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EX. A-G

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF MICHIGAN
SOUTHERN DIVISION

ORIGINAL

MELEA LIMITED, a Gibraltar corporation, and **PLASTIC MOLDED TECHNOLOGIES, INC.**, a Michigan corporation,

Plaintiffs,

vs.

ALLIANCE GAS SYSTEMS INC., a Michigan corporation, **DOVEPORT SYSTEMS, LLC**, a Michigan limited liability company, **DAIMLERCHRYSLER CORPORATION**, a Delaware corporation, and **COLLINS & AIKMAN PRODUCTS CO.**, a Delaware corporation,

Defendants.

HONORABLE GERALD E. ROSEN
MAGISTRATE JUDGE DONALD A. SCHEER
CIVIL ACTION NO. 04-70530

JURY TRIAL DEMANDED

FILED 04 JUL -7 PM 3:36

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SECOND AMENDED AND SUPPLEMENTAL COMPLAINT FOR PATENT INFRINGEMENT AND DECLARATORY RELIEF AND JURY DEMAND

[This pleading is being filed pursuant to ¶ 6 of the Scheduling Order, dated June 24, 2004, Docket No. 19.]

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I. THE PARTIES

1. Plaintiff, Melea Limited ("Melea"), is a Gibraltar corporation, having an address at Suites 2 & 3, 215 Main Street, Gibraltar Heights, Gibraltar.

2. Plaintiff, Plastic Molded Technologies, Inc. ("PMT"), is a Michigan corporation, having an address at 44440 Phoenix Drive, Sterling Heights, Michigan 48315.

3. Defendant, Alliance Gas Systems Inc. ("Alliance"), is a Michigan corporation, having its main offices at 46449 Continental Drive, Chesterfield Township, Michigan 48047, and has appointed Ronald W. Thomas as its agent for service of process.

4. Defendant, Doveport Systems, LLC ("Doveport"), is a Michigan limited liability company, having its main offices at 15700 Common Road, Roseville, Michigan 48066, and whose registered agent is Alex L. Parrish, 2290 First National Building, Detroit, Michigan 48226.

5. Defendant, DaimlerChrysler Corporation ("DaimlerChrysler"), is a Delaware corporation, who has appointed The Corporation Company as its agent for service of process, 30600 Telegraph Road, Bingham Farms, Michigan 48025.

6. Defendant, Collins & Aikman Products Co. ("C&A"), is a Delaware corporation, having an address at 350 Stephenson Highway, Troy, Michigan 48083.

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II. JURISDICTION

7. The patent infringement claims pleaded herein arise under the Patent Act, 35 U.S.C. § 1 *et seq.*

8. Subject matter jurisdiction for the patent infringement claims is conferred upon the Court by 28 U.S.C. § 1338(a).

9. The declaratory judgment claims pleaded herein address defendant C&A, and the patent license it holds which form the basis of the "patent misuse" affirmative defense and counterclaim, and the "breach of contract" counterclaims, pled by defendant-counterclaimants Doveport and DaimlerChrysler.

10. The declaratory judgment claims plead a case of actual controversy for which the Court may declare the rights and legal relations of the parties, on justiciable issues that are so related to the claims and counterclaims in the action that they form part of the same case or controversy under Article III of the United States Constitution.

11. The Court has jurisdiction for the declaratory judgment claims pleaded herein under 28 U.S.C.§§ 1367 and 2201.

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III. PATENT INFRINGEMENT

12. On March 24, 1992, U.S. Patent No. 5,098,637 ("the '637 patent") was duly and lawfully issued to James W. Hendry for "Process For Injection Molding And Hollow Plastic Article Produced Thereby." A true and correct copy of the '637 patent is attached at Exhibit A.

13. On August 22, 1995, U.S. Patent No. 5,443,087 ("the '087 patent") was duly and lawfully issued to Colin K. Myles for "Method And System For Controlling A Pressurized Fluid And Valve Assembly For Use Therein." A true and correct copy of the '087 patent is attached at Exhibit B.

14. On May 19, 1992, U.S. Patent No. 5,114,660 ("the '660 patent") was duly and lawfully issued to James W. Hendry for "Method Of Injecting Molding." A true and correct copy of the '660 patent is attached at Exhibit C.

15. Melea is the owner by assignment of the '637 patent, the '087 patent, and the '660 patent as evidenced by the records of the Assignment Branch of the United States Patent And Trademark Office.

16. PMT has been appointed by Melea as its representative for licensing of Melea's proprietary and patented technology, and to sell manufactured or fabricated products which may be covered by such technology.

17. PMT does business as "GAIN Technologies," and its business includes products and services in the field of gas-assisted plastic injection molding technology. (www.gaintechnologies.com.)

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18. Defendant Alliance has induced infringement of the '637 patent by defendants Doveport, DaimlerChrysler, and C&A (and possibly others) by actively and knowingly aiding and abetting the direct infringement of the '637 patent by defendants Doveport, DaimlerChrysler, and C&A.

19. Upon information and belief, defendant Alliance has also directly infringed the '637 patent by (a) using the process of claim 1 of the '637 patent within the United States, and (b) offering to sell, and selling within the United States plastic articles molded in accordance with the process of claim 1 of the '637 patent, all without the consent of Melea. *See* www.gasassist.com/moldingservices.html. (Exhibit D.)

20. Defendant Doveport has directly infringed the '637 patent by (a) using within the United States the process of claim 1 of the '637 patent, and (b) offering to sell and selling within the United States plastic articles molded in accordance with the process of claim 1 of the '637 patent, all without the consent of Melea.

21. Defendant Doveport has also induced infringement of the '637 patent by defendants DaimlerChrysler and C&A (and possibly others) by actively and knowingly aiding and abetting the direct infringement of the '637 patent by DaimlerChrysler and C&A.

22. Defendants DaimlerChrysler and C&A have directly infringed the '637 patent by offering to sell, selling, and using, within the United States, plastic articles molded in accordance with the process of claim 1 of the '637 patent, without the consent of Melea.

23. Defendants DaimlerChrysler and C&A have also induced infringement of the '637 patent by actively and knowingly aiding and abetting the direct infringement of the '637 patent by others.

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24. An exemplar of an infringing product is the DaimlerChrysler 2004 Dodge Durango Handle Assembly — "B" Pillar Assist, Part No. OYS11BDXAA ("the Dodge Durango Handle").

25. The Dodge Durango Handle is (a) used and sold by DaimlerChrysler, (b) molded by Doveport Systems using the process of claim 1 of the '637 patent, (c) under control of the Alliance LGC-8 Gas Controller Unit, all without the consent of Melea.

26. Upon information and belief, all defendants know of and participate jointly in the unauthorized use of the process of claim 1 of the '637 patent.

27. Exhibit E consists of a set of documents evidencing the use of the process of claim 1 of the '637 patent in the molding of the Dodge Durango Handle, where (i) the first page is a copy of claim 1 with alphabetical designations of each process step, (ii) the second through fifth pages are photographs of the Dodge Durango Handle with annotations linking the product to the elements of claim 1, and (iii) sixth page is a photograph of the DaimlerChrysler packaging, including a bar-coded label.

28. Upon information and belief, on July 12, 2004, defendant Doveport will surrender the mold tool(s) for making the Dodge Durango Handle to C&A, who is expected to have the Dodge Durango Handle made by another source.

29. Defendant Alliance has directly infringed the '087 patent by making, using, selling, and offering for sale, gas controller units which embody and operate in accordance with the respective control systems and control methods defined in the claims of the '087 patent, without the consent of Melea.

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30. Defendant Alliance has also induced infringement of the '087 patent by others by actively and knowingly aiding and abetting the direct infringement of the '087 patent by defendant Doveport and other Alliance customers for gas-assist control equipment.

31. Defendant Doveport has directly infringed the '087 patent by using the control systems and control methods defined by the claims of the '087 patent in the United States, without the consent of Melea.

32. Defendant Doveport has also induced infringement of the '087 patent by actively and knowingly aiding and abetting the direct infringement of the '087 patent by DaimlerChrysler and others.

33. Defendants DaimlerChrysler and C&A have directly infringed the '087 patent by using, selling and offering for sale, within the United States, plastic articles molded in accordance with the method claims of the '087 patent, without the consent of Melea.

34. Exhibit F is a compendium of documents demonstrating infringement of the '087 patent by the Alliance Model LGC-8 Gas Controller (used by Doveport to mold gas-assisted parts for DaimlerChrysler).

35. The cover sheet of Exhibit E is claim 1 of the '087 patent, with reference numerals added in parentheses to correlate to the illustrative embodiment shown in the drawing and described in the specification of the '087 patent.

36. Defendant Alliance has induced infringement of the '660 patent by defendants Doveport, DaimlerChrysler and C&A (and possibly others) by actively and knowingly aiding and abetting the direct infringement of the '660 patent by defendants

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Doveport and DaimlerChrysler. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

37. Upon information and belief, defendant Alliance has also directly infringed the '660 patent by (a) using the process of claim 1 of the '660 patent within the United States, and (b) offering to sell, and selling with the United States plastic articles molded in accordance with the process of at least claim 1 of the '637 patent, all without the consent of Melea. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

38. Defendant Doveport has directly infringed the '660 patent by (a) using within the United States the process of at least claim 1 of the '660 patent, and (b) offering to sell and selling within the United States plastic articles molded in accordance with the process of at least claim 1 of the '660 patent, all without the consent of Melea. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

39. Defendant Doveport has also induced infringement of the '660 patent by defendants DaimlerChrysler and C&A (and possibly others) by actively and knowingly aiding and abetting the direct infringement of the '660 patent by DaimlerChrysler and C&A. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

40. Defendants DaimlerChrysler and C&A have directly infringed the '660 patent by offering to sell, selling, and using, within the United States, plastic articles molded in accordance with the process of at least claim 1 of the '660 patent, without the consent of

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Melea. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

41. Upon information and belief, all defendants know of and participate jointly in the unauthorized use of the process of at least claim 1 of the '660 patent. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

42. Upon information and belief, defendants have at all relevant times had notice of the exclusive rights secured by the '637 patent, the '087 patent, and the '660 patent. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

43. Upon information and belief, defendants have proceeded in willful and deliberate disregard of the '637 patent, the '087 patent, and the '660 patent. This allegation is likely to have evidentiary support after a reasonable opportunity for discovery.

44. Defendants are liable, jointly and severally, to Melea and PMT for patent infringement, direct and by inducement, as pleaded herein.

45. Melea and PMT have been harmed, pecuniarily and irreparably, by defendants' infringing conduct.

46. Defendants' infringing conduct will continue unless enjoined by the Court.

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IV. CASE OF ACTUAL CONTROVERSY ON THE AGREEMENT OF FEBRUARY 2, 1990

47. On February 2, 1990, non-party Michael Ladney and non party Automotive Plastics Technologies, Inc. ("APT") entered into an Agreement adjunct to the sale of the assets of numerous member companies of what was then known as the DPM Plastics Group. A true and correct copy of the Agreement is at Exhibit G.

48. The effective date of this Agreement was defined as the date of closing of the sale of assets under the Conditional Asset Purchase Agreement, dated November 13, 1989, by and between Michael Ladney, Detroit Plastic Molding Company, Nashville Plastic Products, Inc. and North American Plastics Co. Limited and APT.

49. Melea Limited is the successor by assignment of the "Licensed Patents" of the Agreement of February 2, 1990, and C&A claims to be the successor to APT as licensee.

50. The business purpose of the Agreement was to permit the acquiring company, APT, to maintain continuity in the gas-assist molding operations already in place at the member companies of the DPM Plastics Group, whose assets APT would be acquiring as going businesses.

51. The patent license contained within the Agreement granted no more rights than necessary to maintain continuity of these operations.

52. Paragraph 4 of the Agreement states the patent license grant, reproduced as follows:

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> 4. LADNEY hereby grants to APT a non-exclusive license, with no right to grant sublicenses, to (a) make, use and sell any product (excluding only molding apparatus used to make gas assisted injection molded parts, hereafter referred to as "Apparatus") covered by a claim of the Licensed Patents, (b) make, have made for its own use and use (but not sell) any Apparatus covered by a claim of the Licensed Patents, and (c) make, use and sell any product made by a process covered by a claim of the Licensed Patents.

53. The second clause ("with no right to grant sublicenses") unambiguously precludes APT (or any successor) from granting sublicenses under the license grants of parts (a)-(c).

54. Absent in parts (a) and (c), is any license for APT to "have made" any products covered by a claim, or made by a process covered by a claim, of the Licensed Patents. The "have made" language *is* found in part (b) only, relating to molding apparatus used to make gas-assisted injection molded parts.

55. In the transactional context of the February 2, 1990 Agreement there was no business purpose or need to license APT (or any successor) to "have made" products covered by any claim of the Licensed Patents (excepting Apparatus).

56. There is no ambiguity within the four corners of the Agreement of February 2, 1990. The plain meaning of the language in paragraph 4 of this Agreement forecloses the original defendants from contending their challenged conduct is within the scope of any patent license held by C&A, as successor to APT.

57. Concomitantly, none of the original defendants can plausibly argue it is a third-party beneficiary under the February 2, 1990 Agreement.

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58. The '087 patent-in-suit and the '660 patent-in-suit are based on patent applications not in existence on February 2, 1990, and are not "Licensed Patents" under the Agreement of February 2, 1990.

59. The application of the '087 patent was filed December 13, 1993, and the rights to the invention was assigned on December 7, 1993, as evidenced by the Assignment recorded at Reel 6854, Frame 937 in the Assignment Branch of the United States Patent and Trademark Office.

60. The application of the '660 patent-in-suit was filed on July 16, 1990, and the rights to the invention were subsequently assigned on August 1, 1990, as shown by the Assignment recorded at Reel 5459, Frame 246 in the Assignment Branch of the United States Patent and Trademark Office.

61. Defendant-counterclaimant DaimlerChrysler Corporation has pled "patent misuse" as its Sixth Affirmative Defense and lodged Count III of its counterclaim for unenforceability based on alleged "patent misuse."

62. Defendant-counterclaimant Doveport has lodged Count III of its counterclaim for unenforceability based on patent misuse (although not recited in terms).

63. The defense of patent misuse is defined as follows:

> The defense of patent misuse arises from the equitable doctrine of unclean hands, and relates generally to the use of patent rights to obtain or to coerce an unfair commercial advantage. Patent misuse relates primarily to a patentee's actions that affect competition in unpatented goods or that otherwise extend the economic effect beyond the scope of the patent.

64. There is nothing in the Agreement of February 2, 1990 that obtains or coerces any unfair commercial advantage.

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65. The Agreement does not affect competition in unpatented goods, or otherwise extend the lawful scope of any Licensed Patent.

66. The affirmative defenses and counterclaims pled by DaimlerChrysler and Doveport based on alleged "patent misuse" are based on the Agreement of February 2, 1990.

67. Defendants-counterclaimants DaimlerChrysler and Doveport have pled *mutatis mutandis* counterclaims for breach of contract premised on the assertion these counterclaimants are third-party beneficiaries of the February 2, 1990 Agreement, and have standing under Michigan law to assert breach of contract.

68. There is no "class" of third-party beneficiaries described in the February 2, 1990 Agreement.

69. The transactional context and business purpose of the February 2, 1990 Agreement was to permit APT to carry on in the molding of gas-assist plastic injection molding operations already in place at the member companies of the DPM Plastics Group, and nothing more.

70. The breach of contract claims lodged by counterclaimants DaimlerChrysler and Doveport are brought without standing by these parties.

71. Paragraph 13 of the Agreement of February 2, 1990 requires APT (and its successors) to mark all gas-assisted injected molds for plastic parts covered by a Licensed Patent. Paragraph 13 is reproduced in its entirety as follows:

> 13. APT will make reasonable efforts to mark all gas assisted injected molds for plastic parts covered by a Licensed Patent by including the following marking on the mold:

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> This mold is designed to produce gas injected plastic parts according to a proprietary process. Possession of this mold carries no authorization to use this patented and proprietary process without a license from Michael Ladney.

72. Upon information and belief, C&A has not marked molds pursuant to paragraph 13 of the Agreement, and is in material breach.

73. Accordingly, there exists a justiciable controversy arising from the Agreement of February 2, 1990 as to: (a) whether any of the patents asserted by plaintiffs as infringed by defendants in this action have been "misused" by reason of plaintiffs having brought the original Complaint in this action against defendants Alliance, Doveport and DaimlerChrysler; (b) whether C&A has any license to "have made" the products covered by the Licensed Patents in the Agreement of February 2, 1990; (c) whether C&A will be inducing infringement if it places the mold tool for making the Dodge Durango Handle with an alternative source; (d) whether Doveport and DaimlerChrysler have standing to bring any claim for breach of contract of the Agreement of February 2, 1990; (e) whether there has been in fact any breach of contract by either plaintiff of the Agreement of February 2, 1990; (f) whether the Agreement of February 2, 1990 applies to the '087 patent-in-suit and/or the '660 patent-in-suit; and (g) whether C&A has marked molds, as required by paragraph 13 of the Agreement of February 2, 1990, and (h) if not, whether it is a material breach of that Agreement.

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V. DEMAND FOR RELIEF

WHEREFORE, plaintiffs demand entry of a judgment granting relief against defendants Alliance, Doveport, DaimlerChrysler, and C&A as follows:

A. A determination that Alliance has infringed the '637 patent, the '087 patent, and the '660 patent directly and by inducement;

B. A determination that Doveport has infringed the '637 patent, the '087 patent, and the '660 patent, directly and by inducement;

C. A determination that DaimlerChrysler has infringed the '637 patent, directly and by inducement, has directly infringed the '087 patent and the '660 patent;

D. A determination that C&A has infringed the '637 patent, directly and by inducement, has directly infringed the '087 patent and the '660 patent;

E. A determination that such infringements have been willful and deliberate;

F. An award of damages adequate to compensate for such infringements;

G. An enhancement of the compensatory damages, up to three times against each defendant;

H. A determination this case is "exceptional," in the sense of 35 U.S.C. § 285;

I. An order preliminarily and permanently enjoining Alliance, Doveport, DaimlerChrysler, and C&A and their officers, agents, servants, contractors, suppliers and attorneys, and those persons in active concert or participation with them who receive actual

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notice of the order by personal service or otherwise, from committing further acts of infringement of the '637 patent, the '087 patent, and the '660 patent;

J. An award in favor of Melea and PMT, and against defendants Alliance, Doveport and DaimlerChrysler, for the costs incurred in bringing and maintaining this action, including reasonable attorneys' fees;

K. A declaratory judgment that plaintiffs have not "misused" any of the patents-in-suit, in the sense of the "patent misuse" doctrine of patent law;

L. A declaratory judgment that license grant of paragraph 4 of the Agreement of February 2, 1990 does not include in its scope any license for C&A to "have made" any products made by a process covered by a claim of the patents-in-suit (*incivile est, nisi tota sententia inspecta, de aliqua parte judicare*);

M. A declaratory judgment that C&A will be inducing infringement if it places the mold(s) for the Dodge Durango Handle with an unlicensed supplier who makes the product using the process of claim 1 of the '637 patent-in-suit;

N. A declaratory judgment that DaimlerChrysler and Doveport have no standing to bring a claim for breach of the Agreement of February 2, 1990;

O. A declaratory judgment there has been no breach of the Agreement of February 2, 1990 by either or both of the plaintiffs;

P. A declaratory judgment the Agreement of February 2, 1990 does not include within its scope the '087 patent-in-suit and the '660 patent-in-suit;

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Q. A declaratory judgment that C&A (or any predecessor-in-interest or successor-in-interest) to the licensee's position under the Agreement of February 2, 1990 is obligated to mark molds with the notice mandated by paragraph 13; and

R. Such other, further and different relief as may be just and equitable on the proofs.

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VI. JURY DEMAND

Plaintiffs demand trial by jury for all issues so triable.

Respectfully submitted,

BROOKS KUSHMAN P.C.

By: [signature]

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Dated: **July 7, 2004**

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CERTIFICATE OF SERVICE

I certify that I served:

SECOND AMENDED AND SUPPLEMENTAL COMPLAINT FOR PATENT INFRINGEMENT AND DECLARATORY RELIEF, AND JURY DEMAND

on July 7, 2004 by:

__ delivering

_X_ mailing (via First-Class mail)

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US005098637A

United States Patent [19]

Hendry

[11] Patent Number: 5,098,637

[45] Date of Patent: * Mar. 24, 1992

[54] PROCESS FOR INJECTION MOLDING AND HOLLOW PLASTIC ARTICLE PRODUCED THEREBY

[75] Inventor: James W. Hendry, Brooksville, Fla.

[73] Assignee: Milad Limited Partnership, Naples, Fla.

[*] Notice: The portion of the term of this patent subsequent to Jul. 2, 2008 has been disclaimed.

[21] Appl. No.: 217,175

[22] Filed: Jul. 11, 1988

[51] Int. Cl.[5] B29C 45/00; B29C 45/34; B29D 22/00

[52] U.S. Cl. 264/572; 264/328.7; 264/328.8; 264/328.12; 264/328.13

[58] Field of Search .... 264/101, 102, 328.1, 264/537, 572, 85, 500, 328.7, 328.8, 328.12, 328.13; 425/130, 812; 215/1 C; 428/35.7, 36.9, 36.92, 166, 188

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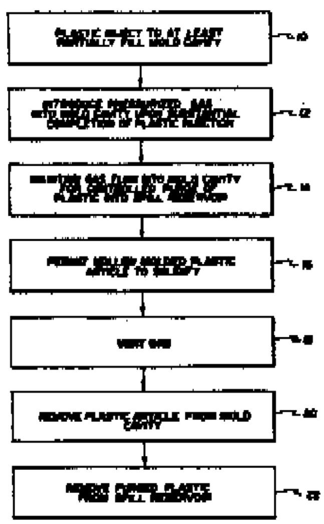
Primary Examiner—Leo B. Tentoni
Attorney, Agent, or Firm—Brooks & Kushman

[57] ABSTRACT

A process for injection molding hollow plastic articles includes the steps of sequentially injecting fluent plastic and gas into a mold cavity. A quantity of fluent plastic is initially injected to substantially fill the mold cavity. A charge of pressurized gas is then injected into the mold cavity to displace a portion of the still fluent plastic into a spill cavity flow coupled to the mold cavity. The article may be formed with an internal wall by introducing first and second gas charges into the mold cavity at separate entry points. In one embodiment, the first and second charges are introduced substantially simultaneously. In a second embodiment, the charges are introduced sequentially. After the hollow plastic article has solidified, the gas is vented.

9 Claims, 5 Drawing Sheets



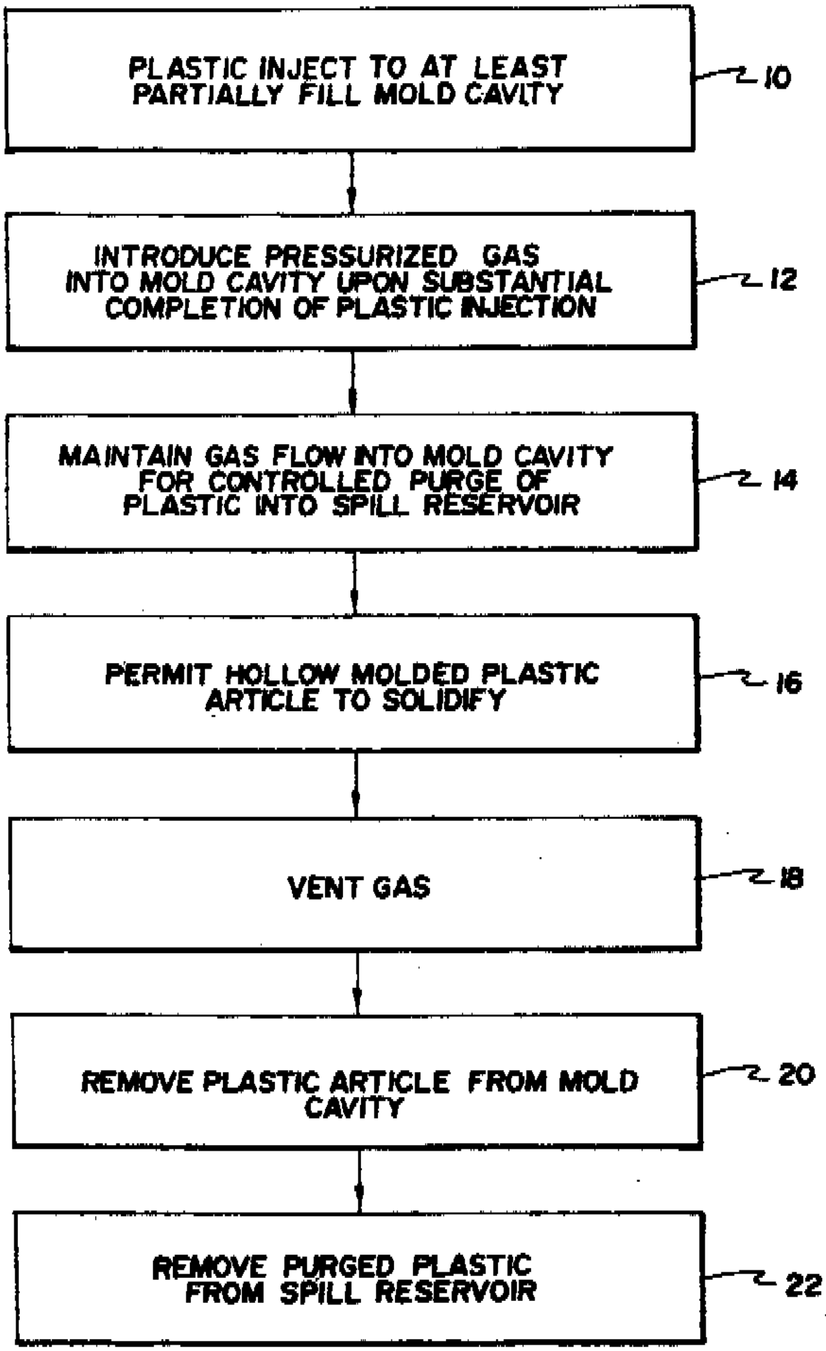

PLASTIC INJECT TO AT LEAST PARTIALLY FILL MOLD CAVITY
10
INTRODUCE PRESSURIZED GAS INTO MOLD CAVITY UPON SUBSTANTIAL COMPLETION OF PLASTIC INJECTION
12
MAINTAIN GAS FLOW INTO MOLD CAVITY FOR CONTROLLED PURGE OF PLASTIC INTO SPILL RESERVOIR
14
PERMIT HOLLOW MOLDED PLASTIC ARTICLE TO SOLIDIFY
16
VENT GAS
18
REMOVE PLASTIC ARTICLE FROM MOLD CAVITY
20
REMOVE PURGED PLASTIC FROM SPILL RESERVOIR
22

Fig. 1

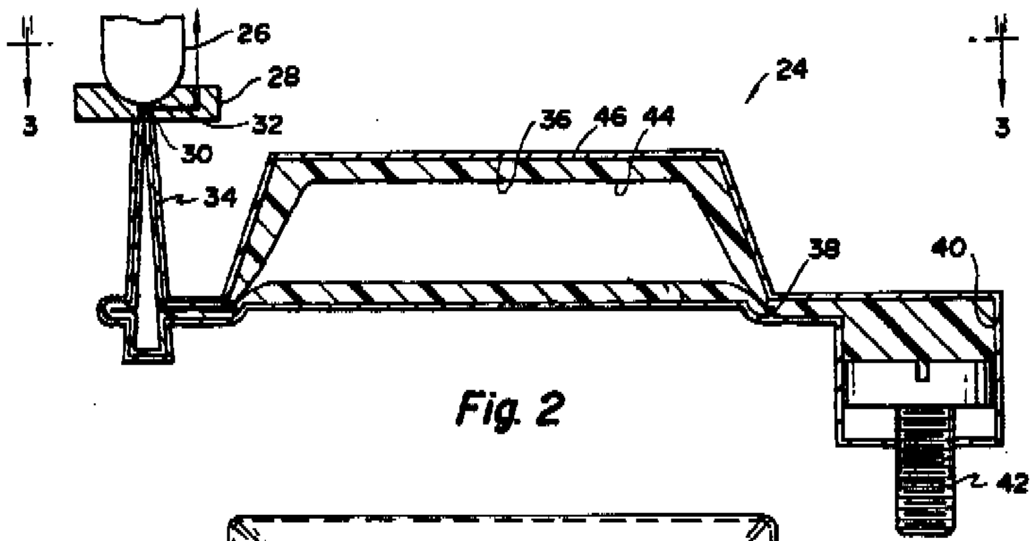


Fig. 2

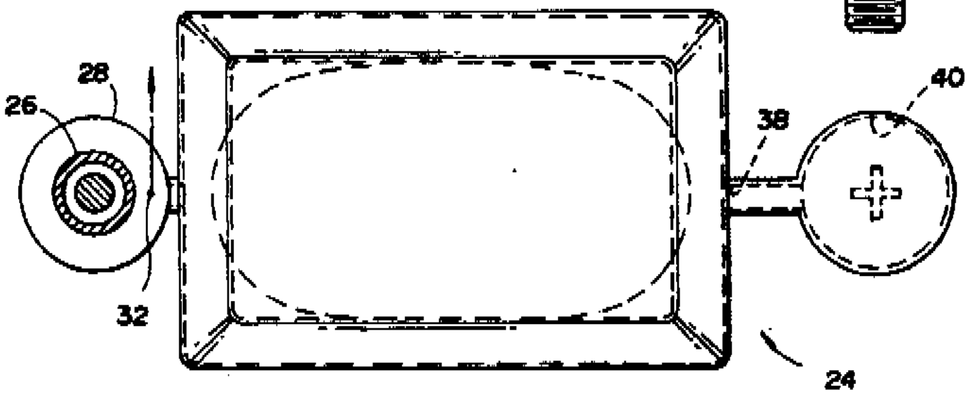


Fig. 3

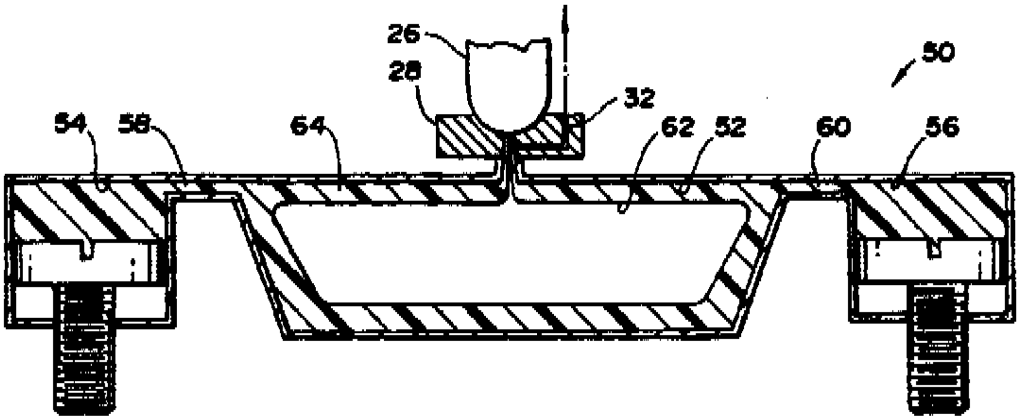


Fig. 4

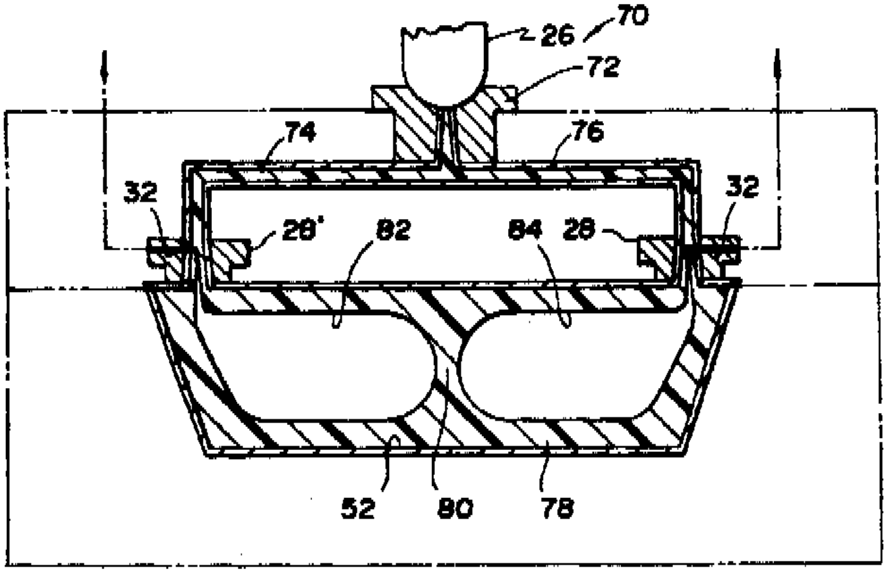


Fig. 5

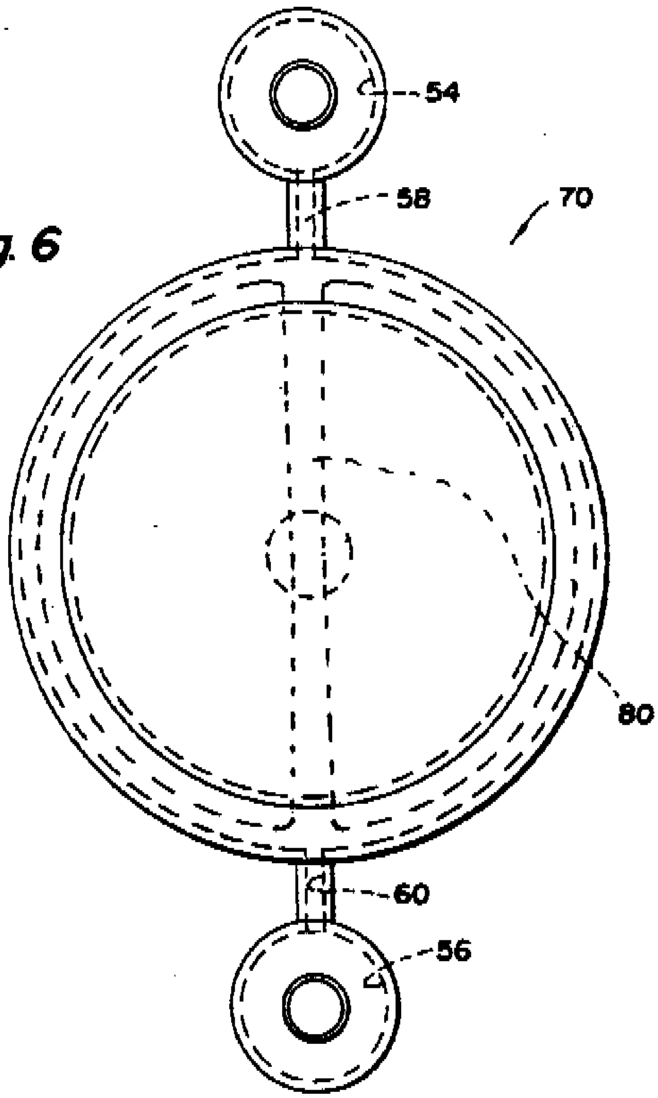


Fig. 6

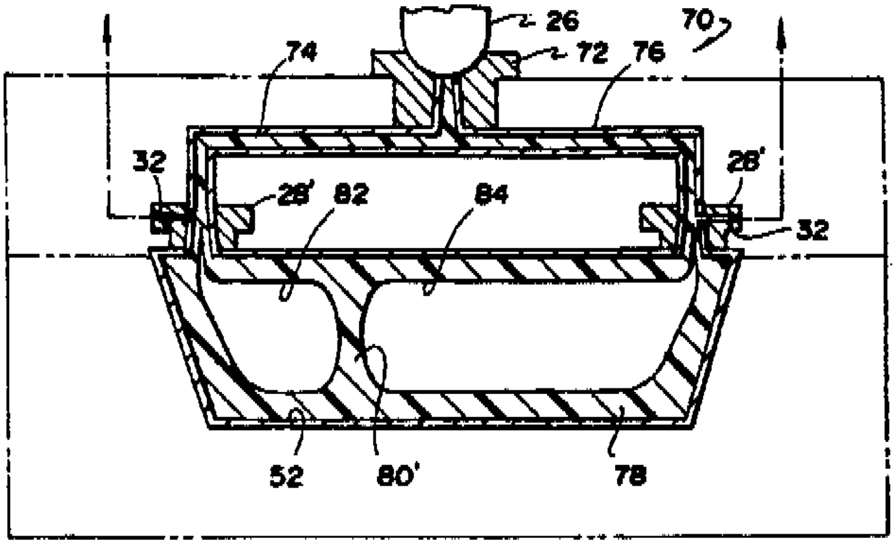


Fig. 7

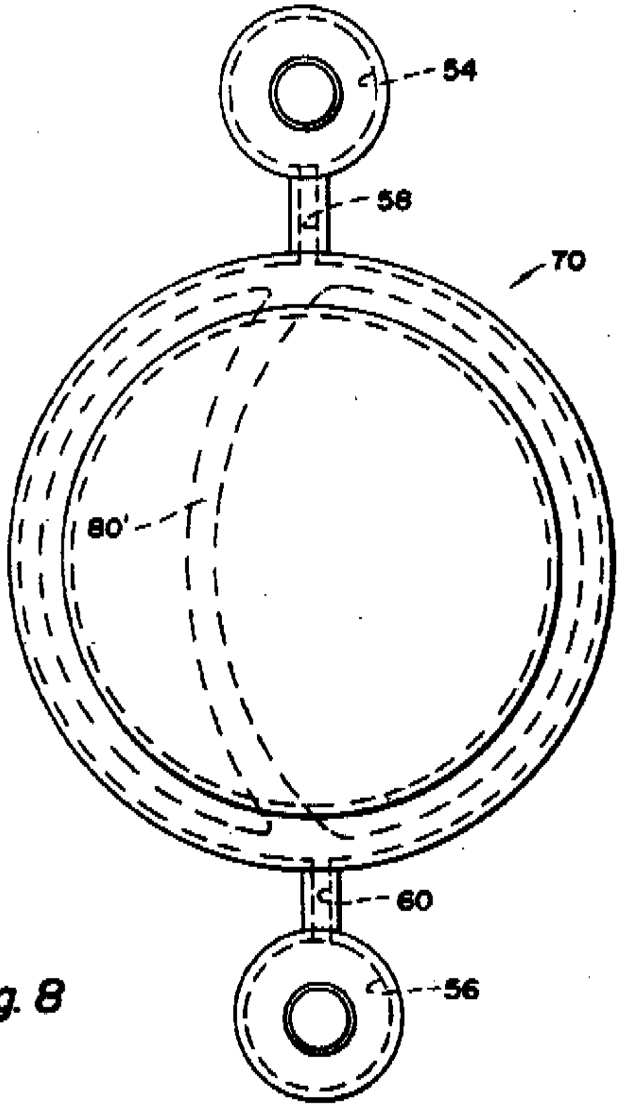


Fig. 8

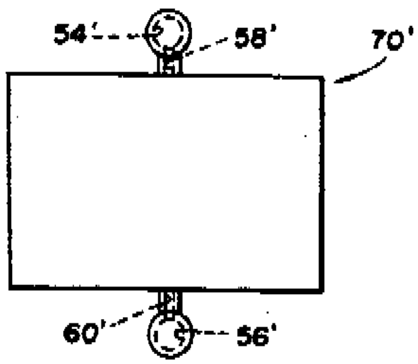


Fig. 9

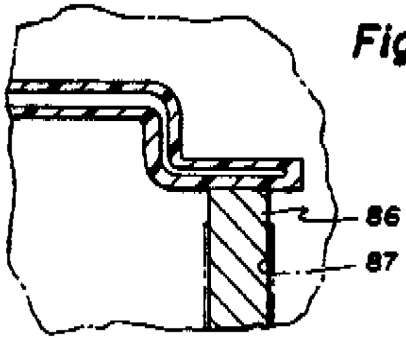


Fig. 10

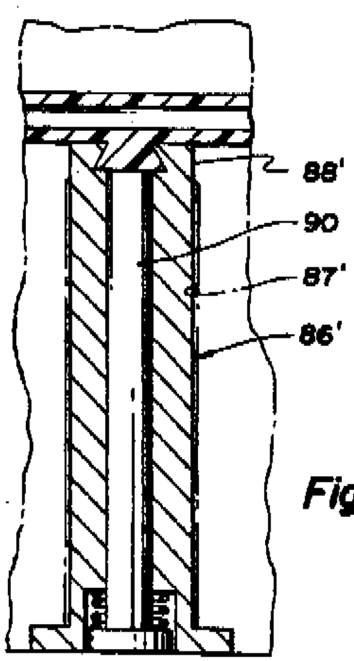


Fig. 11

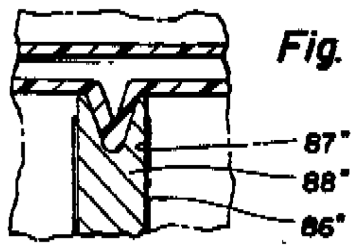


Fig. 12A

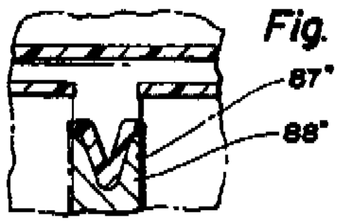


Fig. 12B

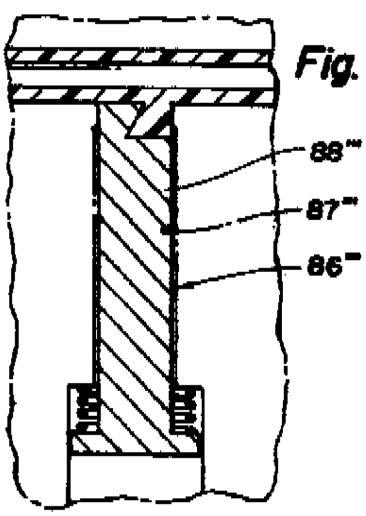


Fig. 13A

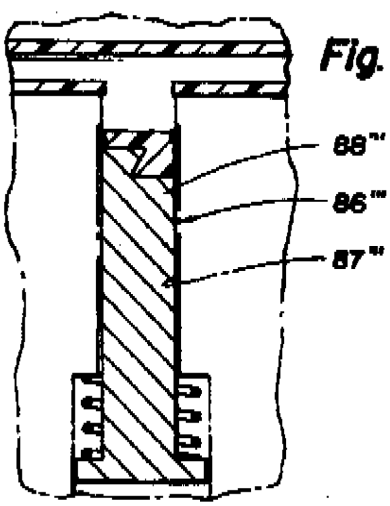


Fig. 13B

PROCESS FOR INJECTION MOLDING AND HOLLOW PLASTIC ARTICLE PRODUCED THEREBY

TECHNICAL FIELD

This invention relates to plastic injection molding and articles produced thereby, and, more particularly, to plastic injection molding and plastic articles having hollow interior portions produced thereby.

CROSS REFERENCE TO RELATED APPLICATIONS

This application is related to U.S. patent applications entitled "Apparatus and Method for the Injection Molding of Thermoplastics", Ser. No. 071,363 filed July 9, 1987 now U.S. Pat. No. 4,781,554; Method and Apparatus for the Injection Molding of Plastic Articles", Ser. No. 098,862 filed Sept. 21, 1987 and now U.S. Pat. No. 4,855,094 and "Method and System for Localized Fluid-Assisted Injection Molding and Body Formed Thereby", Ser. No. 133,900, filed Dec. 16, 1987 which has been refiled as Ser. No. 351,271 on May 10, 1989, all of which have the same Assignee as the Assignee of the present invention and all of which are hereby expressly incorporated by reference.

BACKGROUND ART

In the plastic injection molding art, the usual challenges facing a product designer is to design an article having requisite strength for the product application and uniform surface quality for satisfactory appearance, but to avoid excessive weight, material usage and cycle time. A design compromise must often be made between strength and plastic thickness. A relatively thicker plastic section in the article, such as a structural rib, will incur greater weight, material usage, cycle time and induce sink marks and other surface defects due to thermal gradients in the area of the thickened section.

It is known in the plastic molding art to use pressurized fluid in conjunction with the plastic molding of articles. The pressurized fluid is typically nitrogen gas which is introduced into the mold cavity at or near the completion of the plastic injection. The pressurized fluid serves several purposes. First, it allows the article so formed to have hollow interior portions which correspond to weight and material savings. Second, the pressurized fluid within the mold cavity applies outward pressure to force the plastic against the mold surfaces while the article solidifies. Third, the cycle time is reduced as the gas migrates through the most fluent inner volume of the plastic and replaces the plastic in these areas which would otherwise require an extended cooling cycle. Fourth, the gas pressure pushes the plastic against the mold surfaces, thereby obtaining the maximum coolant effect from the mold.

However, as the dimensions of the molded article increase, the gas must do more work to migrate through the volume of the mold cavity to assist in setting up the article within the cavity If the pressure of the gas is too great as it enters the mold cavity, there is a risk that it may rupture or blow out the plastic within the mold cavity, i.e., the gas is not contained within the plastic. Thus, there have been practical limitations in the adaptation of gas injection in the plastic molding field.

DISCLOSURE OF THE INVENTION

One aspect of the present invention is a method for injection molding hollow plastic articles with pressurized gas which provides for displacement by the gas of a portion of plastic from the mold cavity into a flow coupled spill cavity. This feature enables plastic articles of relatively greater dimensions to be successfully molded with the advantages of established gas injection molding techniques.

More specifically, the process involves the initial injection of a quantity of fluent plastic into a mold cavity having a shape defining at least a portion of the plastic article to be molded. At or near the completion of the plastic injection, a charge of pressurized gas is introduced into the mold cavity to displace a portion of the still fluent plastic. The displaced plastic flows through a passage from the mold cavity into a connected spill cavity or reservoir. The reservoir may alternatively serve as: (i) an appendage of the complete article; (ii) a separate article; or (iii) a cavity to receive spilled plastic for regrinding. The plastic which is displaced is generally the hottest and most fluent. In this regard, the introduction of the charge of pressurized gas into the mold cavity can be timed to modulate the amount of plastic displaced, i.e., the longer the delay in introduction, the cooler and less fluent the plastic in the mold cavity.

In another feature of the invention, the hollow plastic article may be formed with an integral internal wall by introduction of two or more charges of pressurized gas. Each gas charge tends to form a cell within the article, and the cells are divided by membranes which serve as integral internal walls to enhance the structural properties of the article.

In yet still another feature of the inventing, venting of the gas from the mold cavity is accomplished by moving a support mechanism for a portion of the solidified injected plastic to allow the gas to burst through the unsupported plastic portion at the reservoir, the runner or an inconspicuous part of the article itself.

The present invention admits to molding of relatively large size structural articles for use in diverse product fields, such as a box-sectioned frame member for an automobile or refrigerator door or the hood of a car having a reenforcing beam.

Other advantages and features of the present invention will be made apparent in connection with the following description of the best mode for carrying out the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow chart indicating the basic steps involved in practice of the process of the present invention;

FIG. 2 is a schematic side view of a plastic injection molding apparatus adapted to carry out the process of the present invention;

FIG. 3 is a top plan view of the apparatus of FIG. 2;

FIG. 4 is another schematic view of a plastic injection molding apparatus illustrating an alternative arrangement for practicing the process of the present invention;

FIG. 5 is a side schematic view in cross-section showing still another plastic injection molding apparatus adapted to mold a hollow plastic article having an integral internal wall in accordance with the process of the present invention;

FIG. 6 is a plan view of the apparatus shown schematically in FIG. 5;

FIG. 7 is a view similar to FIG. 5 wherein the internal wall is displaced from the central location of FIG. 5;

FIG. 8 is a plan view of the apparatus of FIG. 7;

FIG. 9 is a plan view of yet still another plastic injection molding apparatus;

FIG. 10 is an enlarged side schematic view of the apparatus of FIG. 9, partially broken away and illustrating one embodiment of a venting step;

FIG. 11 is a view similar to FIG. 10 illustrating a second embodiment of the venting step;

FIG. 12A is a view similar to FIG. 10 illustrating a third embodiment of the venting step;

FIG. 12B is a view of the third embodiment after venting;

FIG. 13A is a view similar to FIG. 10 illustrating a fourth embodiment of the venting step; and

FIG. 13B is a view of the fourth embodiment after venting.

BEST MODE FOR CARRYING OUT THE INVENTION

FIG. 1 is a flow chart of the steps involved in practicing the process of the present invention.

In step 10, a quantity of molten plastic is injected from an injection molding machine into a mold cavity. The plastic is any thermoplastic and works particularly well with glass or mineral filled thermoplastic polyester, commonly known by the trademark VALOX of General Electric Co. The quantity is sufficient to provide the mass of the article to be molded, but desirably less than the quantity which would fill the mold cavity.

In step 12, a charge of pressurized gas is introduced into the mold upon substantial completion of the injection of the quantity of molten plastic.

In step 14, the gas flow into the mold is maintained in pressure and duration in amount and time sufficient to displace a controlled quantity of plastic from the mold cavity into a spill cavity which is flow coupled to the mold cavity. The gas tends to displace the hottest, most fluent plastic in the central portion of the mold cavity. Consequently, the molded plastic article has a hollow interior where the least viscous plastic has been displaced. The presence of the gas affords savings in weight and material usage. Added benefits include enhanced surface quality due to the outward pressure exerted by the gas, and reduced cycle time due to displacement of the relatively hot plastic from the central portion of the article.

In step 16, the article is permitted to solidify within the mold cavity while the internal gas pressure is maintained.

In step 18, the pressurized gas is vented from the interior of the molded article preparatory to opening the mold. Numerous ways of venting are possible such as described in the Friederich U.S. Pat. No. 4,101,617 or as described in co-pending patent application Ser. No. 071,363 now U.S. Pat. No. 4,781,554 noted above.

In step 20, the plastic article is removed from the mold.

In step 22, the purged or displaced plastic is removed from the spill cavity or reservoir. In certain cases, steps 20 and 22 can be the common operation of ejecting the moldings so formed from the article cavity and the spill cavity.

FIGS. 2 and 3 are schematic side and plan views, respectively, of a plastic injection molding apparatus, generally indicated at 24, adapted to carry out the process of the present invention.

A nozzle 26 of a plastic injection molding machine is brought into registering position with a modified sprue bushing 28 associated with a mold. The sprue bushing 28 may be of the type disclosed in the above-noted co-pending application Ser. No. 098,862, filed Sept. 21, 1987 now U.S. Pat. No. 4,855,094. The sprue bushing 28 has a plastic flow path 30 formed at its center to permit the passage of molten plastic through a sprue 34 into a mold cavity 36.

The modified sprue bushing also includes a gas path 32 to permit the introduction and venting of a charge of pressurized gas.

The mold cavity 36 is flow coupled through a runner segment 38 to a spill cavity 40. The volume of the spill cavity 40 may be varied by any well-known means to control the quantity of displaced plastic such as by a lead screw 42.

A molded article 46 produced by the process described in reference to FIG. 1 includes an interior void 44 formed by the presence and influence of the pressurized gas. The spill cavity 40 may be formed to mold an integral appendage of the article 46, or a separate article, or simply scrap for regrinding.

FIG. 4 is another schematic view of a plastic injection molding apparatus, generally indicated at 50, illustrating an alternative arrangement for practicing the process of the present invention. In this case, the apparatus 50 employs first and second spill cavities 54 and 56 which are flow coupled through runners 58 and 60, respectively, to a mold volume 52. Again, a nozzle 26 from an injection molding machine registers with the sprue bushing 28 to inject a quantity of molten plastic into the mold cavity. A charge of pressurized gas flows along the gas path 32 in the modified sprue bushing 28 and into the cavity 52 to displace the least viscous plastic from the mold cavity 52 into the first and second spill cavities 54 and 56. This process, when performed in accordance with the steps of FIG. 1, will yield a molded article 64 having a central void 62 due to the displacement of plastic by the pressurized gas.

FIGS. 5 and 6 are side and plan schematic views, respectively, of still another plastic injection molding apparatus, generally indicated at 70, adapted to mold a hollow plastic article 78 having an integral internal wall 80. In this case, the injection molding machine nozzle 26 aligns with a sprue 72 which divides into a pair of runners 74 and 76. Each of the runners 74 and 76 connects to a bushing 28', which is modified from the sprue bushing 28 of FIG. 1 only to the extent required to remove it to the ends of the runners 74 and 76. In this example, the pair of bushings 28' are situated at opposite lateral extremes of the mold cavity 52 to produce a molded article 78 with an integral internal wall 80 at the center. The positioning of the bushings 28', as defining the gas entry points, will determine the resulting position of the integral internal wall 80.

In the apparatus 70 of FIGS. 5 and 6, the gas charges introduced through the paths 32 in the bushings 28' are simultaneous. Each gas charge tends to form a cell, as shown by voids 82 and 84, within the article 78. The cells are divided by a membrane which serves an integral internal wall 80.

In other respects the apparatus 70 of FIGS. 5 and 6 is essentially similar to the apparatus 50 of FIG. 4. Specifically, the apparatus 70 likewise employs first and second spill cavities 54 and 56 flow coupled to the mold cavity 52 through runners 58 and 60, respectively.

In the apparatus 70 of FIGS. 7 and 8, the gas charges introduced through the paths 32 in the bushings 28' are sequential so that the membrane which serves as an integral wall 80' is displaced to one side. For example, the interval between the gas charges may be between 0.25 and 1.0 seconds apart.

FIGS. 9 and 10 are plan and side schematic views, respectively, of another plastic injection molding apparatus, generally indicated at 70', adapted to mold a hollow plastic article. The apparatus 70' employs spill cavities 54' and 56' coupled to the mold cavity through runners 58' and 60', respectively.

The plastic in at least one of the spill cavities 54' and 56' is supported during plastic solidification by a movable mold part such as a pin 86 supported within the mold of the apparatus 70'. The gas is vented by moving the pin away from the supported plastic prior to opening the mold to the atmosphere so that the pressurized gas bursts through the now unsupported plastic within the spill cavity. The gas then travels around the pin 86, through the mold and to the atmosphere in a controlled fashion. The pin 86 may be moved relative to the mold in any well-known fashion and is supported in a bore 87 in the mold leaving approximately 0.005 inches clearance around the pin 86 to permit the gas to travel around the pin 86.

FIGS. 11, 12A and 13B show alternate embodiments of a pin, generally indicated at 86', 86'' and 86''', respectively, for venting the gas from the article. FIGS. 12B and 13B show the pins 86'' and 86''' in their venting positions, respectively. Each of the pins 86', 86'' and 86''' include an angled end portion 88', 88'' and 88''', respectively, for receiving and retaining a portion of the solidified injected plastic therein at a plastic reservoir, a runner segment, a sprue portion or an inconspicuous part of the article itself. Movement of the pins 86', 86'' and 86''' away from their respective supported portions of injected plastic causes their respective end portions 88', 88'' and 88''' to carry a portion of plastic therewith to facilitate the venting step, as illustrated in FIGS. 12B and 13B.

In the embodiment of FIG. 11, the pin 86' includes a central ejector 90 which can be operated in any well-known fashion to subsequently eject the solidified plastic from the end portion 88' after venting and prior to the next cycle.

The invention has been described in illustrative embodiments, but it will be evident to those skilled in the art that variations may be made from the foregoing teachings without departing from the scope of the following claims.

What is claimed is:

1. A process for injection molding a hollow plastic article comprising the steps of:

injecting a quantity of fluent plastic into a mold cavity having a shape defining at least a portion of the article;

displacing a portion of the plastic from the mold cavity into a spill cavity flow coupled to the mold cavity by introduction of a charge of pressurized gas into the mold cavity;

permitting the injected plastic to solidify;

venting the gas from the mold cavity; and

removing the plastic article from the mold.

2. A process for injection molding a hollow plastic article having an integral internal wall comprising the steps of:

injecting a quantity of fluent plastic into a mold cavity having a shape defining at least a portion of the article;

introducing first and second charges of gas into the mold cavity at spaced locations and at pressures sufficient to displace quantities of plastic into oppositely disposed spill cavities flow coupled to the mold cavity;

permitting the injected plastic to solidify;

venting the gas from the mold cavity; and

removing the plastic article from the mold.

3. The invention as claimed in claim 2 wherein the first and second charges of gas are introduced into the mold cavity substantially simultaneously.

4. The invention as claimed in claim 2 wherein the first and second charges of gas are introduced into the mold cavity in a predetermined sequence.

5. A process for injection molding a hollow plastic article including the steps of injecting a quantity of fluent plastic into a mold cavity of a mold having a shape defining at least a portion of the article, introduction of a charge of pressurized gas into the mold cavity upon substantial completion of plastic injection, permitting the injected plastic to solidify by supporting the injected plastic in the mold, venting the gas from the mold cavity, and removing the plastic article from the mold, wherein the improvement comprises: a portion of the injected plastic is supported within the mold by a movable support means of the mold during plastic solidification and wherein the step of venting is accomplished by moving the support means to a non-support position to allow the gas to burst through the thereby unsupported plastic portion.

6. The process as claimed in claim 5 wherein the support means includes an angled end portion for receiving and retaining the portion of the injected plastic therein and wherein movement of the support towards the non-support position removes the portion of the injected plastic from the rest of the injected plastic.

7. The process as claimed in claim 5 wherein the mold has a spill cavity coupled to the mold cavity and wherein the portion of the injected plastic is located in the spill cavity.

8. The process as claimed in claim 6 wherein the mold has a runner segment coupled to the mold cavity and wherein the portion of the injected plastic is located in the runner segment.

9. The process as claimed in claim 6 wherein the support means includes a movable pin having extended and retracted positions for removing the portion of the injected plastic from the angled end portion in the extended position of the pin.

* * * * *

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US005443087

United States Patent [19]
Myles

[11] **Patent Number:** **5,443,087**
[45] **Date of Patent:** **Aug. 22, 1995**

[54] **METHOD AND SYSTEM FOR CONTROLLING A PRESSURIZED FLUID AND VALVE ASSEMBLY FOR USE THEREIN**

[75] Inventor: **Colin K. Myles**, Waterford, Mich.

[73] Assignee: **Melea Limited**, Southfield, Mich.

[21] Appl. No.: **166,255**

[22] Filed: **Dec. 13, 1993**

[51] **Int. Cl.**[6] **G05B 11/50**
[52] **U.S. Cl.** **137/14**; 137/102; 137/596.15; 137/596.16
[58] **Field of Search** 91/433; 137/102, 596.15, 137/596.16, 14, 487.5

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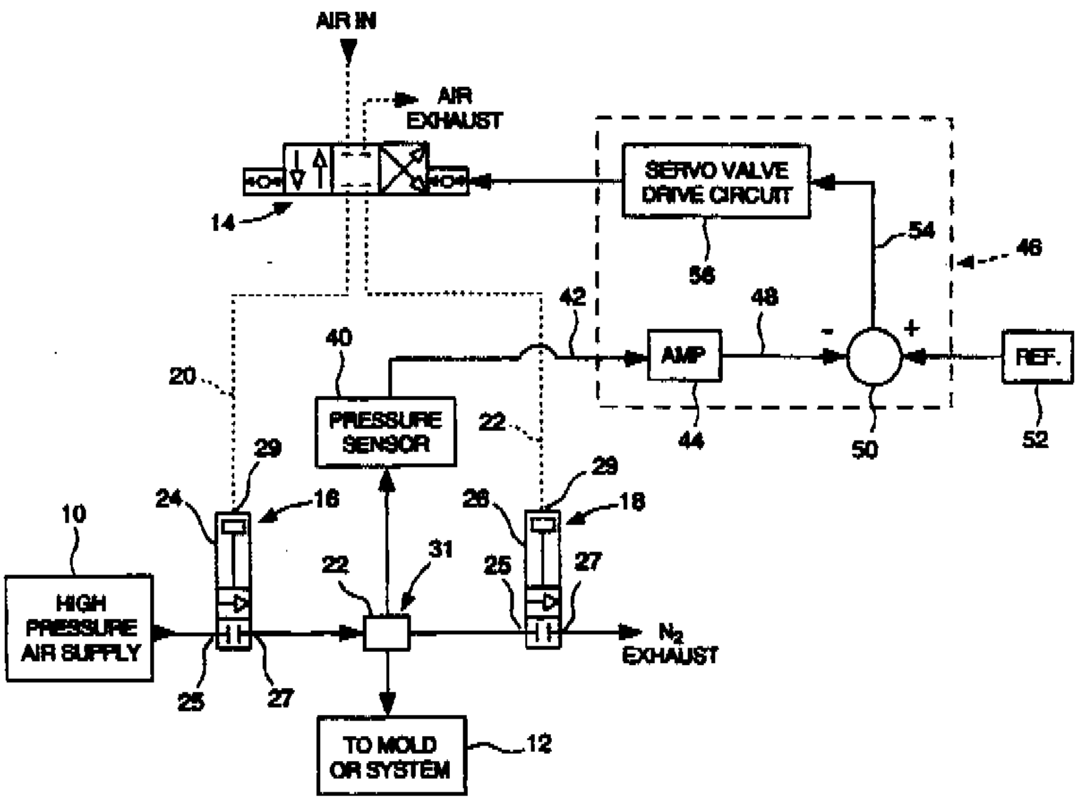
5,142,483	8/1992	Basham et al. .	
5,257,640	11/1993	Delajoud	137/14

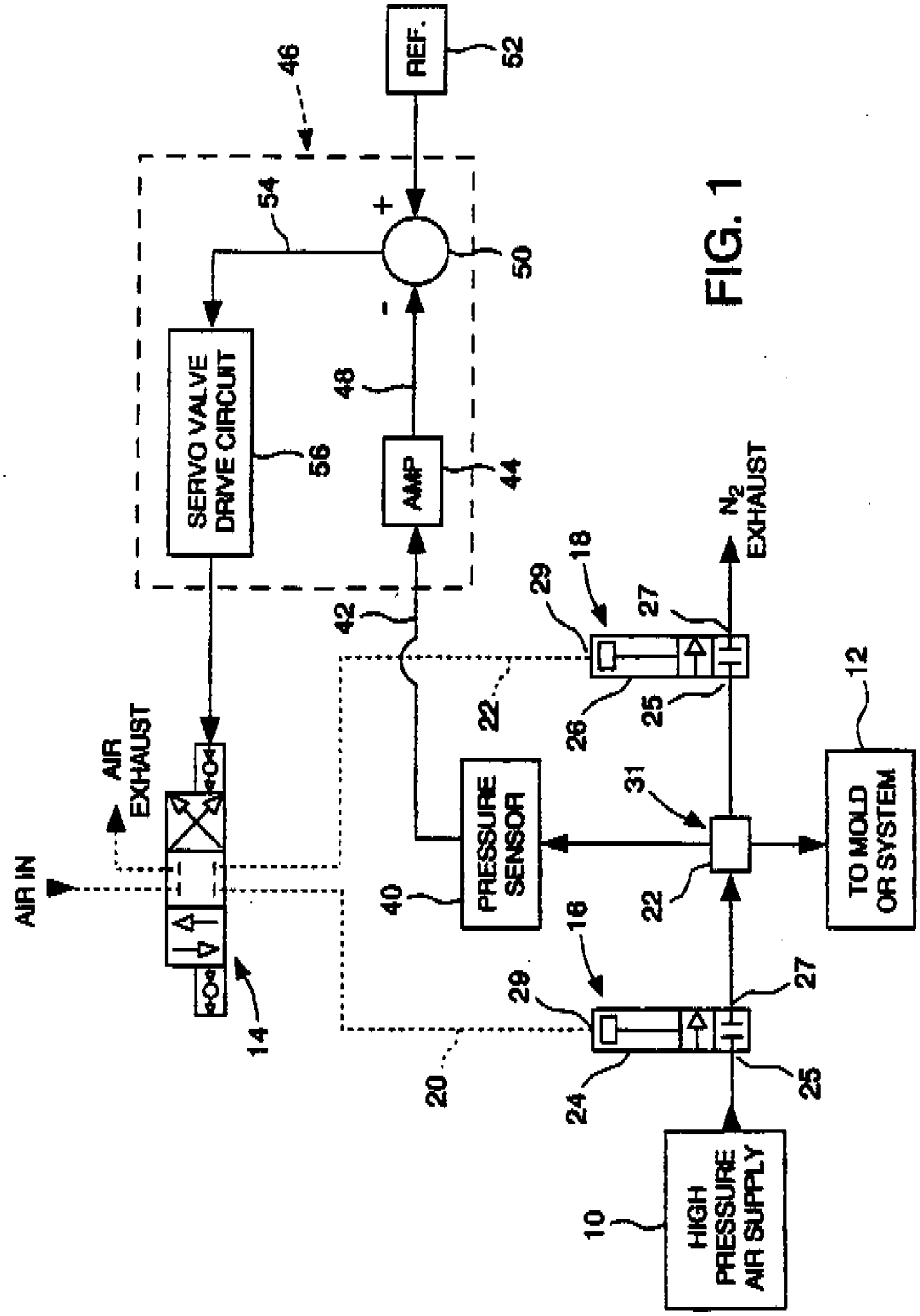
Primary Examiner—Gerald A. Michalsky
Attorney, Agent, or Firm—Brooks & Kushman

[57] **ABSTRACT**

A method and system are provided for controlling a pressurized fluid such as nitrogen gas which may be initially stored at a pressure as high as 20,000 psi. The pressurized nitrogen gas may be utilized in high pressure gas systems such as in gas-assisted injection molding systems or low pressure gas systems such as robotic control and actuators. A valve assembly is utilized in the method and system and includes an electric proportioning device such as a pneumatic servovalve and a pair of pneumatic, fluidly-coupled valves which are piloted by the servovalve to regulate the pressure of the pressurized nitrogen gas. In the method and system, the servovalve operates in a closed loop fashion by utilizing feedback from a feedback device such as a pressure transducer. A controller in the closed loop is responsive to a pressure signal from the pressure transducer and a preset reference signal to provide an error control signal to the servovalve.

18 Claims, 2 Drawing Sheets

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12
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HIGH PRESSURE AIR SUPPLY
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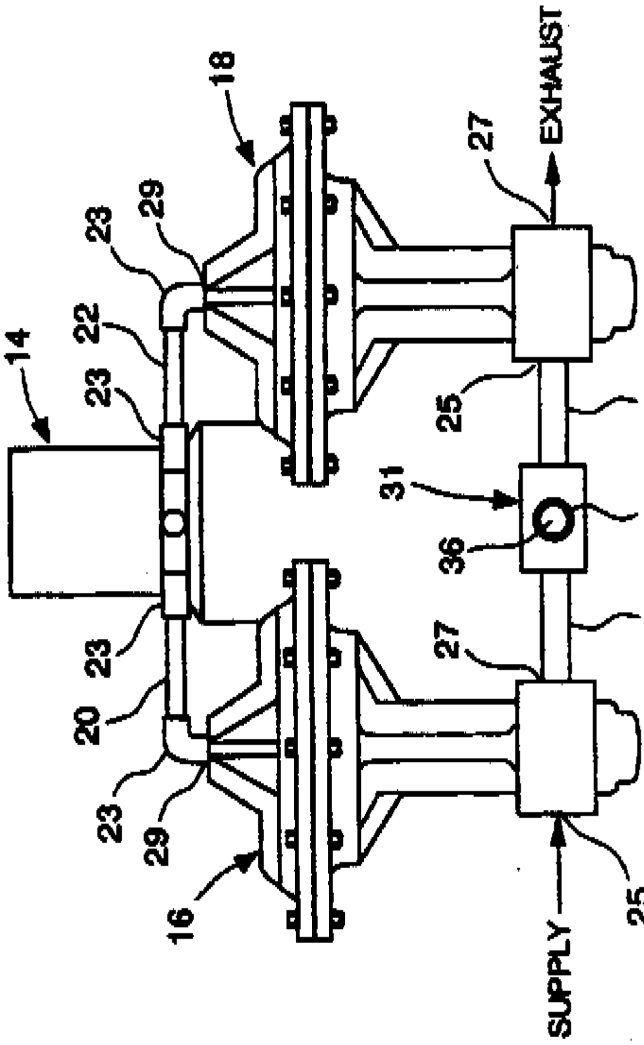
FIG. 1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EXHAUST
SUPPLY

FIG. 2

METHOD AND SYSTEM FOR CONTROLLING A PRESSURIZED FLUID AND VALVE ASSEMBLY FOR USE THEREIN

TECHNICAL FIELD

This invention relates to methods and systems for controlling pressurized fluids and valve assemblies for use therein and, in particular, to closed loop methods and systems for controlling high or low pressure fluids and valve assemblies for use therein.

BACKGROUND ART

U.S. Pat. No. 5,114,660 discloses a method and system for the injection molding of plastic articles in an injection molding system including a pneumatically-operated gas compression unit having a high pressure gas receiver. A fluid pressure reducing valve, together with a directional control valve, controlled by a controller reduces the pressure of the high pressure nitrogen gas and communicates the pressurized fluid from the gas receiver to the injection molding system.

Briefly, gas-assisted injection molding is a thermoplastic molding process which provides stress-free large parts with a class A surface and virtually no sink marks. Gas-assisted injection molding is a low pressure molding process compared to conventional injection molding. In this process, inert gas such as nitrogen is injected into the plastic after it enters a mold. By controlling the gas pressure, the quantity of plastic injected into the mold (short shot) and the rate of gas flow, a predetermined network of hollow interconnected channels is formed within the molded part. The gas pressure remains constant in the network of hollow channels during the molding. This compensates for the tendency of the plastic to shrink at the thicker areas of the molding preventing warpage and reducing stress. The gas pressure is relieved just prior to opening the mold. Because of the relatively low injection pressure, large parts can be molded with substantial reductions in clamp tonnage.

Consequently, gas supply equipment must provide precise control of pressure, timing and volume of gas which is injected into the part, all of which are important to the control of the gas-assisted injection process.

In general, prior art valve assemblies exhibit relatively slow response and have a considerable amount of on-board electronics and take up a considerable amount of room, especially when multiple valve assemblies are required to service a number of injection molds or parts of molds.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and system for controlling a pressurized fluid and a valve assembly for use therein wherein the resulting regulated pressurized fluid can be used in high or low pressure, fast response applications.

Another object of the present invention is to provide a method and system for controlling a pressurized fluid and valve assembly for use therein wherein the valve assembly has a relatively small amount of on-board electronics, is relatively inexpensive, and also provides a compact structure to allow for multiple valve assemblies in a relatively small space.

In carrying out the above objects and other objects of the present invention, a method is provided for controlling a pressurized fluid having a first pressure to provide the pressurized fluid at a regulated, desired pressure less than the first pressure. The method includes the step of providing a pair of pneumatically-operated, fluidly-coupled valves, and an electric proportioning device for operating the valves. The pressurized fluid is communicated to the valves. The method also includes the steps of generating a reference signal representative of the desired pressure, generating a reference control signal based on the reference signal and coupling the reference control signal to the proportioning device to control the pressure of the pressurized fluid regulated by the valves. The method also includes the steps of generating a feedback signal as a function of the actual pressure of the regulated pressurized fluid and generating an error signal based on the difference between the reference signal and the feedback signal. The error signal is representative of a desired amount of fluid pressure change. The method finally includes the step of generating an error control signal as a function of the error signal to control the proportioning device. The proportioning device, in turn, operates the valves to provide the pressurized fluid at the regulated desired pressure.

Further in carrying out the above objects and other objects of the present invention, a system is provided for carrying out each of the above method steps.

Also provided is a valve assembly for controlling a pressurized fluid having a first pressure to provide the pressurized fluid at a regulated desired pressure less than the first pressure. The valve assembly includes a first valve having an input port adapted to receive the high pressure fluid, an outlet port, and a control port adapted to receive a first pneumatic control signal to selectively open and close the input port. The assembly also includes a second valve having an input port, an output port, and a control port adapted to receive a second pneumatic control signal to selectively open and close the output port of the second valve to exhaust the pressurized fluid. A mechanism for fluidly communicating the outlet port of the first valve to the inlet port of the second valve is also provided. The mechanism also includes an output port for communicating the regulated pressurized fluid. Finally, the valve assembly includes an electric proportioning device for providing the first and second pneumatic control signals to control the first and second valves, respectively, based on the electrical control signal so that regulated pressurized fluid at the desired pressure is available at the output port of the mechanism.

Preferably, each of the valves is a pilot operated pneumatic valve and the proportioning device is a pneumatic servovalve for communicating a pneumatic control signal to each of the valves in response to the electrical control signal to control the opening and closing of the valves to, in turn, regulate the pressure of the pressurized fluid.

Also preferably, in one embodiment the pressurized fluid is a high pressure fluid such as nitrogen gas having a pressure in the range of 1,000–20,000 psi for use in a gas-assisted injection molding system. In another embodiment the pressurized fluid has a pressure capable of controlling robots and actuators.

The advantages according to the method, system and valve assembly of the present invention are numerous. For example, the method, system and valve assembly are capable of operating in high or low pressure, fast response pressure control applications. Furthermore, the valve assembly has fewer on-board electronics and exhibits considerable cost savings over competitive assemblies. Finally, the valve assembly is relatively compact and allows for the use of multiple valve assemblies in a relatively small space.

The above objects and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram illustrating the method, system and valve assembly of the present invention; and

FIG. 2 is a schematic front elevational view of the valve assembly of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to the drawing figures, there is illustrated in FIG. 1 in block diagram form, a method, system and valve assembly constructed with the present invention to control a high pressure fluid such as a nitrogen gas which is stored in a high pressure air supply or receiver 10. The high pressure nitrogen gas may be stored in a gas pressure receiver such as illustrated in U.S. Pat. No. 5,114,660 at a pressure of 1,000–20,000 psi. As described in U.S. Pat. No. 5,114,660, the gas is stored at high pressure to provide a ready source of high pressure gas for use in a gas-assisted injection mold or system, as illustrated at 12 in FIG. 1 and as described in U.S. Pat. No. 5,114,660. However, it is to be understood that the method, system and valve assembly can be used to supply low pressure (i.e. approximately 80 psi) fluid for use in robotic or actuator control. The method and system provide the pressurized gas at a regulated desired pressure less than the pressure at which the gas is stored as is described in greater detail hereinbelow.

In general, the valve assembly of the present invention includes an pneumatic servovalve, generally indicated at 14, or other air or gas operated proportional valve. The valve assembly also includes first and second pneumatically-operated, fluidly-coupled valves generally indicated at 16 and 18, respectively. The valves 16 and 18 are piloted or controlled along control lines 20 and 22, respectively, by the servovalve 14. Fittings 23 secure the lines 20 and 22 to the servovalve 14 and the valves 16 and 18.

Each of the pneumatic valves 16 and 18 includes an actuator section 24 and 26, respectively, which includes a diaphragm which responds to a pneumatic control signal on its respective control line. The control signals from the servovalve 14 control the opening and closing of the valves 16 and 18 to thereby regulate the pressure of the high pressure nitrogen gas.

Each of the pneumatic valves 16 and 18 also includes an inlet port 25, an outlet port 27 and a control port 29 for receiving control signals from the servovalve 14. The inlet port 25 of the first valve 16 opens or closes in response to the control signal received at its input port 29. In like fashion, the outlet port 27 of the second valve 18 opens or closes in response to the control signal received at its input port 29.

Preferably, the pneumatic servovalve is an Atchley air servo having Model No. 204PN500S/NO60. Also preferably, each of the pilot-operated pneumatic valves is a Dragon air-operated two-way valve having Model No. 85C053KV.

The two-way valves 16 and 18 are plumbed together by a means or assembly 31 for fluidly communicating the outlet port 27 of the pneumatic valve 16 with the inlet port 25 of the pneumatic valve 18. The assembly 31 is preferably an HIP cross assembly including a high pressure cross 32 and a number of adapters 34 to fluidly connect the cross 32 to the valves 16 and 18 and a pressure sensor 40. An adaptor 34 also fluidly connects an outlet port 36 of the cross 32 to the system 12.

While the pneumatic servovalve 14 is gas or air operated, it operates electronically in a closed loop system. A feedback mechanism such as the pressure sensor or transducer 40 is capable of generating a feedback signal as a function of the actual pressure of the regulated high pressure fluid at the cross assembly 31. The pressure sensor 40 supplies the signal along line 42. The fluid pressure signal is representative of the actual pressure of the regulated high pressure fluid. The fluid pressure signal is typically amplified by an amplifier 44 of a controller, generally indicated at 46. Then the amplified signal is set along a line 48 where it is subtracted from a reference signal at a junction block 50. Typically, the reference signal is output by a reference block 52 which may be a manual setting on the controller 46. The reference signal represents the desired pressure for the high pressure nitrogen gas to be utilized by the system 12.

The junction block 50, in turn, generates an error signal on a line 54 which is utilized by a servo-valve drive circuit 56 of the controller 46. The servovalve drive circuit 56 utilizes the error signal appearing on the line 54 to output to the pneumatic servovalve 14 an appropriate error control signal to drive the pneumatic servovalve 14.

Preferably, the controller 46 is located remotely from the valve assembly.

Briefly, the pneumatic servovalve 14 initially receives an electrical reference control signal from the controller 46 based on a value set by the reference block 52. In response to the electrical control signal, the pneumatic servovalve 14 allows a proportionate amount of pneumatic pressure into the actuator sections 24 and 26 of the valves 16 and 18, respectively. The two-way valves 16 and 18, in turn, open or close in order to either let high pressure in at the inlet port 25 of the valve 16 from the high pressure air supply 10 or let pressure out in a form of nitrogen gas exhausted at the outlet port of the valve 18. The actual pressure of the regulated high pressure gas which is sent to the system 12 is read by the pressure sensor 40 and fed back to the controller 46 to provide feedback control.

Then, the feedback signal is utilized with the reference signal to generate an error signal at the junction 50. The error signal is representative of a desired amount of fluid pressure change. The drive circuit 56 uses the error signal which drives the servovalve 14.

As previously mentioned, the method, system and valve assembly have numerous advantages. For example, control electronics are not located on-board the valve assembly. This has the benefit of allowing electronics to be mounted in a less hazardous environment for increased reliability. Furthermore, the valve assembly is more cost effective than existing valve assemblies. Finally, the compactness of the valve assembly allows for the mounting of multiple valve assembly in a confined space to service multiple gas-assisted injection molding systems.

While the best mode for carrying out the invention has been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

What is claimed is:

1. A method for controlling a pressurized fluid having a first pressure to provide the pressurized fluid at a regulated desired pressure less than the first pressure, the method comprising the steps of:

providing a pair of pneumatically-operated, fluidly-coupled valves and an electric proportioning device for opening and closing the valves;

communicating the pressurized fluid to the valves; generating a reference signal representative of the desired pressure;

generating a reference control signal based on the reference signal;

coupling the reference control signal to the proportioning device to control the pressure of the pressurized fluid regulated by the valves;

generating a feedback signal as a function of actual pressure of the regulated pressurized fluid;

generating an error signal based on the difference between the reference signal and the feedback signal, the error signal being representative of a desired amount of fluid pressure change; and

generating an error control signal as a function of the error signal to control the proportioning device, the proportioning device, in turn, communicating a pneumatic control signal to each of the valves in response to the reference and error control signals to control the opening and closing of the valves to, in turn, regulate the pressure of the pressurized fluid.

2. The method of claim 1 wherein the step of generating the feedback signal includes the step of measuring the actual pressure of the regulated pressurized fluid with a pressure transducer to obtain a fluid pressure signal.

3. The method of claim 1 wherein each of the valves is a pilot-operated pneumatic valve.

4. The method of claim 3 wherein the proportioning device is a pneumatic servovalve.

5. The method of claim 1 wherein the pressurized fluid is nitrogen gas having a pressure in the range of 1,000-20,000 psi for use in a gas-assisted injection molding system.

6. The method of claim 1 wherein the pressurized fluid has a pressure capable of controlling robots and actuators.

7. A control system for controlling a pressurized fluid having a first pressure to provide the pressurized fluid at a regulated desired pressure less than the first pressure, the control system comprising:

a pair of pneumatically-operated, fluidly-coupled valves;

an electric proportioning device coupled to the valves for opening and closing the valves as a function of control signals to control the pressure of the pressurized fluid regulated by the valves;

means for generating a reference signal representative of the desired pressure;

feedback means for generating a feedback signal as a function of actual pressure of the regulated pressurized fluid;

means for generating an error signal as a function of the difference between the reference signal and the feedback signal, the error signal being representative of a desired amount of pressurized fluid change; and

a controller for initially generating a reference control signal based on the reference signal and then generating an error control signal as a function of the error signal to control the electric proportioning device, the proportioning device, in turn, communicating a pneumatic control signal to each of the valves in response to the control signals to control the opening and closing of the valves to, in turn, regulate the pressure of the pressurized fluid.

8. The control system of claim 7 wherein the feedback means includes a pressure transducer for measuring the actual pressure of the regulated pressurized fluid to obtain a fluid pressure signal.

9. The control system of claim 7 wherein each of the valves is a pilot-operated pneumatic valve.

10. The control system as claimed in claim 9 wherein the proportioning device is a pneumatic servovalve.

11. The control system as claimed in claim 7 wherein the pressurized fluid is nitrogen gas having a pressure in the range of 1,000-20,000 psi for use in a gas-assisted injection molding system.

12. The system of claim 7 wherein the pressurized fluid has a pressure capable of controlling robots and actuators.

13. A valve assembly for controlling a pressurized fluid having a first pressure to provide the pressurized fluid at a regulated desired pressure less than the first pressure, the valve assembly comprising:

a first valve having an input port adapted to receive the pressurized fluid, an outlet port, and a control port adapted to receive a first pneumatic control signal to selectively open and close the input port;

a second valve having an input port, an output port, and a control port adapted to receive a second pneumatic control signal to selectively open and close the output port of the second valve to exhaust the pressurized fluid;

means for fluidly communicating the outlet port of the first valve to the inlet port of the second valve, said means for fluidly communicating having an output port for communicating the regulated pressurized fluid; and

an electric proportioning device for providing the first and second pneumatic control signals to control the opening and closing of the first and second valves, respectively, based on an electrical control signal so that regulated pressurized fluid at the desired pressure is available at the output port of the means for fluidly communicating.

14. The valve assembly as claimed in claim 13 wherein each of the valves is a pilot-operated pneumatic valve.

15. The valve assembly as claimed in claim 14 wherein the proportioning device is a pneumatic servovalve.

16. The valve assembly as claimed in claim 13 wherein the pressurized fluid is nitrogen gas having a pressure in the range of 1,000-20,000 psi for use in a gas-assisted injection molding system.

17. The valve assembly as claimed in claim 13 wherein the means for fluidly communicating includes a cross assembly.

18. The valve assembly as claimed in claim 13 wherein the pressurized fluid has a pressure capable of controlling robots and actuators.

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US005114660A

United States Patent [19]

Hendry

[11] **Patent Number: 5,114,660**

[45] **Date of Patent: * May 19, 1992**

[54] **METHOD OF INJECTING MOLDING**

[75] Inventor: **James W. Hendry**, Brooksville, Fla.

[73] Assignee: **Milad Limited Partnership**, Naples, Fla.

[*] Notice: The portion of the term of this patent subsequent to Jul. 16, 2008 has been disclaimed.

[21] Appl. No.: **552,909**

[22] Filed: **Jul. 16, 1990**

[51] **Int. Cl.**[5] **B29C 45/00**; B29D 22/00

[52] **U.S. Cl.** **264/572**; 264/328.8; 264/328.12; 264/328.13

[58] **Field of Search** 264/85, 328.8, 328.12, 264/500, 572, 328.13; 425/812

[56] **References Cited**

U.S. PATENT DOCUMENTS

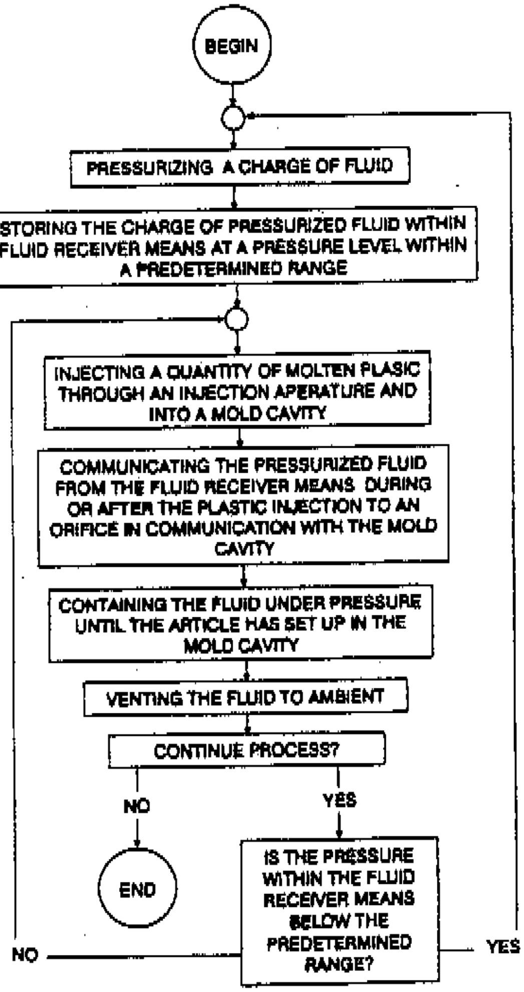
4,101,617	7/1978	Friederich	264/572
4,855,094	8/1989	Hendry	264/40.3
4,935,191	6/1990	Baxi	264/572
4,948,547	8/1990	Hendry	264/500
5,039,463	8/1991	Loren	264/40.3

Primary Examiner—Leo B. Tentoni
Attorney, Agent, or Firm—Brooks & Kushman

[57] **ABSTRACT**

A method and system for the injection molding of plastic articles in an injection molding system including a pneumatically operated gas compression unit having a high pressure gas receiver. The injection molding system includes a resin injection nozzle and a mold having an injection aperture and mold cavity for receiving molten resin from the nozzle. The gas compression unit includes a gas booster which pressurizes a first charge of gas to the pressure setting of a pressure switch. The gas receiver stores the first charge of pressurized gas at a pressure level within a predetermined range of pressures. At least one fluid pressure reducing valve reduces the pressure of the gas as it is communicated from the fluid receiver to an orifice in the mold to an acceptable level for molding the article. The gas compression unit is capable of servicing a plurality of injection molding machines and corresponding molds when a like plurality of pressure reducing valves are provided.

5 Claims, 2 Drawing Sheets



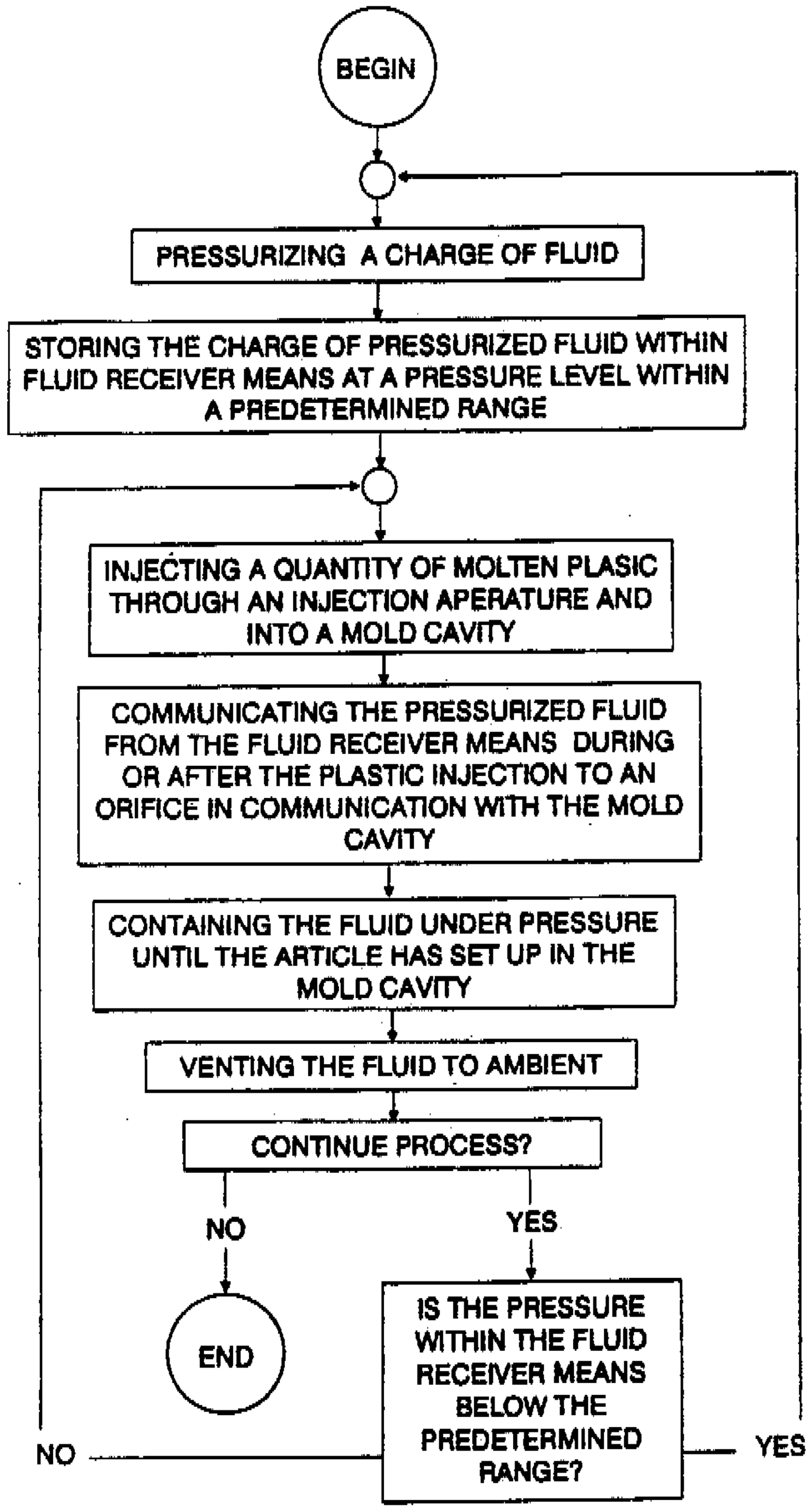

BEGIN
PRESSURIZING A CHARGE OF FLUID
STORING THE CHARGE OF PRESSURIZED FLUID WITHIN FLUID RECEIVER MEANS AT A PRESSURE LEVEL WITHIN A PREDETERMINED RANGE
INJECTING A QUANTITY OF MOLTEN PLASIC THROUGH AN INJECTION APERATURE AND INTO A MOLD CAVITY
COMMUNICATING THE PRESSURIZED FLUID FROM THE FLUID RECEIVER MEANS DURING OR AFTER THE PLASTIC INJECTION TO AN ORIFICE IN COMMUNICATION WITH THE MOLD CAVITY
CONTAINING THE FLUID UNDER PRESSURE UNTIL THE ARTICLE HAS SET UP IN THE MOLD CAVITY
VENTING THE FLUID TO AMBIENT
CONTINUE PROCESS?
NO
YES
END
IS THE PRESSURE WITHIN THE FLUID RECEIVER MEANS BELOW THE PREDETERMINED RANGE?
NO
YES

FIG. 1

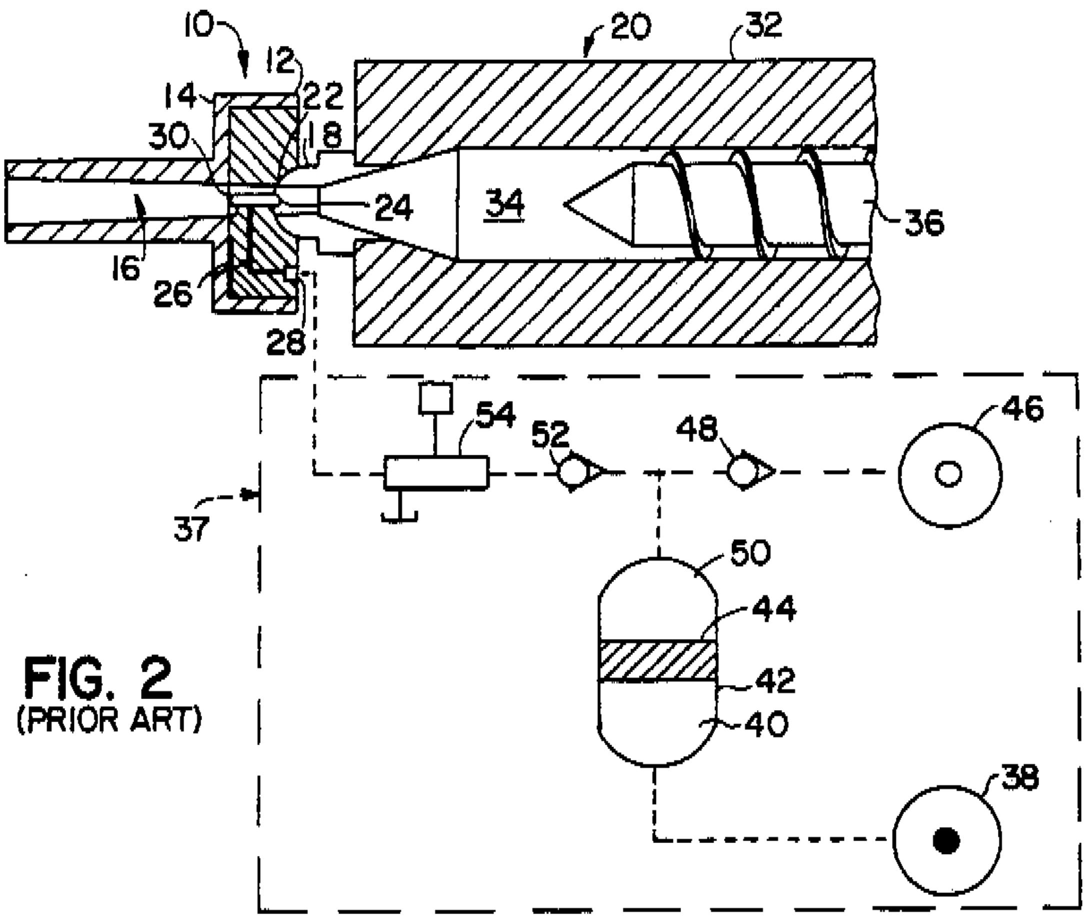


FIG. 2
(PRIOR ART)

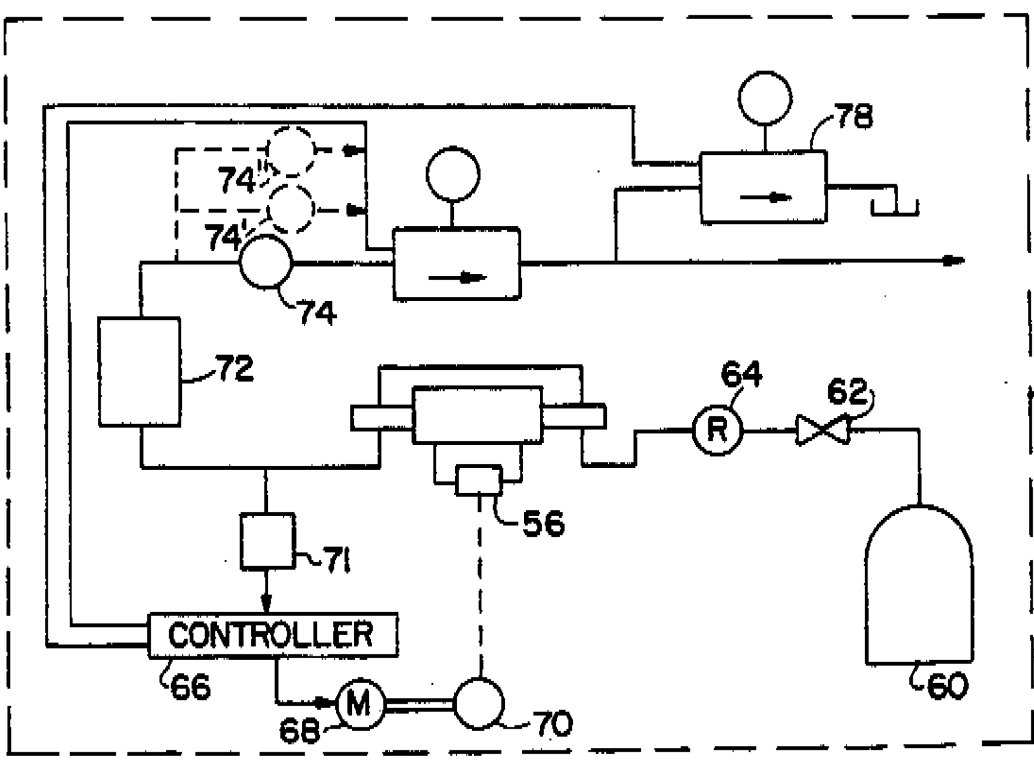


FIG. 3

METHOD OF INJECTING MOLDING

TECHNICAL FIELD

This application relates to method and systems for injection molding of plastic articles using fluid pressure and, in particular, to method and systems for the injection molding of plastic articles using fluid pressure to assist in the making of plastic articles.

BACKGROUND ART

It is known in the plastic molding art to use pressurized fluid in conjunction with the plastic molding of articles, as disclosed in the Friederich U.S. Pat. No. 4,101,617.

Gas-assisted injection molding is a thermoplastic molding process which provides stress-free large parts with a class A surface and virtually no sink marks. Gas-assisted injection molding is a low-pressure molding process compared to conventional injection molding. In this process, inert gas is injected into the plastic after it enters the mold. The gas does not mix with the plastic but remains in the middle of the thicker sections of the molding. By controlling the gas pressure, the quantity of plastic injected into the mold (short shot) and the rate of gas flow, a predetermined network of hollow interconnecting channels is formed within the molded part. The gas pressure remains constant in the network of hollow channels throughout the molding. This compensates for the tendency of the plastic to shrink at the thicker areas of the molding, preventing warpage and reducing stress. The gas pressure is relieved just prior to opening the mold. Because of the relatively low injection pressure, large parts can be molded with substantial reductions in clamp tonnage.

The gas system equipment provides the precise control of pressure, timing and volume of gas which is injected into the part, all of which are important to the control of the gas-assisted injection process.

In U.S. Pat. No. 4,948,547 entitled "Improved Method for the Use of Gas Assistance in the Molding of Thermoplastic Articles," assigned to the Assignee of the present invention, a method of gas-assisted injection molding is disclosed in which a charge of pressurized gas is injected into the mold but not into the article-defining cavity. The gas charge is of a predetermined quantity and pressure, sufficient to assist in filling out the article defining cavity with resin and promoting surface quality.

FIG. 2 is a general schematic view of a prior art apparatus suited for practicing plastic injection molding, generally of the type of which the present invention is directed.

The controlled entry of pressurized fluid, typically nitrogen gas, is accomplished by the use of a modified mold sprue 10. The sprue 10 includes a disc-shaped insert 12 disposed within a sprue body 14.

The mold sprue 10 cooperates with a conventional plastic injection molding machine 20, the nozzle 18 of the molding machine 20 mates with a concave surface 22 on the face of the insert to provide a continuous path 16 for the flow of plastic from the machine 20 through the sprue 10 and into a mold cavity (not shown).

The flow of molten plastic through the insert 10 may be diverted by a conventional torpedo 4 of the type well known in the art.

The introduction of pressurized fluid to the flow path is through passage segments 26 and 28 formed (by drilling or the like) in the insert. The passage 26 opens into the flow path through an orifice 30 of sufficiently small dimension, for example, 0.005 to 0.040 inches, depending on the viscosity of the plastic to actively prevent entry of the relatively high viscous molten plastic during injection.

The plastic injection molding machine 20 includes a barrel 32 with a central cylindrical opening 34. A screw 36 serves to plasticize and advance resin toward the nozzle area. Upon complete plasticization of the resin, the screw 36 is hydraulically advanced toward the head of the barrel 32 to inject molten plastic through the nozzle 18. The plastic passes through the sprue insert 12 at a nominal plastic injection pressure through the stroke of the screw 36. This pressure falls upon substantial completion of the stroke and discharge of the plastic from the barrel 32 of the molding machine 20.

The insert 12 is shown mounted concentrically in a recess in the sprue body 14. Molten plastic passes from the nozzle 18 and around the torpedo through a pair of kidney-shaped apertures (not shown) which serves as first and second branches in the flow path. The pressurized fluid is communicated to the plastic flow path through passage segment 26 and orifice 30 which is mediate the plastic flow branches and colinear therewith.

The temperature of the insert 12 can be controlled, depending on the processing specification of the plastic being used by employing electrical heater bands or other types of auxiliary heat sources, as is well known in the art.

The apparatus of FIG. 2 also includes a mechanism 37 for charging and communicating the pressurized fluid or gas to the sprue insert 12. For example, a hydraulic fluid supply 38 directs a working fluid, such as oil under pressure to a chamber 40 of an accumulator 42 effectively separated into two chambers, having mutually and inversely variable volumes by a compression piston 44. A fluid supply 46 is provided for directing a charge of gas through a first check valve 48 into the second chamber 50 of the accumulator 42 for pressurization. A control valve 54 controls communication of the gas from the chamber 50 to the sprue insert 12. A check valve 52 is connected in series with the control valve 54.

The mechanism for charging a pressurized fluid or gas for use in the prior art molding process is described in greater detail in U.S. Pat. No. 4,855,094. Also, a detailed description of the operation of the mechanism 37 is described in this patent which is assigned to the Assignee of the present application.

One limitation of the prior art mechanism 37 is that the hydraulic unit can only recharge after the plastic injection molding cycle is substantially completed (typically 75%). Also, such a hydraulic unit must be recharged after each cycle. Consequently, a relatively constant pressure is not always available with such a hydraulic unit which uses a multiplier system.

Another drawback of such a hydraulic unit is that it is not flexible to adapt to more than one concurrently operating molding process. Consequently, a separate hydraulic unit must be provided for each injection molding machine and mold combination.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a method and system for the injection molding of plastic articles wherein charges of fluid can be pressurized at any time during an injection molding process.

Another object of the present invention is provide a method and system for the injection molding of plastic articles wherein it is not required that fluid charge means for pressurizing charges of fluid need be recharged for each injection molding cycle.

Yet still another object of the present invention is to provide a method and system for the injection molding of plastic articles wherein a fluid, having a relatively constant pressure, is always available during the injection molding process.

Yet still further another object of the present invention is to provide a method and system for the injection molding of plastic articles wherein a fluid charge means and fluid receiver means are adapted to run more than one injection molding system with a minimum amount of adaptation.

In carrying out the above objects and other objects of the present invention, a method for the injection molding of plastic articles in an injection molding system is provided. The injection molding system includes a resin injection nozzle and a mold having an injection aperture and a mold cavity for receiving molten resin from the nozzle. The method includes the steps of pressurizing a charge of fluid, storing the charge of pressurized fluid within a fluid receiver means at a level within a predetermined range of pressures and injecting a quantity of molten plastic from the injection nozzle through the injection aperture and into the mold cavity. The method further includes the steps of communicating the pressurized fluid from the fluid receiver means to an orifice in communication with the mold cavity simultaneously with or after the step of injecting. Also, the fluid is contained under pressure within the mold until the article has set up from the mold cavity, after which the fluid is vented to the mold. Finally, the steps of injecting, communicating, containing and venting are repeated until the pressure within the fluid receiver means is below the range of pressures at which time the steps of pressurizing and storing are repeated in preparation for molding another article.

Further in carrying out the above objects and other objects of the present invention, a system is provided for carrying out each of the above-noted method steps.

Preferably, the method also includes the step of reducing the pressure of the fluid from the fluid receiver means to an acceptable level for molding of articles during the step of communicating. This method step is typically performed by a fluid pressure reducing mechanism, such as a pressure reducing valve. A plurality of such pressure reducing valves may be provided in order that the charging and communicating system is capable of running of plurality of injection molding machines and their associated molds.

The objects, features and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flowchart setting forth the operational steps of the method of the present invention;

FIG. 2 is a general schematic view of a system constructed in accordance with the prior art; and

FIG. 3 is a general schematic view of a mechanism for charging and communicating pressurized fluid or gas to replace the mechanism illustrated in FIG. 2 to obtain the system of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention will be first described by reference to the operational steps of the method. Then, the system employed in the preferred embodiment will be described.

General Method of Operation

FIG. 1 is a flowchart setting forth the general operational steps involved in the method of the present invention. In overview, the method provides for molding of plastic articles with hollow interior sections where pressurized fluid is present in formation of the article in the mold cavity. The presence of the pressurized fluid creates an outward pressure which minimizes sink marks and reduces the material requirements and weight of the molded article. However, it is to be understood that the method is capable of providing for the molding of plastic articles with solid interior where pressurized fluid is injected into the mold but not into the article-defining cavity. The gas charge is of predetermined quantity and pressure sufficient to assist in filling out the article-defining cavity with resin and promoting surface quality as described in greater detail in U.S. Pat. No. 4,948,547 entitled "Method for the Use of Gas Assistance in the Molding of Plastic Articles".

In step 1, a charge of fluid is pressurized or boosted to a predetermined pressure level.

In step 2, the charge of pressurized fluid is stored within a fluid receiver means or mechanism at a level within a predetermined range of pressures. This pressure may be reduced to the pressure required by the injection molding process.

In step 3, a quantity of molten plastic is injected from the nozzle of a conventional injection molding machine to a flow path into a mold cavity at an injection pressure. The quantity of molten plastic, i.e. the plastic shot, is less than the quantity of plastic which would ordinarily be required to fill the mold cavity if a hollow article is to be filled.

In step 4, the charge of pressurized fluid, preferably nitrogen gas, is communicated from the fluid receiver means during or after the plastic injection, to an orifice in communication with the mold cavity. Preferably, the orifice has a sufficiently small dimension to resist entry of the relatively viscous molten plastic.

In step 5, the pressurized gas is contained under pressure within the mold, until the article has set up in the mold cavity. During the formation of hollow plastic articles, the pressurized gas exerts outward pressure which forces the plastic to conform to the detail of the mold surface and exhibit fine detail with minimal sink marks or other surface defects.

In step 6, the gas is vented to ambient from the mold prior to opening the mold and removing the finished molded article.

In step 7, a decision must be made whether the injection molding process is to be continued.

In step 8, if the process is to continue, it is determined whether the pressure within the fluid receiver means is below the predetermined range. If it is, the process is continued at step 1 to begin pressurizing a second charge of gas. If the pressure within the fluid receiver means is still within the predetermined range, the process continues at step 3 wherein another quantity of molten plastic is injected from the nozzle into the injection aperture and into the mold cavity. At this point there is no need to pressure a second charge of gas since the pressure of the gas within the fluid receiver means is sufficient to mold another plastic article.

Description of the System

Referring now to FIG. 3, there is illustrated a mechanism 37' for charging and communicating pressurized fluid or gas to the sprue insert 12 and which replaces the mechanism 37 of FIG. 2.

A pneumatic air supply 56 directs a working fluid, such as air under pressure to a compartment (not shown) of a gas booster 58 effectively separated into first and second chambers. The first chamber receives the working gas and pressurizes the charge of fluid in the second chamber.

A gas supply 60 is provided for directing a charge of gas to a check valve 62 and regulated by a pressure regulator 64 into the second chamber of the gas booster 58 for pressurization.

The operation of the gas booster 58 is controlled by a controller 66 which controls the operation of a motor 68 to drive a pump 70 to provide pressurized gas to the air supply 56. In turn, the pressurized gas from the air supply 56 boosts the pressure of the fluid charge within the gas booster 58 to a predetermined pressure range set by a pressure switch 71 coupled to the controller 66. The pressurized gas is stored in a gas pressure receiver 72. Once the charge of fluid is pressurized to the pressure range setting of the pressure switch 71 by the booster 58, the booster 58 will stop under control of the controller 66.

The pressure of the gas from the pressure receiver 72 can be reduced to the proper pressure needed by the injection molding process by adjusting a pressure reducing valve 74. When the pressurized gas is needed for the injection molding process, a directional control valve 76 which had previously retained the gas within the gas receiver 72, is energized under control of the controller 66 and is open long enough to communicate the gas within the pressure gas receiver 72 through the passages 26 and 28 and insert 12 as shown in FIG. 2 to the injection orifice 30.

When a sufficient amount of gas has been communicated from the gas receiver 72, the directional control valve 76 is deenergized.

After the fluid has been contained under pressure to allow the article to set up in the mold cavity, the fluid is vented to ambient or to a reservoir by energizing a directional control valve 78 to open the valve 78, thereby venting the gas from the mold at a metered rate controlled by the valve 78. Thereafter, the directional control valve 78 is closed and the completed article is ejected from the mold.

Alternatively, the fluid may be vented to ambient by separating the mold and the injection nozzle 18 after the molten resin has cooled beneath its softening point.

The pneumatic mechanism 37' can be adapted to run more than one gas-assisted injection molding process and apparatus by adding a plurality of fluid pressure reducing valves 74' and 74'' which, in turn, would be connected to their respective directional control valves in the same fashion as the pressure reducing valve 74 is connected to its respective directional control valves 76 and 78. The additional pressure reducing valves may have different pressure settings to accommodate fluids of differing pressures. Prior art hydraulic units are not as flexible and would be difficult to adapt to more than one injection molding machine or mold pair.

When the pressure in the gas receiver 72 drops below the low setting of the pressure switch 71, the booster 58 starts again recharging the gas receiver 72 until the setting of the pressure switch 71 is again reached.

The advantages accruing to the use of the pneumatic gas compression unit 37' are numerous. For example, the booster 58 can be in operation at any time during an injection molding process cycle. This is to be contrasted with the prior art hydraulic units wherein they are rechargeable only after the injection molding process is substantially through its cycle (i.e. 75%).

Also, the mechanism or unit 37' typically need not be recharged for several injection molding cycles. This is to be contrasted with a hydraulic unit, such as the unit 37, which must be recharged after each injection molding cycle.

Also, the mechanism or unit 37' is always available with a relatively constant pressure within a predetermined range of pressures wherein this is not necessarily so with a hydraulic unit (i.e. having a hydraulic multiplier system).

Also, a timer may be provided to time the relationship of plastic/gas injection to eliminate a "hesitation mark" in the plastic.

The invention has been described in an illustrative manner and, it is to be understood that, the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A method for the injection molding of plastic articles in an injection molding system including a resin injection nozzle and a mold having an injection aperture and a mold cavity for receiving molten resin from the nozzle, the method comprising the steps of:

(a) pressurizing a charge of fluid;

(b) storing the charge of pressurized fluid within a fluid receiver means at a pressure level within a predetermined range of pressures;

(c) injecting a quantity of molten plastic from the injection nozzle through the injection aperture and into the mold cavity;

(d) communicating the pressurized fluid from the fluid receiver means to an orifice in communication with the mold cavity simultaneously with or after the step of injecting;

(e) containing the fluid under pressure within the mold until the article is set up in the mold cavity thereby completing the formation of the plastic article;

(f) venting the fluid from the mold;

(g) repeating steps (c) through (f) until the pressure within the fluid receiver means falls below the range of pressures; and

(h) repeating steps (a) and (b) as soon as the pressure within the fluid receiver falls below the range of pressures in preparation for molding another article wherein the method further comprises the step of reducing the pressure of the fluid from the fluid receiver means to an acceptable level for molding the articles during step (d).

2. The method of claim 1 wherein the fluid is a gas.

3. The method of claim 1 wherein the mold includes a sprue, the sprue having the injection aperture and wherein the charge of pressurized fluid is introduced to the mold cavity from the sprue.

4. The method of claim 1 wherein the step of venting includes the step of separating the mold and the injec-

tion nozzle after the molten resin has cooled beneath its softening point.

5. The method of claims 1 or 4 wherein the fluid is vented from the article through the same orifice as which it was introduced.

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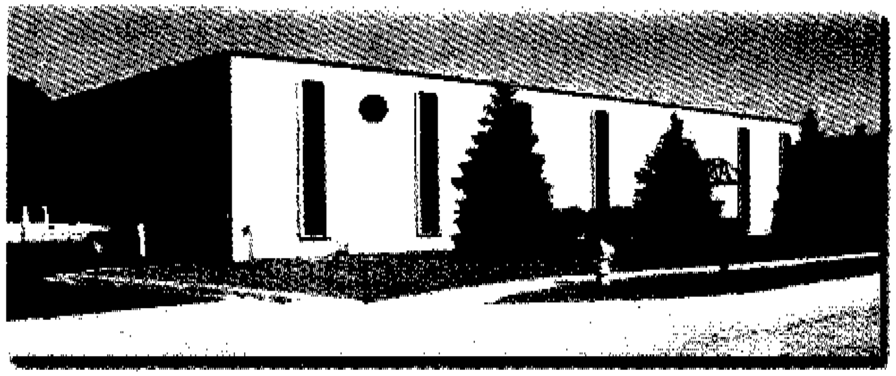

Alliance has completed the expansion of our headquarters in Chesterfield Township, Michigan and the installation of three more new molding machines to provide comprehensive tool tryouts, process and development on gas assisted, conventional and **Hydrojection**™ water assisted injection molding programs.

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E

Claim 1 of U.S. Patent 5,098,637

What is claimed is:

1. A process for injection molding a hollow plastic article comprising the steps of:

[a] injecting a quantity of fluent plastic into a mold cavity having a shape defining at least a portion of the article;

[b] displacing a portion of the plastic from the mold cavity into a spill cavity flow coupled to the mold cavity by introduction of a charge of pressurized gas into the mold cavity;

[c] permitting the injected plastic to solidify;

[d] venting the plastic article from the mold.