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(54) **Shot tube plunger for a die casting system**

(57) A shot tube plunger (128) for a die casting system includes a first face (41), an opposing second face (43) and an outer surface (45) disposed between said first face (41) and said opposing second face (43). A

channel (51) circumferentially extends about the outer surface (45). The channel (51) is operable to receive a portion of a charge of material (M) introduced into the die casting system.

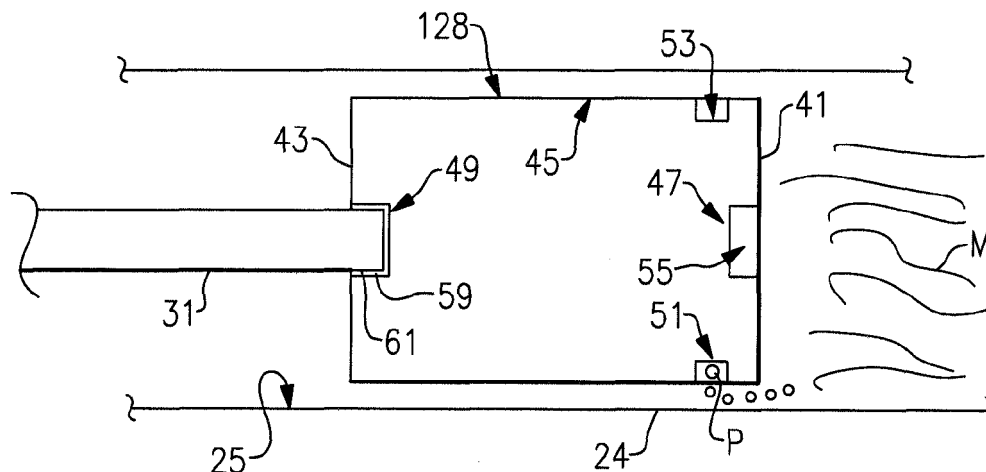


FIG. 2A

Description

BACKGROUND

[0001] This disclosure relates generally to a die casting system, and more particularly to a shot tube plunger for a die casting system.

[0002] Casting is a known technique used to yield substantially net-shaped components. For example, investment casting is often used in the gas turbine engine industry to manufacture net-shaped components, such as blades and vanes having relatively complex shapes. Investment casting involves pouring molten metal into a ceramic shell having a cavity in the shape of the component to be cast. Investment casting can be relatively labor intensive, time consuming and expensive.

[0003] Another known casting technique is die casting. Die casting involves injecting molten metal directly into a reusable die to yield a net-shaped component. Die casting has typically been used to produce components that do not require high thermal mechanical performance. For example, die casting is commonly used to produce components made from relatively low melting temperature materials that are not exposed to extreme temperatures. Die casting has not traditionally been a cost effective method for manufacturing parts made from high temperature alloys.

SUMMARY

[0004] In an exemplary embodiment, a shot tube plunger for a die casting system includes a first face, an opposing second face and an outer surface disposed between said first face and said opposing second face. A channel circumferentially extends about the outer surface. The channel is operable to receive a portion of a charge of material introduced into the die casting system.

[0005] In another exemplary embodiment, a die casting system includes a die, a shot tube, a shot tube plunger and a disposable piston head. The die includes a plurality of die components that define a die cavity. The shot tube is in fluid communication with the die cavity. The shot tube plunger is moveable within the shot tube to communicate a charge of material into the die cavity. The disposable piston head is removably attached to the shot tube plunger. The disposable piston head includes a first face and an opposing second face. The first face includes an engagement member that contacts a portion of the charge of material and the opposing second face includes an attachment member that removably attaches the disposable piston head to the shot tube plunger.

[0006] In yet another exemplary embodiment, a method of die casting a component with a die casting system includes removably attaching a disposable head to a shot tube plunger of the die casting system, injecting a charge of material into a die cavity of the die casting system with the shot tube plunger and attached disposable piston head, and capturing a portion of the charge of material

in a channel that circumferentially extends about an outer surface of the disposable piston head during the step of injecting the charge of material.

[0007] The various features and advantages of this disclosure will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1 illustrates an example die casting system. Figures 2A-2C illustrates an example shot tube plunger for use with a die casting system.

Figure 3 illustrates another example shot tube plunger for use with a die casting system.

Figure 4A-4F illustrates a first feature of the shot tube plunger of Figure 3.

Figure 5A-5C illustrates another feature of the shot tube plunger of Figure 3.

Figure 6A-6E illustrates another feature of the shot tube plunger of Figure 3.

Figure 7 illustrates a disposable piston head of a shot tube plunger.

DETAILED DESCRIPTION

[0009] Figure 1 illustrates a die casting system 10 including a reusable die 12 having a plurality of die elements 14, 16 that function to cast a component 15. The component could include aeronautical components, such as gas turbine engine blades or vanes, or non-aeronautical components. Although two die elements 14, 16 are depicted in Figure 1, it should be understood that the die 12 could include more or fewer die elements, as well as other parts and configurations.

[0010] The die 12 is assembled by positioning the die elements 14, 16 together and holding the die elements 14, 16 at a desired positioning via a mechanism 18. The mechanism 18 could include a clamping mechanism of appropriate hydraulic, pneumatic, electromechanical and/or other configurations. The mechanism 18 also separates the die elements 14, 16 subsequent to casting.

[0011] The die elements 14, 16 include internal surfaces that cooperate to define a die cavity 20. A shot tube 24 is in fluid communication with the die cavity 20 via one or more ports 26 that extend into the die element 14, the die element 16, or both. A shot tube plunger 28 is received within the shot tube 24 and is moveable between a retracted and injected position (in the direction of arrow A) within the shot tube 24 by a mechanism 30. A shaft 31 extends between the mechanism 30 and the shot tube plunger 28. The mechanism 30 could include a hydraulic assembly or other suitable mechanism, including, but not limited to, hydraulic, pneumatic, electromechanical or any combination of mechanisms.

[0012] The shot tube 24 is positioned to receive a charge of material, such as molten metal, from a melting unit 32, such as a crucible, for example. The melting unit 32 may utilize any known technique for melting an ingot of metallic material to prepare molten metal for delivery to the shot tube 24, including but not limited to, vacuum induction melting, electronic beam melting and induction skull melting. In this example, the molten metal is melted by the melting unit 32 at a location that is separate from the shot tube 24 and the die 12. However, other melting configurations are contemplated as within the scope of this disclosure. The melting unit 32 of this example is positioned in relative close proximity to the shot tube 24 to reduce the transfer distance of the molten metal between the melting unit 32 and the shot tube 24.

[0013] Materials capable of being used to die cast a component 15 include, but are not limited to, nickel-based super alloys, cobalt-based super alloys, titanium alloys, aluminum alloys, zinc alloys, copper-based alloys, iron alloys, molybdenum, tungsten, niobium or other refractory metals. This disclosure is not limited to the disclosed alloys, and other high melting temperature materials may be utilized to die cast the component 15. As used herein, the term "high melting temperature material" is intended to include materials having a melting temperature of approximately 1500°F (815°C) and higher.

[0014] The molten metal is transferred from the melting unit 32 to the shot tube 24 in a known manner. For example, the molten metal may be poured into a pour hole 33 of the shot tube 24. A sufficient amount of molten metal is poured into the shot tube 24 to fill the die cavity 20. The shot tube plunger 28 is actuated to inject the molten metal under pressure from the shot tube 24 into the die cavity 20 to cast the component 15. Although the casting of a single component is depicted, the die casting system 10 could be configured to cast multiple components in a single shot.

[0015] Although not necessary, at least a part of the die casting system 10 can be positioned within a vacuum chamber 34 that includes a vacuum source 35. A vacuum is applied in the vacuum chamber 34 via the vacuum source 35 to render a vacuum die casting process. The vacuum chamber 34 provides a non-reactive environment for the die casting system 10 that reduces reaction, contamination or other conditions that could detrimentally affect the quality of the die cast component, such as excess porosity of the die cast component that can occur as a result of exposure to oxygen. In one example, the vacuum chamber 34 is maintained at a pressure between 1×10^{-3} Torr and 1×10^{-4} Torr, although other pressures are contemplated. The actual pressure of the vacuum chamber 34 will vary based upon the type of component 15 being cast, among other conditions and factors. In the illustrated example, each of the melting unit 32, the shot tube 24 and the die 12 are positioned within the vacuum chamber 34 during the die casting process such that the melting, injecting and solidifying of the high melting temperature material are all performed under vacuum. In an-

other example, the chamber 34 is backfilled with an inert gas, such as Argon, for example.

[0016] The example die casting system 10 depicted in Figure 1 is illustrative only and could include more or fewer sections, parts and/or components. This disclosure extends to all forms of die casting, including but not limited to, horizontal, inclined or vertical die casting systems and other die casting configurations.

[0017] Figures 2A-2C illustrate an example shot tube plunger 128 for use with a die casting system, such as the die casting system 10. In this disclosure, like reference numerals signify like features, and reference numerals signified by adding 100 to the original reference number are slightly modified features. Moreover, selected features of one example embodiment may be combined with selected features of other example embodiments within the scope of this disclosure.

[0018] The shot tube plunger 128 is disposable. That is, the shot tube plunger 128 is removable from the shaft 31 and may be disposed of after injection of a charge of material, such as a charge of a high melting temperature material, to cast a component 15. The sacrificial shot tube plunger 128 can be removed either after a single injection or after multiple injections and replaced with another disposable shot tube plunger 128 for a subsequent injection. In this example, the shot tube plunger 128 is a single-piece device having no mechanical attachments. The shot tube plunger 128 is made from a material capable of withstanding contact with high melting temperature materials, such as the contact that occurs during the injection of a charge of material M during the die casting process, including but not limited to, steel, ceramic, or other refractory materials.

[0019] The shot tube plunger 128 includes a first face 41, a second face 43, and an outer cylindrical surface 45 disposed between the first face 41 and the second face 43. The first face 41 faces the charge of material M within the shot tube 24, while the second face 43 faces the shaft 31. The shot tube plunger 128 may include an engagement member 47, an attachment member 49 and/or a channel 51. Although Figure 2A illustrates the shot tube plunger 128 having each of the engagement member 47, the attachment member 49 and the channel 51, it should be understood that the shot tube plunger 128 could include only one of these features or any combination of such features. It should also be understood that the outer surface 45 of the shot tube plunger 128 could be configured to include non-cylindrical shapes.

[0020] The first face 41 can include the engagement member 47. The engagement member 47 provides an additional contact area for the charge of material M to bond to during injection. Once the injection is complete and the charge of material M is solidified within the die cavity 20, the disposable shot tube plunger 128 remains attached to the cast component 15 (See Figure 2B) via cast portion 17 that bonds to the engagement member 47, but is detached from the shaft 31. The shot tube plunger 128 is then removed from the component 15 by re-

moving the cast portion 17 and can then be disposed of.

[0021] In one example, the engagement member 47 includes a recess 55 (see Figure 2A). The recess 55 extends from the first face 41, which faces the charge of material M, toward the second face 43. The recess 55 can include a variety of shapes and configurations, including but not limited to, a T-shaped configuration, a triangular configuration, a truncated configuration, etc. Other shapes are also contemplated as within the scope of this disclosure. The first face 41 can include a single recess 55 or multiple recesses 55. In another example, the engagement member 47 includes a protrusion 57 that protrudes from the first face 41 in a direction away from the second face 43 (See Figure 2C). The shot tube plunger 128 could include a single protrusion 57 (Figure 2C) or multiple protrusions 52 (Figure 4E).

[0022] The shot tube plunger 128 can also include an attachment member 49 for aligning and affixing the shot tube plunger 128 relative to the shaft 31. The attachment member 49 is disposed on the second face 43 of the shot tube plunger 128. In one example, the attachment member 49 includes a recess 59 (see Figure 2A). The recess 59 can include multiple shapes and sizes. The recess 59 receives a corresponding protrusion 61 of the shaft 31. In another example, the attachment member 49 includes a protrusion 63 that extends from the second face 43 and is received within a corresponding recess 65 of the shaft 31 (See Figure 2C).

[0023] The shot tube plunger may also include the channel 51. The channel 51 circumferentially extends about the outer cylindrical surface 45. In this example, the channel 51 includes a circumferential groove 53 that extends radially inwardly from the outer cylindrical surface 45. The channel 51 could also include other configurations. For example, the shot tube plunger 128 could include a single channel 51 or multiple channels 51. As the shot tube plunger 128 injects the molten metal during the die casting process, it is possible for a portion P of the molten metal to pass between an inner wall 25 of the shot tube and the outer cylindrical surface 45 of the shot tube plunger 128. When this occurs, the portion P of the charge of material M is captured within the channel 51 thereby leaving the shot tube 24 free of solidified metal particles and avoiding gouging of the inner wall 25 that can occur as the shot tube plunger 128 is retracted.

[0024] Figure 3 illustrates another example shot tube plunger 228. The shot tube plunger 228 includes a disposable piston head 40. The disposable piston head 40 is removably attached to the shot tube plunger 228 and can be disposed of subsequent to an injection of a charge of material during a die casting process. The disposable piston head 40 can be removed from the shaft 31 and disposed of either after a single injection or after multiple injections. The disposable piston head 40 is made from a material capable of withstanding contact with high melting temperature materials. For example, the disposable piston head 40 could be made from steel, ceramic, or other refractory materials.

[0025] The disposable piston head 40 defines a first height H1, and the shot tube plunger 228 defines a second height H2. In this example, the first height H1 of the disposable piston head 40 and the second height H2 of the shot tube plunger 228 are generally equal. Therefore, the shot tube plunger 228 may be reciprocated between a retracted and injected position without creating interference with the inner wall 25 of the shot tube 24.

[0026] Figures 4A-4F illustrate example features of the disposable piston head 40. In these examples, the disposable piston head 40 includes a first face 42, a second face 44 and an outer cylindrical surface 46 disposed between the first face 42 and the second face 44. The first face 42 faces a charge of material M (e.g., molten metal) within the shot tube 24, while the second face 44 faces the shot tube plunger 228 (shown in phantom).

[0027] The first face 42 can include an engagement member 48. The engagement member 48 provides a contact area for the charge of material M to bond to during injection. Once the injection is complete and the metal is solidified within the die cavity 20, the disposable piston head 40 remains attached to the cast component 15 (See Figure 4F) via a cast portion 17. The disposable piston head 40 can then be removed from the component 15 and disposed of.

[0028] In one example, the engagement member 48 includes a recess 50 (see Figures 4A-4C). The recess 50 extends from the first face 42, which faces the charge of material M, in a direction toward the second face 44. The recess 50 can include a variety of shapes and configurations, including truncated triangular configurations (Figures 4A and 4B) and T-shaped configurations (Figure 4C). Other shapes are contemplated as within the scope of this disclosure. The first face 42 can include a single recess 50 (See Figure 4A) or multiple recesses 50 (See Figure 4B).

[0029] Figures 4D-4F illustrate another example engagement member 48 of the disposable piston head 40. In this example, the engagement member 48 includes a protrusion 52 that protrudes from the first face 42 in a direction away from the second face 44. The disposable piston head 40 can include a single protrusion 52 (See Figure 4D), or multiple protrusions 52 (See Figure 4E). The protrusions 52 may have an enlarged head to further secure bonding.

[0030] Figures 5A-5C illustrate another feature of the disposable piston head 40. The disposable piston head 40 includes an attachment member 54 for aligning and affixing the disposable piston head 40 to the shot tube plunger 228. The attachment member 54 is disposed on the second face 44 of the disposable piston head 40, which faces in a direction toward the shot tube plunger 228. That is, the attachment member 54 is positioned on an opposite side of the disposable piston head 40 from the charge of material M.

[0031] In one example, the attachment member 54 includes a recess 56 (see Figures 5A and 5C). The recess 55 can include multiple shapes and sizes, including but

not limited to those depicted in Figure 5A and Figure 5C. The recess 56 receives a corresponding protrusion 60 of the shot tube plunger 228 (shown in phantom) to removably attach the disposable piston head 40 to the shot tube plunger 228.

[0032] In another example, the attachment member 54 includes a protrusion 62 that extends from the second face 44 in a direction toward the shot tube plunger 228. The protrusion 62 is received within a corresponding recess 64 of the shot tube plunger 228 to removably attach the disposable piston head 40 to the shot tube plunger 228.

[0033] Figures 6A-6E illustrate yet another feature of the disposable piston head 40. The disposable piston head 40 can include a channel 58 circumferentially disposed about the outer cylindrical surface 46 of the disposable piston head 40. The channel 58 extends radially inward from the outer cylindrical surface 46 of the disposable piston head 40 to define a circumferential groove 66.

[0034] The channel 58 can define any of a multitude of varying shapes and configurations, such as depicted in Figures 6A-6E. In addition, such as depicted in Figure 6D, the outer cylindrical surface 46 of the disposable piston head 40 can include a plurality of channels 58 defined thereon. As the shot tube plunger 228 injects the charge of material M during the die casting process, it is possible for a portion P of the charge of material M to pass between an inner wall 25 of the shot tube 24 and the outer cylindrical surface 45 of the shot tube plunger 228. When this occurs, the portion P of the charge of material M is captured within the channel 58 thereby leaving the shot tube 24 free of solidified metal particles and avoiding gouging of the inner wall 25 that can occur as the shot tube plunger 228 is retracted (See Figure 6A).

[0035] As detailed above, Figures 3-6 illustrate multiple features of the disposable piston head 40. The disposable piston head 40 could include one or all of the features described herein. For example, the disposable piston head 40 could include the engagement member 48, the attachment member 54 and the channel 58, or any combination of these features. Figure 7, for example, illustrates a disposable piston head 40 having each of the engagement member 48, the attachment member 54 and the channel 58.

[0036] It should be understood that many of the features depicted in Figures 1-7 of this disclosure are not illustrated to the scale they would be in practice. Indeed, many features are shown enlarged to better illustrate their design and function and should not be interpreted as limiting this disclosure in any way.

[0037] The foregoing description shall be interpreted as illustrative and not in any limiting sense. A worker of ordinary skill in the art would understand that certain modifications could come within the scope of this disclosure. For these reasons, the following claims should be studied to determine the true scope and content of this disclosure.

Claims

1. A die casting system (10), comprising:

5 a shot tube plunger (128;228) having a first face (41), an opposing second face (43), and an outer surface (45) disposed between said first face (41) and said opposing second face (43), wherein a channel (51;58) circumferentially extends about said outer surface (45), said channel (51) operable to receive a portion of a charge of material (M) introduced into the die casting system (10).

15 2. The system as recited in claim 1, wherein said channel (51) includes a circumferential groove (53) that extends radially inward from said outer surface (45).

20 3. The system as recited in claim 1 or 2, wherein said first face (41) includes an engagement member (47).

4. The system as recited in claim 3, wherein said engagement member (47) is a recess (55).

25 5. The system as recited in claim 3, wherein said engagement member is a protrusion (57).

30 6. The system as recited in any preceding claim, comprising a shaft (31), wherein said second face (43) includes an attachment member (49) that removably attaches said shot tube plunger (128) to said shaft (31).

35 7. The system as recited in claim 6, wherein said attachment member (49) includes one of a recess (59) and a protrusion (63) and said shaft (31) includes the other of said recess (65) and said protrusion (61).

40 8. The system as recited in any preceding claim, wherein said shot tube plunger (228) includes a disposable piston head (40) and said channel (58) extends circumferentially about said disposable piston head (40).

45 9. The system as recited in claim 8, wherein said disposable piston head (40) includes:

50 a first face (42) and an opposing second face (44), and said first face (42) includes an engagement member (48) that contacts a portion of said charge of material (M) and said opposing second face (44) includes an attachment member (54) that removably attaches said disposable piston head (40) to said shot tube plunger (228).

55 10. A die casting system (10), comprising:

a die (12) including a plurality of die components

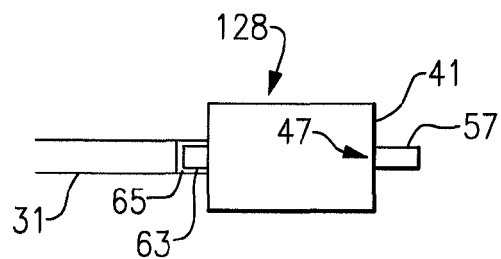
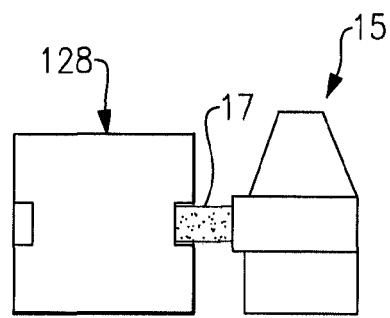
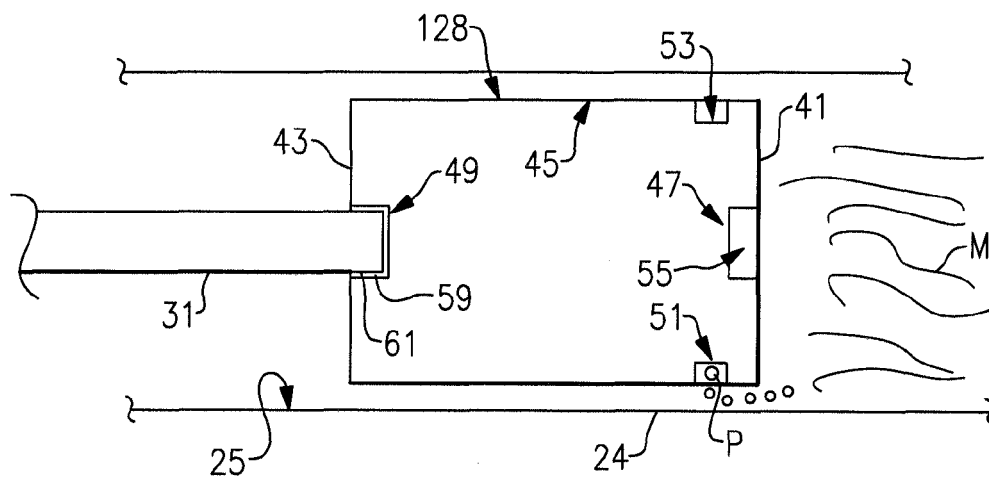
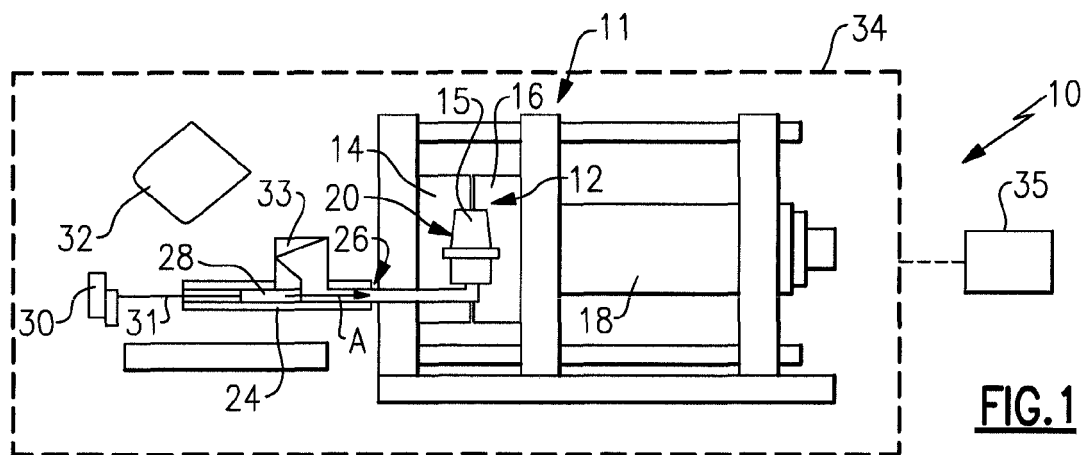
(14,16) that define a die cavity (20);
 a shot tube (24) in fluid communication with said die cavity (20);
 a shot tube plunger (228) moveable within said shot tube (24) to communicate a charge of material (M) into said die cavity (20); and
 a disposable piston head (40) removably attached to said shot tube plunger (228), wherein said disposable piston head (40) includes a first face (42) and an opposing second face (44), and said first face (42) includes an engagement member (48) that contacts a portion of said charge of material (M) and said opposing second face (44) includes an attachment member (54) that removably attaches said disposable piston head (40) to said shot tube plunger (228).

ther comprising the steps of:

(f) removing the disposable piston head (40) from the component; and
 (g) disposing of the disposable piston head (40); and/or

wherein the disposable piston head (40) includes a first face (42) that faces the charge of material (M), the first face (42) including a recess (50), and wherein said step (c) includes capturing a portion of the charge of material (M) within the recess (50).

11. The system as recited in claim 10, wherein said disposable piston head (40) includes an outer surface (46) having a channel (58) that circumferentially extends about said outer surface (46).
12. The system as recited in claim 9, 10 or 11, wherein said engagement member (48) includes one of a recess (50) and a protrusion (52).
13. The system as recited in any of claims 9 to 12, wherein said attachment member (54) includes one of a recess (56) and a protrusion (62) and said shot tube plunger (228) includes the other of said recess (64) and said protrusion (60) to removably attach said disposable piston head (40) to said shot tube plunger (228).
14. A method of die casting a component with a die casting system (10), comprising the steps of:
 - (a) removably attaching a disposable piston head (40) to a shot tube plunger (228) of the die casting system;
 - (b) injecting a charge of material (M) through a shot tube (24) and into a die cavity (20) of the die casting system with the shot tube plunger (228) and attached disposable piston head (40); and
 - (c) capturing a portion of the charge of material in a channel (51) that circumferentially extends about an outer surface of the disposable piston head (40) during the step of injecting the charge of material (M).
15. The method as recited 14, comprising the steps of:
 - (d) solidifying the charge of material (M) to form the component; and
 - (e) removing the component from the die cavity (20) with the disposable piston head (40) still attached to the component; and, optionally, fur-



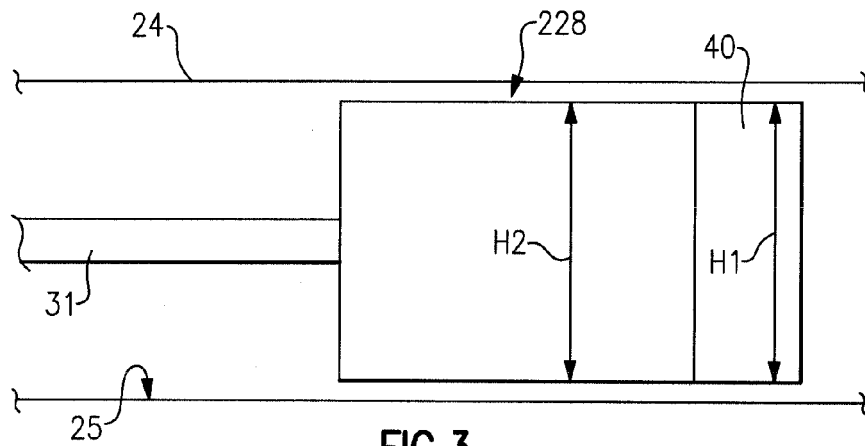


FIG. 3

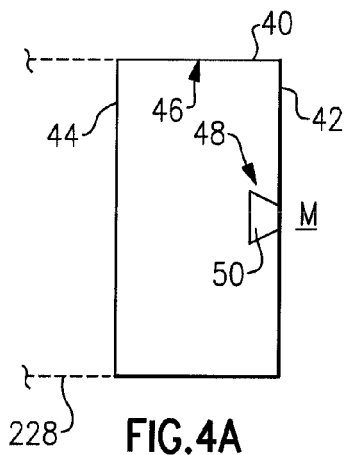


FIG. 4A

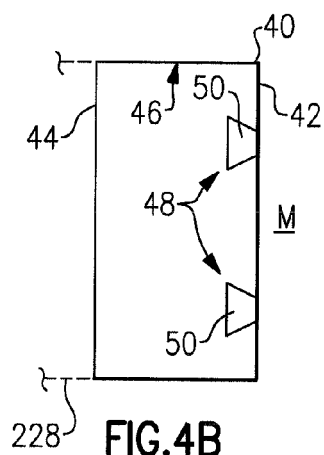


FIG. 4B

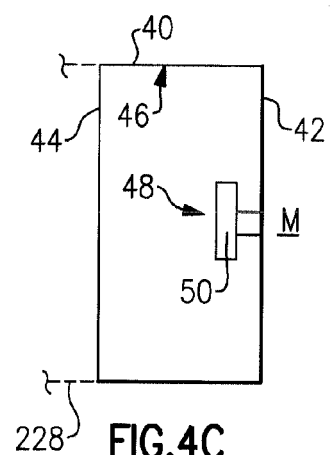


FIG. 4C

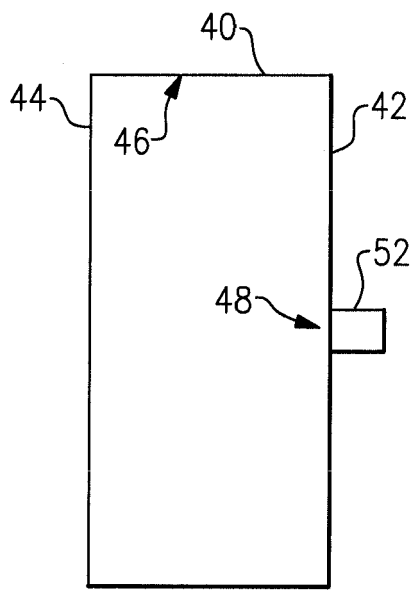


FIG. 4D

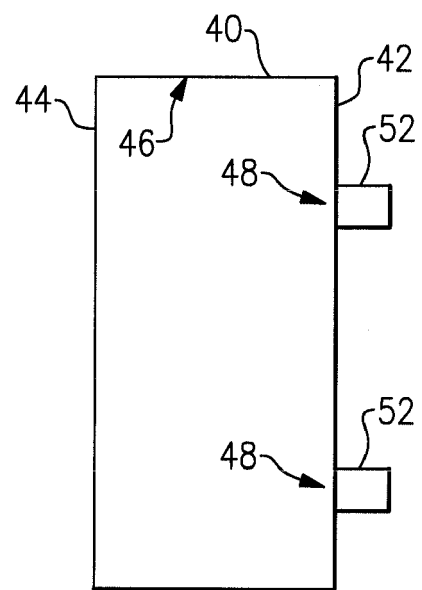


FIG. 4E

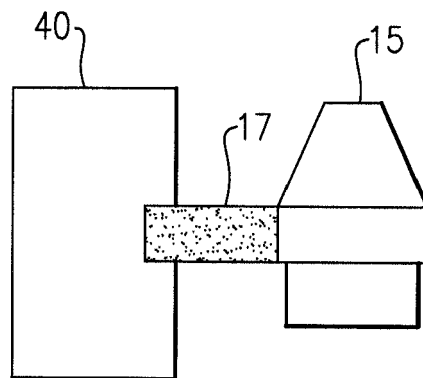
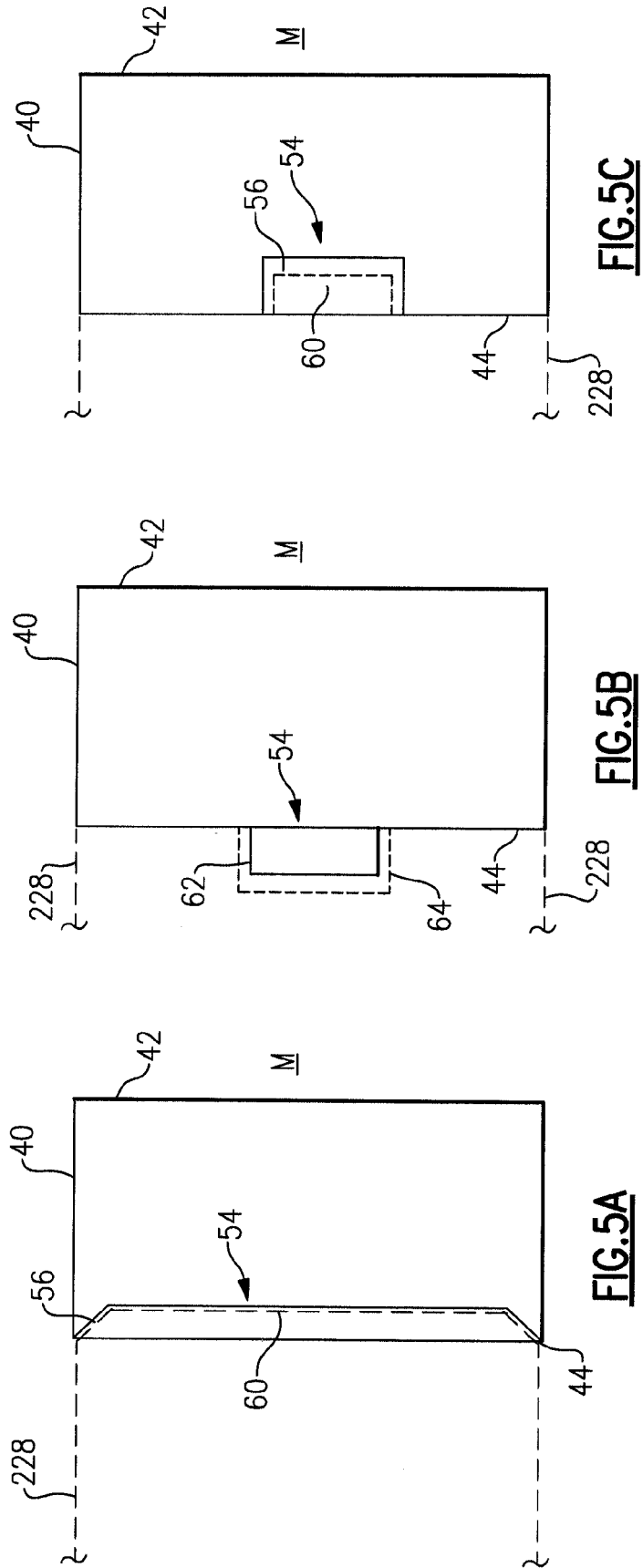


FIG. 4F



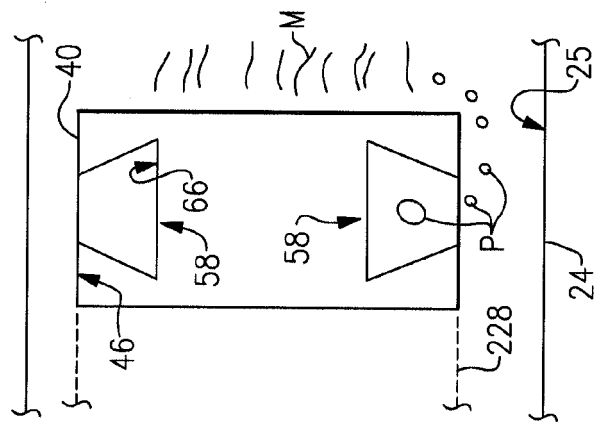


FIG. 6A

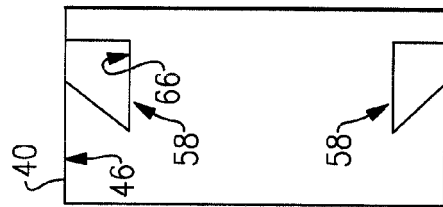


FIG. 6B

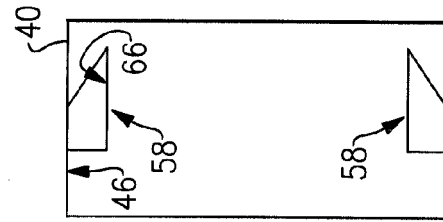


FIG. 6C

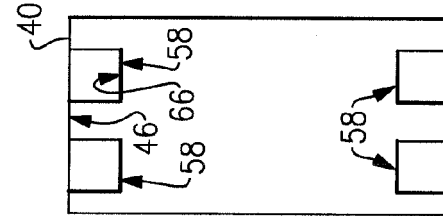


FIG. 6D

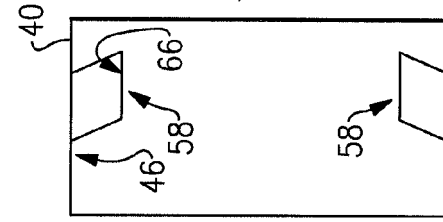


FIG. 6E

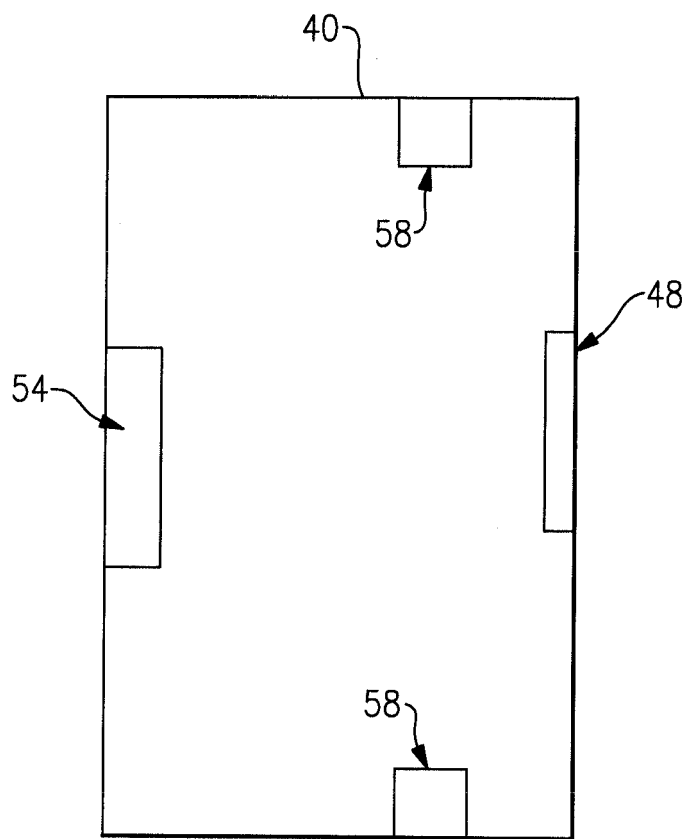


FIG.7