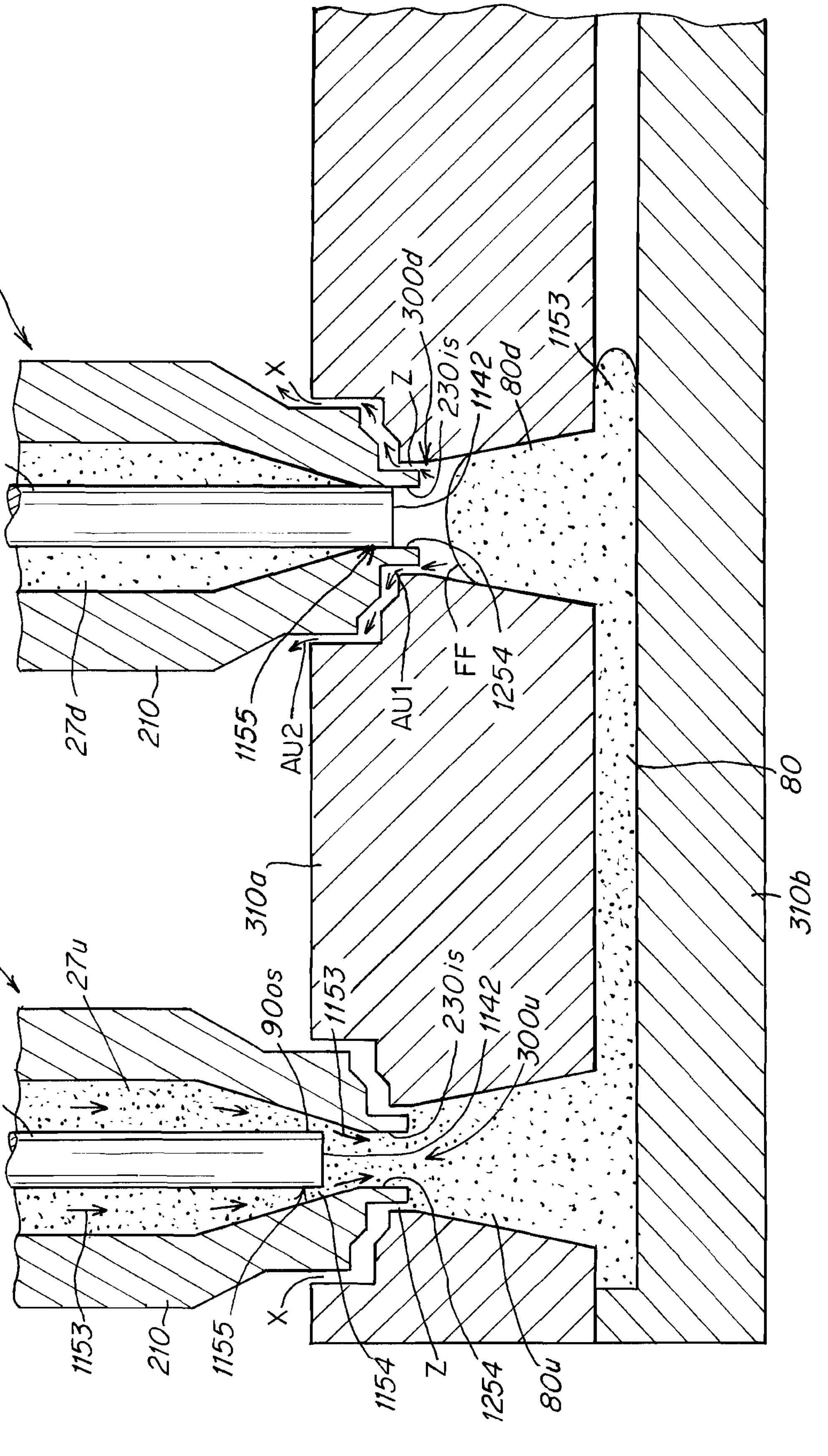
1155
310a
1254
230
310b

Fig. 7A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80d
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AU2
AU1
FF
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310a
310b
200u
27u
90u
90os
1153
230is
1142
300u
1153
210
1155
X
1154
Z
1254
80u

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/029338

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29C45/27
ADD. B29C45/34

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)
B29C B29K

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/248385 A1 (TEN VALERY [CA] ET AL) 4 September 2014 (2014-09-04) paragraphs [0023] - [0036]; figures 1-3D -----	1,2, 6-15, 19-25
X	US 2003/180412 A1 (FONG GARY [CA]) 25 September 2003 (2003-09-25) claims 1-3 figures 1-4 paragraphs [0018] - [0026] -----	1-25
X	CA 2 358 187 A1 (MOLD MASTERS LTD [CA]) 3 April 2003 (2003-04-03) figures 1-3b claims 1, 20-23 paragraphs [0023] - [0039] ----- -/--	1-4, 6-17, 19-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

"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)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 July 2018	10/07/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Raicher, Gerald

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/082263 A1 (OLARU GEORGE [CA]) 1 May 2003 (2003-05-01) paragraphs [0024] - [0038] claim 1; figure 1 -----	1,2, 6-15, 19-25

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2018/029338

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014248385 A1	04-09-2014	NONE	
US 2003180412 A1	25-09-2003	NONE	
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US 2003082263 A1	01-05-2003	US 2003082263 A1	01-05-2003
		US 2005118298 A1	02-06-2005