(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 September 2014 (04.09.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/133702 A1

(51) International Patent Classification:
B29C 45/74 (2006.01)

(21) International Application Number:
PCT/US2014/013299

(22) International Filing Date:
28 January 2014 (28.01.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/769,780 27 February 2013 (27.02.2013) US

(71) Applicant: **HUSKY INJECTION MOLDING SYSTEMS LTD.** [CA/CA]; 500 Queen Street South, Bolton, L7E 5S5 (CA).

(72) Inventor: **BOUTI, Abdeslam**; 3 Howard Estate, St. Albans, VT 05478 (US).

(74) Agent: **MUSGRAVE, Richard J.**; 288 North Road, Milton, VT 05468 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: HOT RUNNER AND COMPONENTS THEREOF WITH A MELT CONDITIONING ZONE

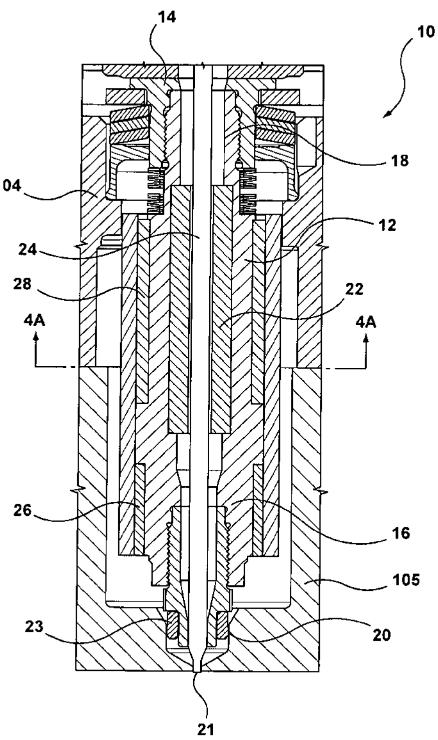

FIG. 1

(57) Abstract: A hot runner for an injection molding machine to condition the melt within the hot runner before entry into a mold cavity is disclosed. The melt temperature conditioning zone may be defined within a melt passageway, such as in the sprue bushing, in the manifold channel and/or in the bore of the nozzle body. At least one heater may cooperate with the melt temperature conditioning zone to produce a substantially homogenous thermal profile in the melt along the melt temperature conditioning zone.

WO 2014/133702 A1

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

HOT RUNNER AND COMPONENTS THEREOF WITH A MELT CONDITIONING ZONE

FIELD

The disclosed embodiments are generally directed to hot runners of injection molding machines, and more particularly to structures suitable to condition the melt within the hot runner.

BACKGROUND

Injection molding machines are used to produce plastic molded parts. It is well known in the art to use manifolds in these machines to transfer melt from a melt source to one or more nozzles. During a typical multi-cavity injection molding process, melt enters a sprue bushing and into a manifold where it travels through flow channels coupled to respective nozzles, each of which feeds melt to a mold cavity.

It is also well known that it is desirable to provide each mold cavity of an injection molding machine with "balanced" melt, namely melt with substantially the same temperature, substantially the same flow, and substantially the same shear effect. Unfortunately, while the melt travels through the heated manifold, because melt is thermally insulative, the melt nearest the channel walls becomes warmer while the temperature of the melt toward the center remains relatively cooler. As a result, when the melt flow splits as it travels through the various flow channels, as is well known, one side or area of the melt flow is relatively hot and another side or area is relatively cold. This non-uniform thermal profile is further propagated in manifolds where the melt continues to split while travelling through the channels and entering the nozzles. The end result is a non-homogeneous thermal profile in the melt before entry into the mold cavities.

This non-homogeneity is also not uniform across all channels and nozzles. Some channels and/or nozzles witness higher melt temperatures than others, resulting in an imbalance across the hot runner. Such an imbalance is undesirable and can lead to reduced productivity and poor quality parts.

SUMMARY

In one embodiment, a melt conditioning nozzle for use with a hot runner of an injection molding machine to pass melt into a mold cavity is disclosed. The melt conditioning nozzle includes a nozzle body with an inlet end, an outlet end, and a melt bore therebetween. A nozzle tip is disposed at the outlet end of the nozzle body. A melt temperature conditioning zone is defined within the melt bore and extends substantially from the inlet end to the outlet and upstream of the nozzle tip. At least one heater cooperates with the melt temperature conditioning zone to produce a substantially homogeneous thermal profile in the melt along the melt temperature conditioning zone before the melt enters the mold cavity.

In another embodiment, a hot runner of an injection molding machine to pass melt into a mold cavity is disclosed. The hot runner includes a melt flow passageway and a melt temperature conditioning zone within the melt flow passageway. At least one heater cooperates with the melt temperature conditioning zone to produce a substantially homogeneous thermal profile in the melt along the melt temperature conditioning zone. A nozzle is also included and comprises a nozzle body and a nozzle tip. The melt conditioning zone is disposed upstream of the nozzle tip.

In still another embodiment, a melt conditioning nozzle for use with a hot runner of an injection molding machine to pass melt into a mold cavity is disclosed. The melt conditioning nozzle includes a nozzle body with an inlet end, an outlet end, and a melt bore therebetween. A nozzle tip is disposed at the outlet end of the nozzle body. A melt conditioning zone is defined within the melt bore and extends substantially between the inlet end and the outlet end and upstream of the nozzle tip. A first heater is located adjacent the melt temperature conditioning zone at the inlet end and a second heater is located adjacent the melt temperature conditioning zone at the outlet end. A first thermocouple provides temperature feedback from the melt conditioning zone near the inlet end and a second thermocouple provides temperature feedback from the melt conditioning zone near the outlet end. The first and second heaters are independently controlled based upon the feedback received from the first and second thermocouples, respectively.

It should be appreciated that the foregoing concepts, and additional concepts discussed below, may be arranged in any suitable combination, as the present disclosure is not limited in this respect.

The foregoing and other aspects, embodiments, and features of the present teachings can be more fully understood from the following description in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are not intended to be drawn to scale. In the drawings, each identical or nearly identical component that is illustrated in various figures is represented by a like numeral. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

Figure 1 is a cross-sectional view of a melt conditioning valve gate nozzle according to one embodiment;

Figure 2 is a cross-sectional view of a melt conditioning hot-tip nozzle according to one embodiment;

Figure 3 is a cross-sectional view of the melt conditioning valve gate nozzle according to one embodiment;

Figures 4A and 4B are cross-sectional views of the melt temperature conditioning zone taken along lines 4A-4A and 4B-4B of Figures 1 and 2, respectively;

Figures 5A and 5B are schematic views of various embodiments of melt temperature conditioning zones;

Figures 6A and 6B are perspective views of straight and spiral-shaped melt conditioning fins, respectively, according to various embodiments;

Figure 7 is a sectional view of a staggered fin arrangement according to one embodiment;

Figures 8A and 8B are schematic perspective views of a rotationally offset fin arrangement according to various embodiments;

Figure 9 is a perspective view of a melt conditioner according to one embodiment; and

Figure 10 is a cross-sectional view of a hot runner.

DETAILED DESCRIPTION

Melt traveling through the various flow channels in the manifold and entering the nozzles may have a non-homogeneous thermal profile resulting from the multiple sequential melt flow splits that may occur within a manifold and from the insulative properties of the melt. This non-homogeneity may also be experienced across all the flow channels and nozzles in an injection molding system, resulting in reduced productivity and poor quality parts. The inventor has recognized a desire to provide a homogeneous thermal profile in the melt before entry into the mold cavities. Further, the inventor has recognized that conditioning the melt can yield such a homogenous thermal profile, and may alleviate melt imbalance that may occur across the hot runner.

As described in more detail below, the melt can be homogenized within a melt temperature conditioning zone that is configured to maximize the contact between the surface area of the structure defining the melt temperature conditioning zone and the volume of the melt passing through the melt temperature conditioning zone. That is, the melt temperature conditioning zone can be configured to maximize the ratio of the surface area of the structure of the melt temperature conditioning zone (A) to the volume of the melt passing through the melt temperature conditioning zone (V). In addition, the structure defining the melt temperature conditioning zone can be configured to minimize the pressure drop of the melt through the melt temperature conditioning zone.

In one aspect, the melt temperature conditioning zone is disposed in the melt flow path at a location at or between the sprue bushing and just upstream of the nozzle tip. Accordingly, the melt conditioning zone may be in the sprue bushing, in the melt flow channel in the manifold and/or in the nozzle body. Thus, in one embodiment, the melt conditioning zone is disposed in the sprue bushing. In yet another embodiment, the melt conditioning zone is disposed within the manifold. In another embodiment, the melt conditioning zone is disposed in the nozzle body. A heater cooperates with the melt conditioning zone to produce a substantially homogenous thermal profile.

In an embodiment where the melt temperature conditioning zone is disposed within the melt bore of a nozzle, the melt conditioning zone is disposed in the nozzle body, and, in one embodiment, substantially along the length of the nozzle body, upstream of the nozzle tip. At least one heater cooperates with the melt temperature conditioning zone to produce a substantially homogenous thermal profile in the melt.

In one embodiment, the melt conditioning zone includes fins extending from the internal surface of the melt bore or melt channel toward the center thereof in order to transmit heat to the central region of the melt flow. The fins may extend longitudinally along the length of the melt channel or bore. The fins may be arranged in a straight or spiraled-shaped pattern. The fins may also be arranged in a staggered pattern, wherein the fins include a first set of fins that extend along a first portion of the melt channel/bore and a second set of fins that extend along a second portion of the melt channel/bore, with the first set of fins being spaced from the second set of fins along the length of the melt channel/bore. In another embodiment, the fins may be arranged in a rotated pattern, wherein the fins include a first set of fins that extend in a first orientation along a first portion of the melt channel/bore and a second set of fins that extend in a second orientation along a second portion of the melt channel/bore and rotationally offset from the first set of fins.

In embodiments where the melt conditioning zone is within a nozzle, the nozzle may further comprise a valve stem reciprocally disposed within the melt bore and that is in contact with the fins. In such an embodiment, the fins can act to support the valve stem.

In yet another embodiment, the melt temperature conditioning zone is defined by at least one of a plurality of pins, protuberances, ripples, undulations, and surface roughness that extend from the internal surface of the melt channel/bore toward the center thereof.

In still another embodiment the melt conditioning nozzle includes a first heater adjacent to the melt temperature conditioning zone near the inlet end and a second heater adjacent to the melt temperature conditioning zone near the outlet end. In this embodiment, a first thermocouple provides temperature feedback from the melt temperature conditioning zone near the inlet end, a second thermocouple provides temperature feedback from the melt temperature conditioning zone near the outlet end, and the first and second heaters are controlled based on the feedback received from the first and second thermocouples, respectively.

It should be further appreciated that the melt conditioning zone can be defined by structure(s) integrally formed in the melt flow passage or it can be defined by a discrete component inserted into the melt flow passage.

Turning now to the figures, Figure 1 shows a nozzle 10 having a melt conditioning zone. The nozzle 10 includes a nozzle body 12 with an inlet end 14, an outlet end 16, and a melt bore 18 therebetween. A nozzle tip 20 is disposed at the outlet end 16 of the nozzle body 12 and is configured to pass melt through a gate 21 and into a mold cavity (not shown). The nozzle tip 20 is a separate component screwed into the outlet end 16 of the nozzle body 12. However, in some embodiments, the nozzle body 12 and nozzle tip 20 may be integrally formed. In still other embodiments, the nozzle tip 40 may be held to the nozzle body 32 via a retainer 41, such as depicted in Figure 2. A sealing piece 23 (as is shown in Figure 1) may be disposed around nozzle tip (as is well known) in order to seal the nozzle at the gate area. The seal piece may be formed integral with the tip or with the tip retainer. Figure 2 depicts a seal piece 43 integrally formed with the retainer 41, though the seal may be otherwise joined to the retainer via brazing, beam welding, press fitting or utilizing other bonding techniques. The nozzle seal piece may be formed of a low thermal conductivity material to limit heat transfer loss to the gate area. The nozzle body may also be made from any suitable material such as tool steel or stainless steel. The nozzle tip may be formed from a material having a relatively high thermal conductivity, such as beryllium copper. Wear resistant materials, such as carbide, may be utilized in the nozzle tip. Other suitable materials may be employed, as the current disclosure is not limited in this regard.

A melt temperature conditioning zone 22 is defined within the melt bore 18 and extends between the inlet end 14 and the outlet end 16, and, in one embodiment, extends substantially between the inlet end 14 and the outlet end 16. In this embodiment, the nozzle 10 is configured in a valve gate nozzle and therefore also includes a valve stem 24 that is substantially extending and reciprocally disposed within the melt bore 18. As is well known, valve gate nozzles start and stop melt flow into the mold cavity by reciprocally moving the valve stem into open and closed positions, respectively.

In one embodiment, at least one heater 26, 28 cooperates with the melt temperature conditioning zone 22. The heater 26, 28, controlled by a controller (not shown) as is conventional, cooperates with the melt temperature condition zone 22. Thus, heat from the heater 26, 28 is transferred to the melt via at least the melt conditioning zone 22 to produce a substantially homogeneous thermal profile in the melt along the melt temperature conditioning zone 22 before the melt enters the mold cavity. Heat, therefore, can be effectively transmitted via the melt conditioning zone 22 to the central region of the melt flow. In this embodiment, the fins, extending toward the center of the melt, can distribute heat to the central portion of the melt aiding in producing a more homogenous melt. The heater controller may communicate with a thermocouple (not shown) in the nozzle 10 to receive temperature feedback information so that the amount of heat supplied to the melt conditioning zone 22 can be controlled. As seen in Figure 1, in one embodiment, the melt conditioning nozzle 10 includes front heater 26 and a back heater 28 that individually or together cooperate with the melt temperature conditioning zone 22. Although two heaters are shown in this embodiment, another embodiment may include one heater that is disposed substantially along the length of the nozzle. Other heater arrangements may also be employed, as the present disclosure is not limited in this regard.

As depicted in Figure 1, the nozzle is disposed within a manifold plate 104, as will be further discussed with reference to Figure 9. The outlet end of the nozzle body including the tip is disposed in a mold plate 105.

In another embodiment, the nozzle is configured in a hot-tip nozzle 30, as shown in Figure 2. In this embodiment, the nozzle 30 includes a nozzle body 32 with an inlet end 34, an outlet end 36, and a melt bore 38 therebetween. A nozzle tip 40 is disposed at the outlet end 36 of the nozzle body 32 to pass melt through gate 21 and into a mold cavity. A melt temperature conditioning zone 22 is defined within the melt bore 38 and extends between, and, in one embodiment, substantially between, the inlet end 34 and the outlet end 36. As with the valve-gate embodiment, in this hot-tip embodiment, at least one heater 44, 46 cooperates with the melt temperature conditioning zone 22 to deliver heat to the melt conditioning zone to the produce a substantially homogeneous thermal profile in the melt along the melt temperature conditioning zone 22. Although a front heater 44 and a back heater 46 are shown in this embodiment, only one heater or more than two heaters may also be employed as the present disclosure is not limited in this regard. As with the valve-gate embodiment, the heaters in this embodiment are also controlled by a suitable controller (not shown) and other suitable heater arrangements may be employed. However, unlike the valve-gate nozzle, as is well known, hot-tip nozzles start and stop the flow of melt into the mold cavity by controlling the temperature of the melt at the tip such that, to inhibit melt flow, the pressure and temperature at the gate are reduced to effectively "freeze" a small portion of the melt material to block flow out of the nozzle, and, to allow flow, the pressure is increased to reopen the gate during injection by pushing the small portion of material.

In one embodiment, as depicted in Figure 3, each heater has its own independent thermocouple to monitor the melt temperature so that the heaters can be independently controlled. In this embodiment, the nozzle 11 includes a first heater 13 adjacent the melt temperature conditioning zone 22 near the inlet end 14 of the nozzle body 12 and a second heater 15 adjacent the melt temperature conditioning zone 22 near the outlet end 15 of the nozzle body 12. In one embodiment, a first thermocouple 17 monitors and provides temperature feedback from the melt temperature conditioning zone 22 near the inlet end 14 of the nozzle body 12 and a second thermocouple 19 monitors and provides temperature feedback from the melt temperature conditioning zone 22 near the outlet end 16 of the nozzle body 12. In one embodiment, the first and second thermocouples 17, 19 are connected to and communicate with a controller 23. In turn, the controller 23 processes the feedback from the first and second thermocouples 17, 19 to control the first and second heaters 13, 15. The controller 23 may have two inputs, each input being connected to one thermocouple 17, 19. However, two controllers 23 may be used, each controller 23 being connected to one thermocouple 17, 19 and each controller 23 controlling one heater 13, 15, respectively. Although two heaters 13, 15 with two corresponding thermocouples 17, 19 are shown in this embodiment, it should be appreciated that in other embodiments there may be two heaters 13, 15 with only one thermocouple or just one heater with a corresponding thermocouple. There also may be more than two heaters with at least one thermocouple in other embodiments. It also should be appreciated while this embodiment is shown in a valve gate nozzle, in other embodiments, a hot-tip nozzle may be used.

Turning to Figures 4A and 4B, cross sections of the nozzle at the melt temperature conditioning zone 22 along lines 4A-4A in Figure 1 and along lines 4B-4B in Figure 2, respectively, are shown. In these embodiments, the melt temperature conditioning zone 22 is defined by a plurality of fins 48 extending from an internal surface 50 of the melt bore towards a center 52 of the melt bore. In one embodiment, shown in Figure 4A, a valve stem 24 extends within the melt bore and is supported by fins 48. Although the valve stem 24 is shown to be in contact with the fins 48 in Figure 4A, it is to be appreciated that the fins and valve stem need not be in contact in all embodiments. In Figure 4B, where a hot-tip embodiment is shown, the fins 48 extend toward the center 52 of the melt bore but no valve stem is employed.

Although six fins 48 are shown in these embodiments, it should be appreciated that more or less fins 48 could be used in the melt temperature conditioning zone 22. It should also be appreciated that the shape and thickness of the fins 48 could vary. In one embodiment, the size and shape of the fins 48 may be uniform throughout the melt temperature conditioning zone 22, however, in other embodiments, the size and shape of the fins 48 could vary from fin to fin. In yet another embodiment, the distance the fins 48 extend inward from the internal surface 50 of the melt bore toward the center 52 of the melt bore may vary. Although not shown in the hot-tip embodiment in Figure 4B, the fins 48 could extend completely into the center of the melt bore, thus contacting each other. Other suitable fin arrangements may also be employed for conducting heat to the center portion of the melt, as the present disclosure is not limited in this regard.

As shown in Figure 5A (which shows portions of the melt flow channels/bores) rather than employing fins, the melt temperature conditioning zone 22 is structured to include at least one of a plurality pins, protuberances, ripples and undulations 54 that extend from the internal surface 50 of the melt bore 49 toward the center 52 of the melt bore 49. As with the fin arrangement, it can be appreciated that the number, size, and thickness of the plurality of pins, protuberances, ripples, and undulations can also be varied. In some embodiments, the distance that the pins, protuberances, ripples, or undulations extend from the internal surface 50 of the melt bore to the center 52 of the melt bore may vary. The melt temperature conditioning zone may also be defined by a surface roughness 56 of the melt bore 49, as shown Figure 5B. Other suitable arrangements for conditioning heat to the center portion of the melt bore 49 may also be employed, as the present disclosure is not limited in this respect.

In one embodiment, the melt temperature conditioning zone 22 is configured to maximize contact between the surface area of the structure of the melt conditioning zone (for example, the fins, pins, protuberances, ripples, undulations, and/or surface roughness, described above) and the melt. The melt temperature conditioning zone 22 may also be configured to maximize the ratio of the surface area of the structure of the melt conditioning zone (A) and the volume of the melt in the melt conditioning zone (V). As described above, the volume of melt passing through the melt channel/bore can be adjusted by varying the number, size, and thickness of the fins, pins, protuberances, ripples, undulations, or surface roughness. In one embodiment, the melt temperature conditioning zone is configured such that for a melt bore with a diameter (D), the A/V ratio is substantially greater than 4/D. In one embodiment, the A/V ratio is approximately 1.77 (1/mm) for a diameter (D) equal to 8 mm. The melt temperature conditioning zone 22 may be further configured to minimize the pressure drop of the melt along the melt temperature conditioning zone 22. In one embodiment, the melt temperature conditioning zone is configured such that the pressure drop does not exceed 4MPa. In one embodiment, the melt temperature conditioning zone is configured such that the pressure drop does not exceed 1.11MPa

In another embodiment, the fins defining the melt temperature conditioning zone 22 extend longitudinally along the length of the melt bore 18. As shown in the schematic perspective view of Figures 6A, in one embodiment, the fins 58 are configured in a straight pattern. In the embodiment depicted in the schematic perspective view of Figure 6B, the fins 60 are configured in a spiral-shape pattern. Although only two fins are shown in these embodiment, it should be appreciated that the number, size, and shape of fins, as well as the distance the fins extend from the internal surface 50 of the melt bore to the center 52 of the melt bore could differ, as previously described. The length of the melt conditioning fins 58, 60 can also be longer or shorter in other embodiments that those shown in Figures 6A and 6B. Other suitable arrangements for the melt conditioning fins may also be employed, as the present disclosure is not limited in this respect.

Turning to Figure 7, in another embodiment, the melt conditioning zone 22 may extend in a non-uniform manner along the length of the melt flow passage, which, in this example, is along the length of the melt bore of a nozzle. It should be appreciated that not all components of the nozzle are labeled in Figure 7. In this embodiment, the melt temperature conditioning zone 22 includes subzones (whether incorporating the straight fins 58 or the spiral-shaped fins 60, the protuberances, pins, ripples, undulations 54, or surface roughness 56, or any combination thereof), with one subzone extending along a first portion of a first length of the melt flow passage and a second subzone extending along a second portion of the melt flow passage such that the first subzone and the second subzone are spaced apart from one another. Although Figure 7 shows a melt temperature conditioning zone 22 with three subzones 64a, 64b, 64c spaced apart from one another, it should be appreciated that the melt conditioning zone 22 can have more or less subzones. In other embodiments, the length of each subzone 64a, 64b, 64c may be longer or shorter than the length shown in Figure 7. It should also be appreciated that the length of each subzone 64a, 64b, 64c does not have to be uniform and could vary between individual subzones. In another embodiment, the space 65 between each subzone can be increased or decreased. In other embodiments, the space 65 between the subzones need not be to uniform and could vary along the length of the melt bore. Other subzone arrangements may also be employed, as the present disclosure is not limited in this regard.

As shown schematically in Figures 8A and 8B, in other embodiments, the subzones (in these examples, the fins) are configured in a rotationally offset arrangement along the length of the melt bore, wherein the first subzone extends in a first orientation along a first portion of the length of the melt bore and a second subzone extends in a second orientation along a second portion of the length of the melt bore and rotationally offset from the first subzone.

As shown in Figure 8A, in one embodiment, straight subsets of fins 68a, 68b, 68c, 68d are rotationally offset along the length of the melt bore. In another embodiment, as shown in Figure 8B, spiral-shaped subset of fins 70a, 70b, 70c, 70d are rotationally offset along the length of the melt bore. Although in one embodiment, as shown, the rotational offset is approximately 90 degrees, it should be appreciated that other angular rotational offsets could be employed, as the present disclosure is not limited in this regard. Also, it should be appreciated that the number of subsets can vary.

Additionally, while the melt temperature conditioning zone 22 has been shown as integrally formed with the nozzle melt bore, it should be appreciated that the melt temperature conditioning zone 22 could also be a separate component that is installed in such a melt flow channel. It should also be appreciated that this melt conditioning component could also be installed in a manifold channel or in a sprue bushing bore. In the embodiment shown in Figure 9, a melt conditioner 80 includes a body 82 having an outer surface 84 for disposition within the melt flow passage, an inner surface 85 for allowing melt to pass therethrough and, in this example, fins 86 extending from the inner surface 85 toward the center 88 of the melt conditioner 80, to define the melt temperature conditioning zone 22. In one embodiment, the melt conditioning zone 22 is configured to maximize contact between the surface area of the melt conditioner and the melt passing through the melt conditioner to produce a substantially homogeneous thermal profile in the melt. As can be appreciated, a number of melt conditioners 80 can be included in the melt flow passageway and, as discussed above, the melt conditioners

80 may be staggered or rotationally offset along the melt temperature conditioning zone. The melt conditioner can be inserted into the melt flow passage way in any suitable manner, including press fit, brazing, or clamping in place. Further, as described above, though the melt conditioner shown in Figure 9 includes fins 86, any other or additional melt conditioning structure may be utilized, including pins, protuberances, ripples, undulations, or surface roughness. Also, more or less fins 86 than those depicted may be employed.

Although various structures defining a melt conditioning zone has been shown and described in a nozzle, as explained, the melt conditioning zone may be located anywhere in a hot runner, such as in a sprue, in a manifold, and/or anywhere else along the melt flow path. Accordingly, any and all of the above-described configurations, whether singularly or in combination, may be employed in one or more other locations along the melt flow path.

One example of a hot runner is depicted in Figure 10. The hot runner 100 includes a first plate 102, a second plate 104, a manifold 224, a nozzle assembly 400, and a nozzle-support structure 101. The first plate 102 may also be referred to as a manifold-backing plate and the second plate 104 may be referred to as a manifold plate. Plate 102 and/or plate 104 may be made from a low-strength steel alloy. Generally, the second plate 104 is coupled with the first plate 102 (preferably by fasteners, such as fastener 223). Once they are coupled together, the second plate 104 and the first plate 102 define a manifold pocket 213.

The manifold 224 includes or defines one or more melt channel(s) 221 configured to convey the melt from the input to the outputs of the manifold 224. The manifold 224 defines a plug receiver 227 that connects with the melt channel 221. The plug receiver 227 is configured to receive a manifold plug (known and not depicted). One purpose of the plug receiver 227 and the manifold plug is to allow gun drilling of the manifold channels, as is well known to those skilled in the art and therefore will not be further described in any detail. However, other suitable manifold manufacturing processes may be employed (such as a split and subsequently bonded 2-piece manifold), as the present disclosure is not limited in this regard.

The manifold 224 is supportively received in the manifold pocket 213. The manifold 224 has an output (usually called a drop 225), an input that is usually connected with a sprue bushing 260, and a distribution network of channels 221 that connects the input with the output (it will be appreciated that there may be more than one output). In one embodiment, the manifold includes a melt conditioning zone 300 within the melt channel 221. The sprue bushing 260 is coupled with a machine nozzle (known and not depicted) of an injection unit (known and not depicted). In one embodiment, the sprue bushing 260 includes a melt conditioning zone 310. Figure 10 depicts the manifold 224 having two drops 225, and it will be appreciated that the manifold 224 may have a single drop or may have multiple drops (or outputs). The nozzle assembly 400 is supportively received in the nozzle hole 229 of the second plate 104. The nozzle assembly 400 is operatively connected with the drop 225 of the manifold 224, so that the nozzle assembly 400 may receive the melt from the drop 225. The nozzle assembly 400 is also received in a mold gate of a mold assembly (known but not depicted) so that melt may flow from the nozzle assembly 400 to a mold cavity (via the mold gate) of the mold assembly. Figure 10 also depicts two examples of the nozzle assembly 400, which are a valve-type nozzle 240, and a thermal-type nozzle 250, though it is conventional that only one type of valve arrangement is typically used in a particular hot runner such that Figure 10 is for illustrative purposes only. As discussed above, in one embodiment, the nozzle includes a melt conditioning zone 320. Although three melt conditioning zones 300, 310, 320 are shown in this figure, it should be appreciated that the hot runner may include only one or two melt conditioning zones in some embodiments or more than three melt conditioning zones in other embodiments.

The manifold plate 104 is configured to receive a guide pin 209 that is used to locate the manifold plate 104 with the mold assembly (known and not depicted). The manifold plate 104 includes or defines a cooling circuit 201 (which is well known in the art and therefore will not be described here in detail), and the nozzle hole 229 that is configured to receive the nozzle assembly 400 and to permit connection of the nozzle assembly 400 with the drop 225 of the manifold 224. The manifold-backing plate 102 defines a cooling circuit 203 (the cooling circuit 203 is well known in the art). The manifold-backing plate 102 is configured to receive the sprue bushing 260, so that the sprue bushing 260 may connect with the input of the manifold 224. A sprue-bushing heater 261 is coupled with the sprue bushing 260. A sprue-bushing fastener 263 couples or connects the sprue bushing 260 with the manifold-backing plate 222.

The melt conditioning zone (whether integrally formed in the melt flow passage or structured as an insert) may be made of a conductive material, such as but not limited to copper alloys. The melt conditioning zone (whether integrally formed in the melt flow passage or structured as an insert) may also be made of a wear resistant material, such as vanadium steel and powder metallurgy alloys. The melt conditioning zone (whether integrally formed in the melt flow passage or structured as an insert) may be formed using any suitable manufacturing process, such as machining, casting, electro discharge machining (EDM), laser cutting, water jet cutting, stamping, powder sintering, etc., as the present disclosure is not limited in this regard.

While the present teachings have been described in conjunction with various embodiments and examples, it is not intended that the present teachings be limited to such embodiments or examples. On the contrary, the present teachings encompass various alternatives, modifications, and equivalents, as will be appreciated by those of skill in the art. Accordingly, the foregoing description and drawings are by way of example only.

What is claimed is:

CLAIMS

1. A melt conditioning nozzle for use with a hot runner of an injection molding machine to pass melt into a mold cavity, the nozzle comprising:

a nozzle body having an inlet end, an outlet end, and a melt bore therebetween;

a nozzle tip disposed at the outlet end;

a melt temperature conditioning zone defined within the melt bore and extending substantially from the inlet end to the outlet end and upstream of the nozzle tip; and

at least one heater cooperating with the melt temperature conditioning zone to produce a substantially homogeneous thermal profile in the melt along the melt temperature conditioning zone before the melt enters the mold cavity.

2. The melt conditioning nozzle of claim 1, wherein the melt bore includes a plurality of fins extending from an internal surface of the melt bore toward a center of the melt bore to define the melt temperature conditioning zone.

3. The melt conditioning nozzle of claim 2, wherein the fins extend longitudinally along a length of the melt bore.

4. The melt conditioning nozzle of claim 3, wherein the fins extend in a straight pattern along the length of the melt bore.

5. The melt conditioning nozzle of claim 4, wherein the fins comprise a first set of fins extending along a first portion of a length of the melt bore and a second set of fins extending along a second portion of a length of the melt bore and spaced from the first set of fins.

6. The melt conditioning nozzle of claim 4, wherein the fins comprise a first set of fins disposed in a first orientation along a first portion of a length of the melt bore and a second set of fins disposed in a second orientation along a second portion of the length of the melt bore that is rotationally offset from the first set of fins.

7. The melt conditioning nozzle of claim 3, wherein the fins extend in a spiral-shaped pattern along a length of the melt bore.

8. The melt conditioning nozzle of claim 7, wherein the fins comprise a first set of fins extending along a first portion of a length of the melt bore and a second set of fins extending along a second portion of a length of the melt bore and spaced from the first set of fins.

9. The melt conditioning nozzle of claim 7, wherein the fins comprise a first set of fins disposed in a first orientation along a first portion of a length of the melt bore and a second set of fins disposed in a second orientation along a second portion of the length of the melt bore that is rotationally offset from the first set of fins.

10. The melt conditioning nozzle of claim 2, further comprising a valve stem extending within the melt bore, wherein at least a portion of the fins contact the valve stem.

11. The melt conditioning nozzle of claim 1, wherein the melt bore includes at least one of a plurality of pins, protuberances, ripples, undulations, and surface roughness extending from an internal surface of the melt bore toward a center of the melt bore to define the melt temperature conditioning zone.

12. The melt conditioning nozzle of claim 1, wherein the melt temperature conditioning zone is configured to maximize contact between a surface area of the melt bore and the melt.

13. The melt conditioning nozzle of claim 12, wherein A is defined as the surface area of a structure defining the melt conditioning zone and V is defined as a volume of the melt in the melt conditioning zone and wherein the melt temperature conditioning zone is configured to maximize an A/V ratio.

14. The melt conditioning nozzle of claim 13, wherein D is defined as a diameter of the melt bore and wherein the A/V ratio is greater than 4/D.

15. The melt conditioning nozzle of claim 12, wherein the melt temperature conditioning zone is configured to minimize a pressure drop of the melt along the melt temperature conditioning zone.

16. The melt conditioning nozzle of claim 15, wherein the pressure drop is less than 4 MPa.

17. A hot runner of an injection molding machine to pass melt into a mold cavity, the hot runner comprising:

a melt flow passageway;

a melt temperature conditioning zone within the melt flow passageway;

at least one heater cooperating with the melt temperature conditioning zone to produce a substantially homogeneous thermal profile in the melt along the melt temperature conditioning zone; and

a nozzle including a nozzle body and a nozzle tip, wherein the melt temperature conditioning zone is disposed upstream of the nozzle tip.

18. The hot runner of claim 17, wherein the melt temperature conditioning zone is disposed in a sprue bushing.

19. The hot runner of claim 17, wherein the melt temperature conditioning zone is disposed in a manifold.

20. The hot runner of claim 17, wherein the melt temperature conditioning zone is disposed in the nozzle body.

21. The hot runner of claim 17, wherein the melt temperature conditioning zone includes a plurality of fins extending towards a center of the melt flow passageway.

22. The hot runner of claim 17, wherein the melt temperature conditioning zone is configured to maximize contact with the melt.

23. The hot runner of claim 17, wherein the melt temperature conditioning zone comprises a melt conditioner disposed within the melt flow passageway.

24. A melt conditioning nozzle for use with a hot runner of an injection molding machine to pass melt into a mold cavity, the nozzle comprising:

a nozzle body having an inlet end, an outlet end, and a melt bore therebetween;

a nozzle tip disposed at the outlet end;

a melt temperature conditioning zone defined within the melt bore and extending substantially from the inlet end to the outlet end and upstream of the nozzle tip;

a first heater disposed adjacent to the melt temperature conditioning zone near the inlet end;

a second heater disposed adjacent the melt temperature conditioning zone at the outlet end;

a first thermocouple providing temperature feedback from the melt temperature conditioning zone near the inlet end; and

a second thermocouple providing temperature feedback from the melt temperature conditioning zone near the outlet end;

wherein each of the first and second heaters are independently controlled based on feedback from the first and second thermocouples.

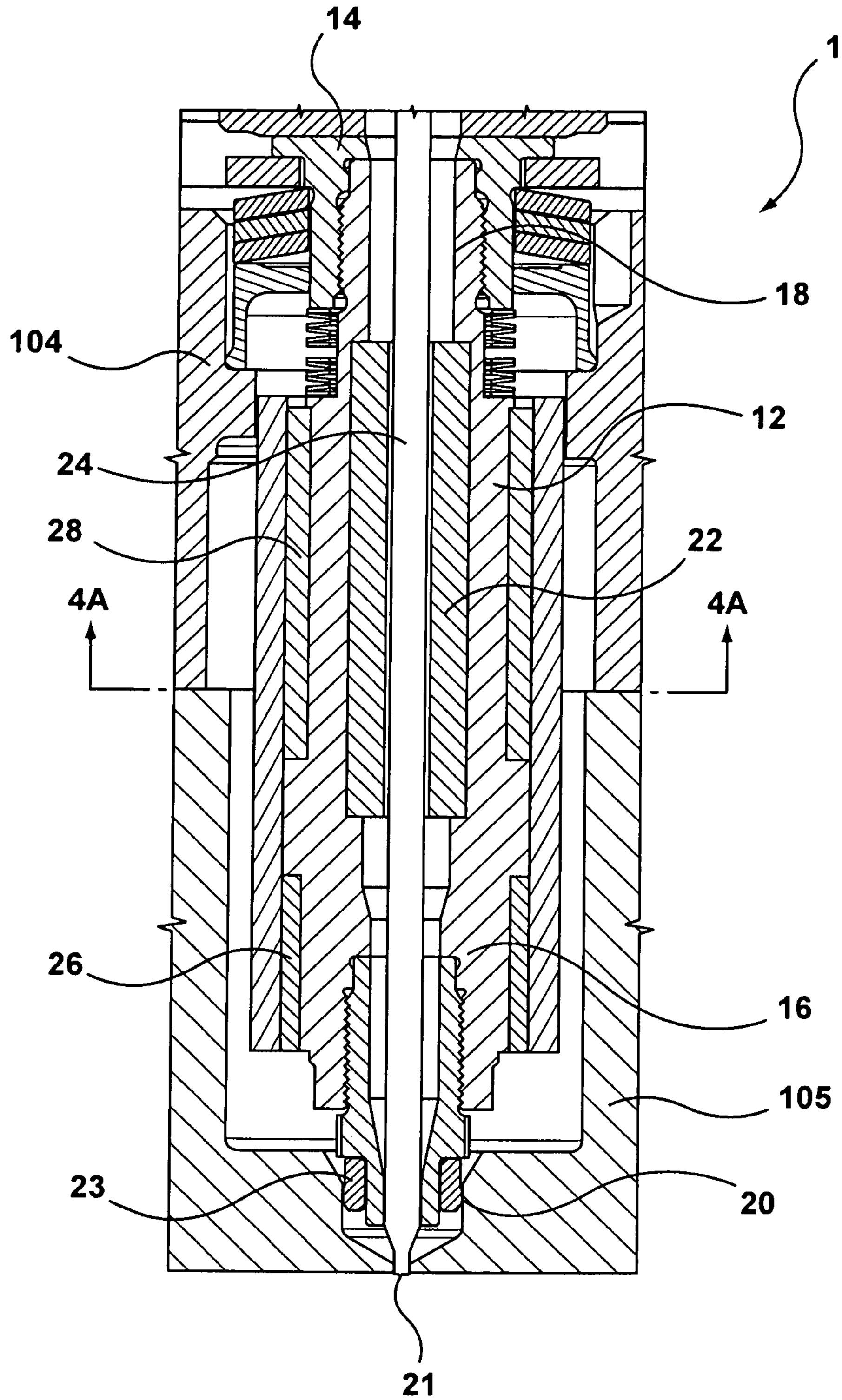

FIG. 1

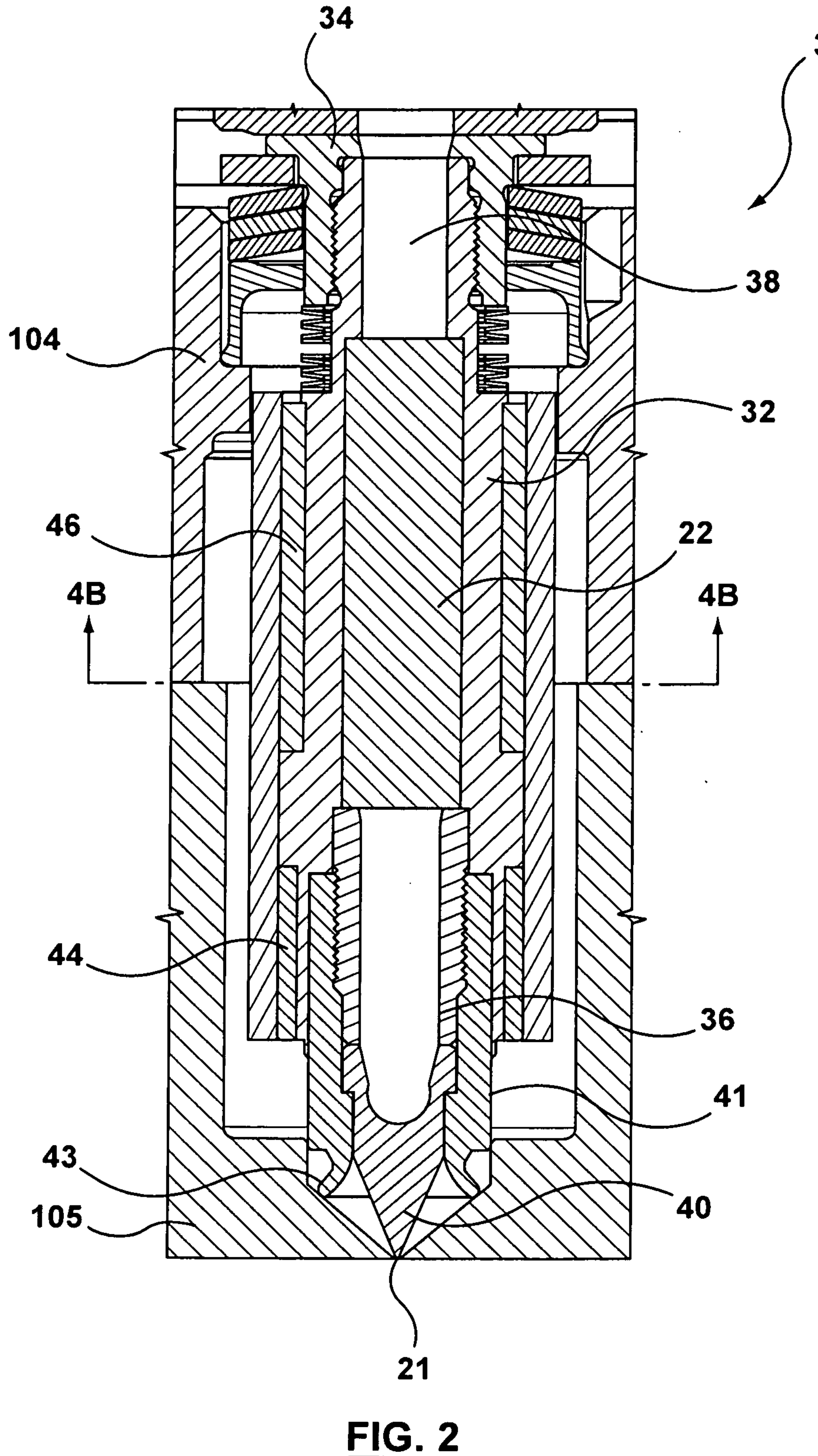

FIG. 2

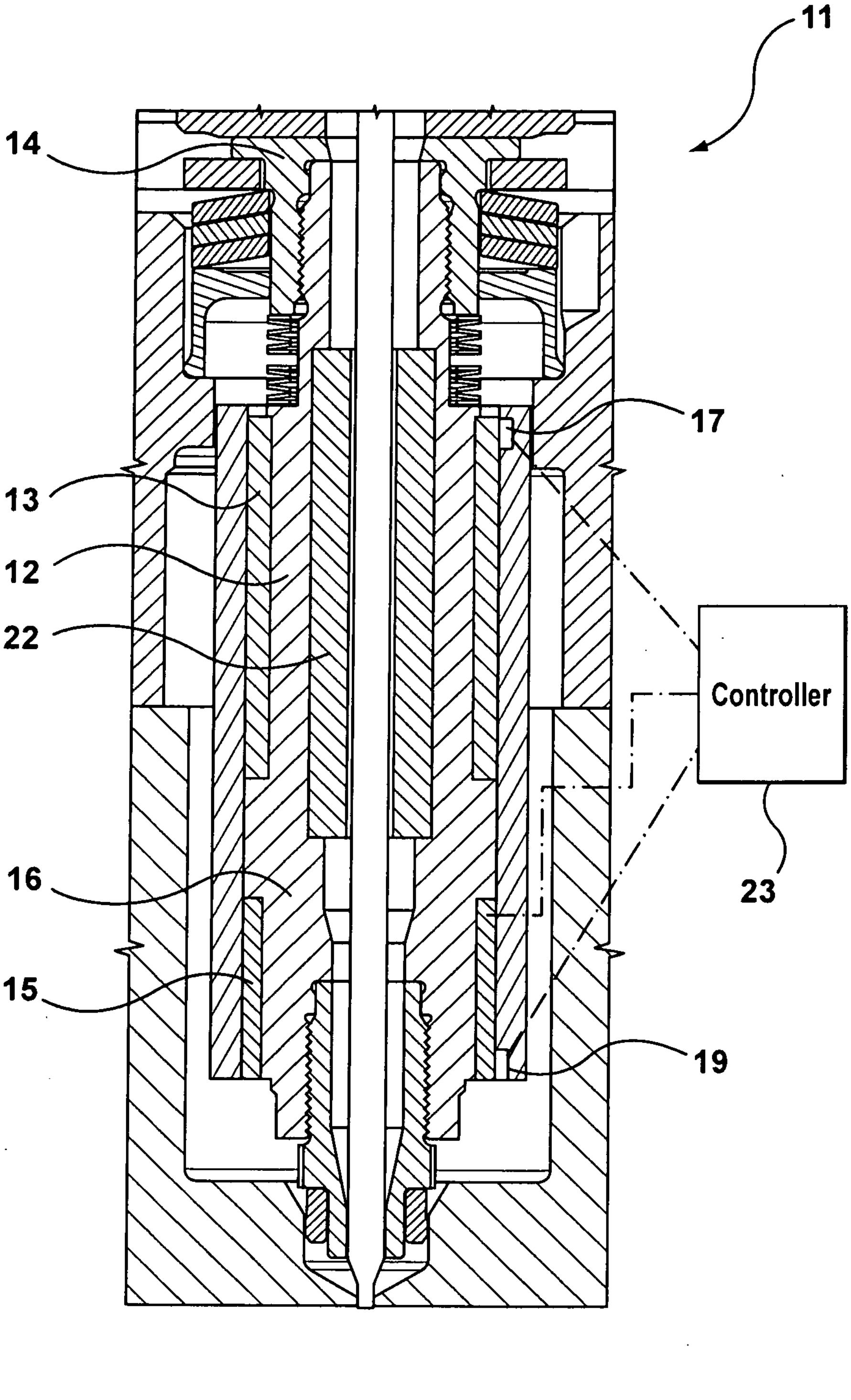

FIG. 3

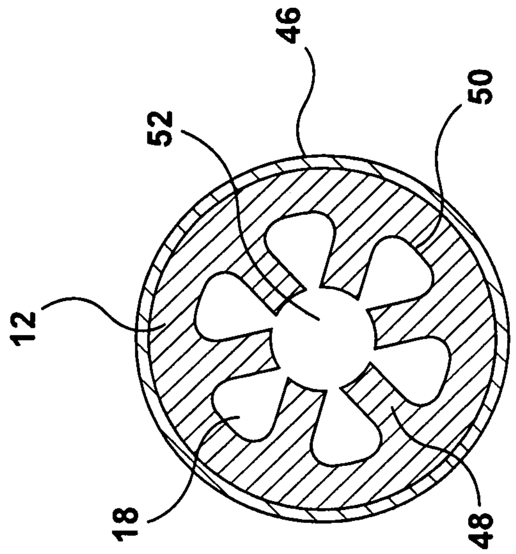

FIG. 4B

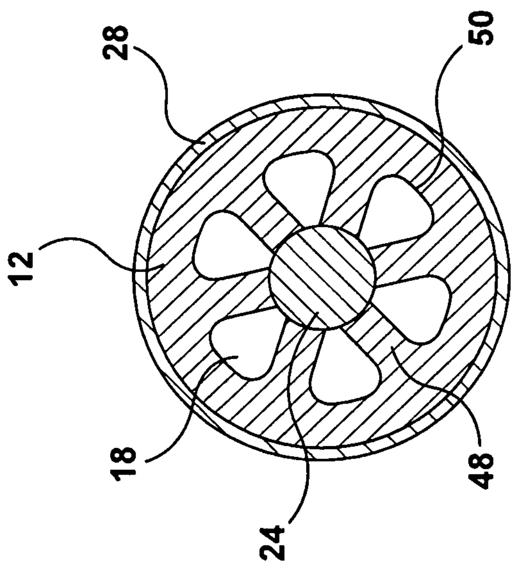

FIG. 4A

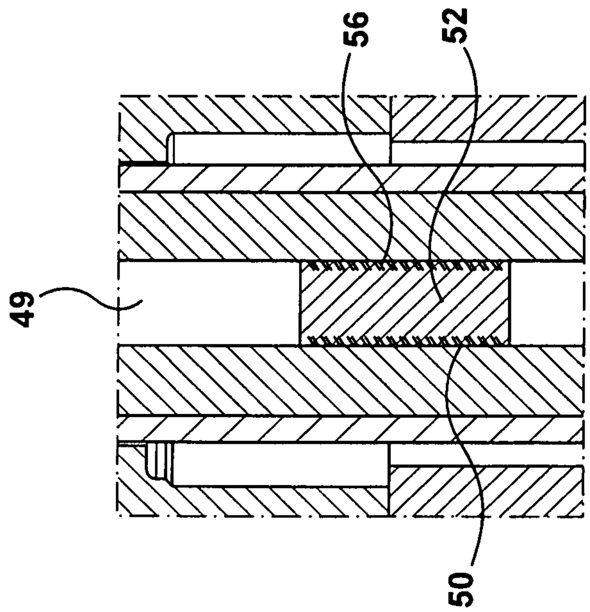

FIG. 5B

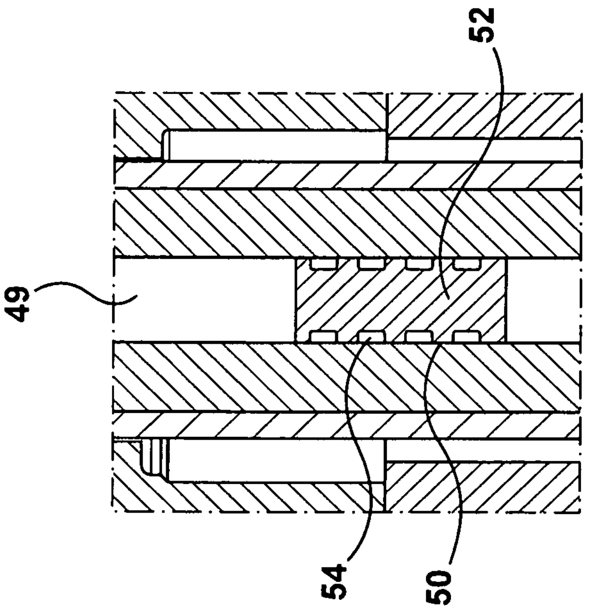

FIG. 5A

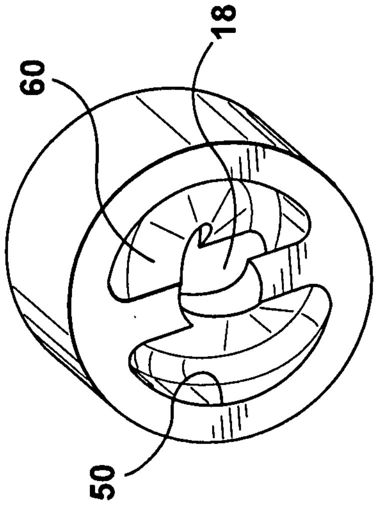

FIG. 6B

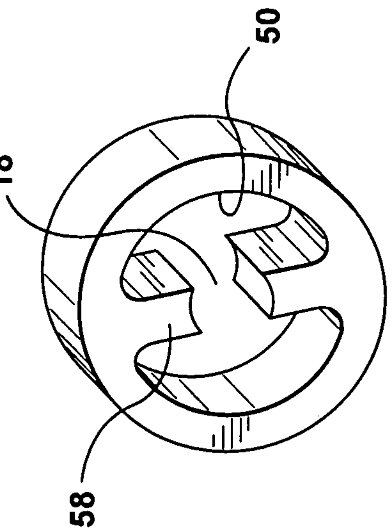

FIG. 6A

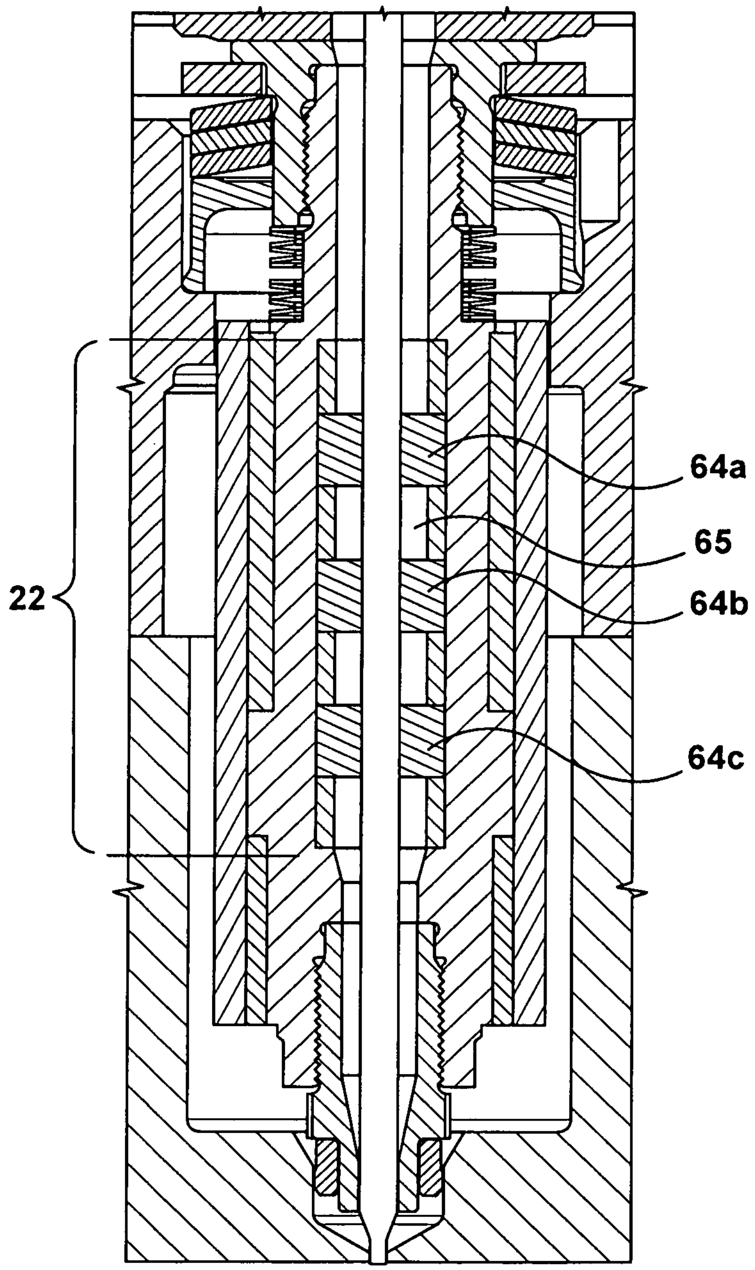

FIG. 7

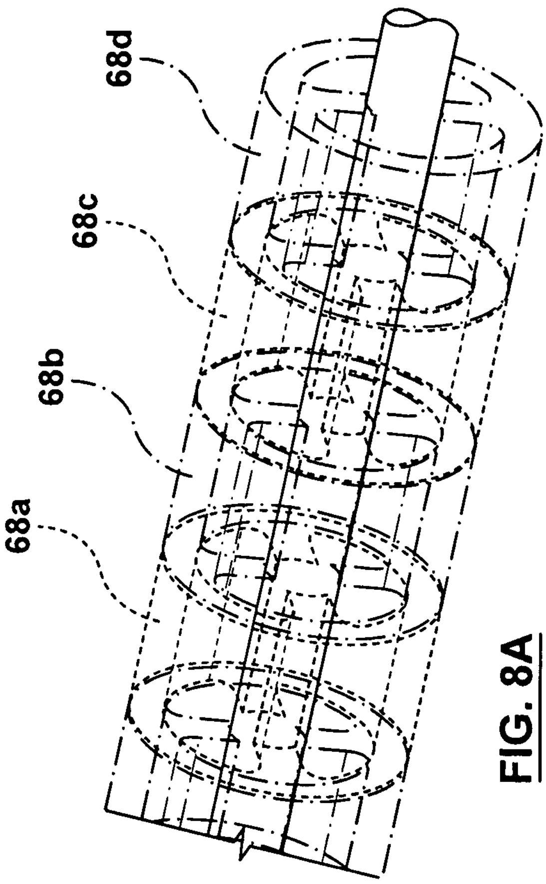

FIG. 8A

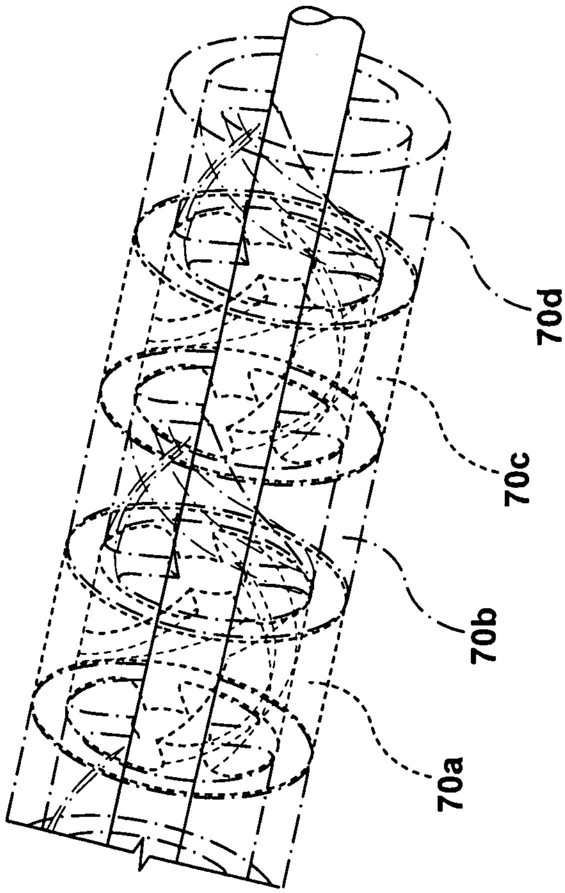

FIG. 8B

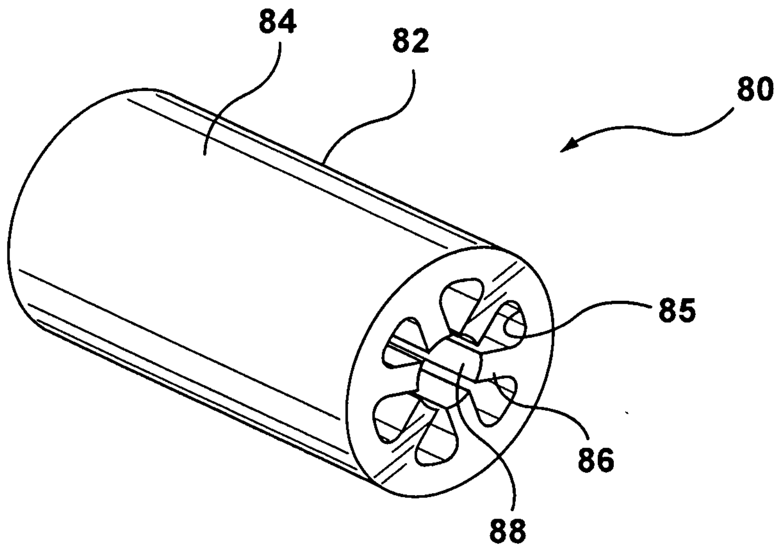

FIG. 9

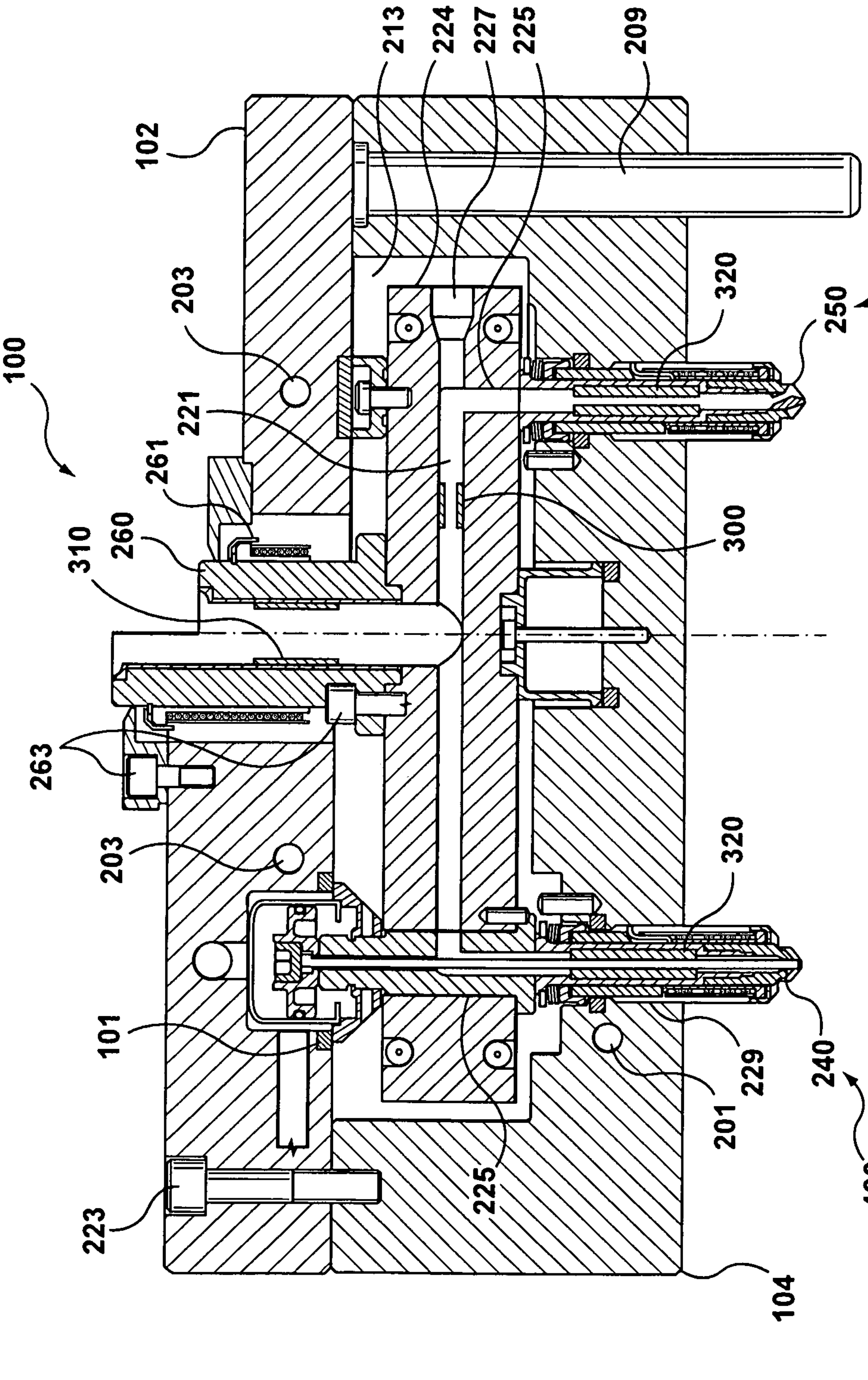
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FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/013299

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B29C 45/74 (2014.01)
USPC - 425/549
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)
IPC(8) - B29C 45/20, 45/72, 45/74 (2014.01)
USPC - 264/328.14, 328.15; 425/547, 548, 549, 568, 572

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - B29C 45/2737, 45/2741, 45/2754 (2014.02)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2010/0159062 A1 (KLOBUCAR et al) 24 June 2010 (24.06.2010) entire document	1-4, 7, 10-17, 19-23 ------ 18
X	US 7,462,030 B2 (FISCHER et al) 09 December 2008 (09.12.2008) entire document	24
Y	US 2011/0038980 A1 (JENKO) 17 February 2011 (17.02.2011) entire document	18
A	US 2004/0166194 A1 (TRUDEAU) 26 August 2004 (26.08.2004) entire document	1-24
A	US 2008/0279979 A1 (FAIRY et al) 13 November 2008 (13.11.2008) entire document	1-24
A	US 7,137,807 B2 (BABIN et al) 21 November 2006 (21.11.2006) entire document	1-24

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2014	14 MAY 2014

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-3201

Authorized officer:
Blaine R. Copenheaver
PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774