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[Continued on next page]

(54) Title: DELIVERING RADIATIVE HEAT TO MOLD TOOL SYSTEM

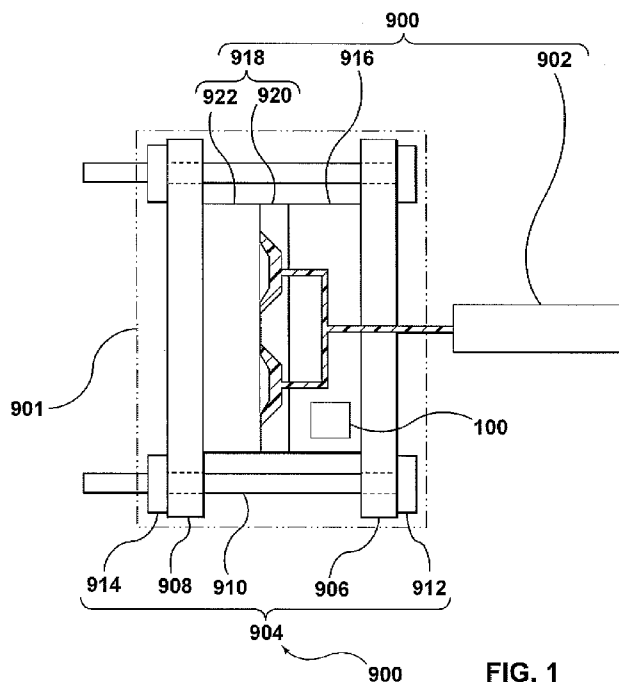


**FIG. 1**

(57) Abstract: A mold-tool system (100), comprising: a heating assembly (102) being configured to deliver heat to a heatable component (101), the heat being delivered to the heatable component (101) by the heating assembly (102) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) by the heating assembly (102) is a combination of conductive heat and convective heat.



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## **DELIVERING RADIATIVE HEAT TO MOLD-TOOL SYSTEM**

### **TECHNICAL FIELD**

An aspect generally relates to (but is not limited to) a mold-tool system and/or a molding  
5 system having the mold-tool system.

### **SUMMARY**

The inventors have researched a problem associated with known molding systems that  
inadvertently manufacture bad-quality molded articles or parts. After much study, the  
10 inventors believe they have arrived at an understanding of the problem and its solution,  
which are stated below, and the inventors believe the public does not know this  
understanding.

The current problem is that electrical resistive heater assemblies supply a fixed wattage per  
15 linear length of the heater assembly. Known installation method depends on installing the  
heater assembly to have good thermal conductance to a component of a runner assembly.  
This arrangement may improve heat transfer. However, heat transfer is a two way street,  
not only does the above arrangement improve heat going out to the manifold from the  
heater assembly, but the above arrangement may also improve cooling of the heater  
20 assembly at the location of heat losses. For an ideal case, the temperature of the electric  
heater is independent of the temperature of the component. However, the next best case  
may be to limit the effect of the component's temperature on the temperature of the heater  
assembly. Instead of transferring a majority of the heat by conductance, the solution may  
reduce, at least in part, heat transfer by conduction and/or may improve heat transfer by  
25 radiation.

To resolve the above, at least in part, according to a first aspect, there is provided a mold-  
tool system (**100**), comprising: a heating assembly (**102**) being configured to deliver heat to  
a heatable component (**101**), the heat being delivered to the heatable component (**101**) by  
30 the heating assembly (**102**) is substantially radiative heat, and the balance of the heat being  
delivered to the heatable component (**101**) by the heating assembly (**102**) is a combination  
of conductive heat and convective heat. Radiative heat transfer is a function of the fourth  
power of temperature difference between two bodies (using an absolute scale), and thus is  
much higher for larger differences in temperature. This then acts as a partially self  
35 regulating heat transfer mode, as the amount of heat transferred increases dramatically as

the temperature differential increases, and correspondingly decreases as the temperature differential decreases. This is in contrast to conductive and convective heat transfer modes, where the heat transfer typically has a linear relationship as a function of the temperature differential. The ideal resistive heater design combines conductive, convective and radiative heat transfer modes with the contribution of each dependent upon numerous parameters, including but not limited to, materials, desired temperature profiles, environmental conditions, etc.

To resolve the above, at least in part, according to a second aspect, there is provided a mold-tool system (100), comprising: a heatable component (101); and a heating assembly (102) being configured to deliver heat to the heatable component (101), the heat being delivered to the heatable component (101) by the heating assembly (102) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) by the heating assembly (102) is a combination of conductive heat and convective heat.

To resolve the above, at least in part, according to a third aspect, there is provided a molding system having any one of the mold-tool system (100) as described above.

To resolve the above, at least in part, according to a fourth aspect, there is provided a runner assembly (916) having the mold-tool system (100) as described above.

To resolve the above, at least in part, according to a fifth aspect, there is provided a method of operating the mold-tool system (100) as described above, the method comprising: delivering heat to a heatable component (101) of the mold-tool system (100), the heat being delivered to the heatable component (101) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) is a combination of conductive heat and convective heat.

Other aspects and features of the non-limiting embodiments will now become apparent to those skilled in the art upon review of the following detailed description of the non-limiting embodiments with the accompanying drawings.

## **DETAILED DESCRIPTION OF THE DRAWINGS**

The non-limiting embodiments will be more fully appreciated by reference to the following detailed description of the non-limiting embodiments when taken in conjunction with the accompanying drawings, in which:

FIGS. 1 to 7 depict schematic representations of a mold-tool system (100).

The drawings are not necessarily to scale and may be illustrated by phantom lines, diagrammatic representations and fragmentary views. In certain instances, details not necessary for an understanding of the embodiments (and/or details that render other details difficult to perceive) may have been omitted.

## **DETAILED DESCRIPTION OF THE NON-LIMITING EMBODIMENT(S)**

FIGS. 1 to 7 depict the schematic representations of the mold-tool system (100). The mold-tool system (100) may include components that are known to persons skilled in the art, and these known components will not be described here; these known components are described, at least in part, in the following reference books (for example): (i) "Injection Molding Handbook" authored by OSSWALD/TURNIG/GRAMANN (ISBN: 3-446-21669-2), (ii) "Injection Molding Handbook" authored by ROSATO AND ROSATO (ISBN: 0-412-99381-3), (iii) "Injection Molding Systems" 3<sup>rd</sup> Edition authored by JOHANNABER (ISBN 3-446-17733-7) and/or (iv) "Runner and Gating Design Handbook" authored by BEAUMONT (ISBN 1-446-22672-9). It will be appreciated that for the purposes of this document, the phrase "includes (and is not limited to)" is equivalent to the word "comprising". The word "comprising" is a transitional phrase or word that links the preamble of a patent claim to the specific elements set forth in the claim that define what the invention itself actually is. The transitional phrase acts as a limitation on the claim, indicating whether a similar device, method, or composition infringes the patent if the accused device (etc) contains more or fewer elements than the claim in the patent. The word "comprising" is to be treated as an open transition, which is the broadest form of transition, as it does not limit the preamble to whatever elements are identified in the claim.

FIG. 1 depicts a schematic representation of a molding system (900) having the mold-tool system (100). The molding system (900) may also be called an injection-molding system for example. According to the example depicted in FIG. 1, the molding system (900) includes (and is not limited to): (i) an extruder assembly (902), (ii) a clamp assembly (904), (iii) a

runner assembly (916), and (iv) a mold assembly (918). By way of example, the extruder assembly (902) is configured, to prepare, in use, a heated, flowable resin, and is also configured to inject or to move the resin from the extruder assembly (902) toward the runner assembly (916). Other names for the extruder assembly (902) may include injection unit, melt-preparation assembly, etc. By way of example, the clamp assembly (904) includes (and is not limited to): (i) a stationary platen (906), (ii) a movable platen (908), (iii) a rod assembly (910), (iv) a clamping assembly (912), and (v) a lock assembly (914). The stationary platen (906) does not move. The stationary platen (906) may be fixedly positioned relative to the ground or floor. The movable platen (908) is configured to be movable relative to the stationary platen (906). A platen-moving mechanism (not depicted but known) is connected to the movable platen (908); the platen-moving mechanism is configured to move, in use, the movable platen (908). The rod assembly (910) extends between the movable platen (908) and the stationary platen (906). The rod assembly (910) is configured to guide movement of the movable platen (908) relative to the stationary platen (906). A clamping assembly (912) is connected to the rod assembly (910). The stationary platen (906) supports the clamping assembly (912). The lock assembly (914) is connected to the rod assembly (910). The movable platen (908) supports the lock assembly (914). By way of example, the runner assembly (916) is attached to or supported by the stationary platen (906). The runner assembly (916) includes (and is not limited to) a mold-tool system (100). The definition of the mold-tool system (100) is as follows: a system that may be positioned and/or may be used in an envelope defined by the stationary platen (906) and the movable platen (908) of the molding system (900). The molding system (900) may include (and is not limited to) the mold-tool system (100). The runner assembly (916) is configured to receive the resin from the extruder assembly (902). By way of example, the mold assembly (918) includes (and is not limited to): (i) a stationary-mold assembly (920), and (ii) a movable-mold assembly (922) that is movable relative to the stationary-mold assembly (920). The movable-mold assembly (922) is attached to or supported by the movable platen (908). The stationary-mold assembly (920) is attached to or supported by the runner assembly (916), so that the movable-mold assembly (922) faces the stationary-mold assembly (920). The runner assembly (916) is configured to distribute the resin from the extruder assembly (902) to the mold assembly (918).

In operation, the movable platen (908) is moved toward the stationary platen (906) so that the stationary-mold assembly (920) is closed against the movable-mold assembly (922), so that the mold assembly (918) may define a mold cavity structure that is configured to

receive the resin from the runner assembly (916). The lock assembly (914) is engaged so as to lock the position of the movable platen (908) so that the movable platen (908) no longer moves relative to the stationary platen (906). The clamping assembly (912) is then engaged to apply a clamping pressure, in use, to the rod assembly (910), so that the clamping pressure then may be transferred to the mold assembly (918). The extruder assembly (902) pushes or injects, in use, the resin to the runner assembly (916), which then the runner assembly (916) distributes the resin to the mold cavity structure defined by the mold assembly (918). Once the resin in the mold assembly (918) is solidified, the clamping assembly (912) is deactivated so as to remove the clamping force from the mold assembly (918), and then the lock assembly (914) is deactivated to permit movement of the movable platen (908) away from the stationary platen (906), and then a molded article may be removed from the mold assembly (918).

It will be appreciated that: (i) all of the above components, assemblies, etc., may: (i) all be sold separately or provided by a combination of multiple vendors, (ii) some vendors may provide a combination of a limited selection of the above components, assemblies, etc., or, (iii) a single vendor may provide all of the above of the above components, assemblies, etc.

In general terms, referring to FIGS. 2 to 7, there is depicted a first example of the mold-tool system (100), in which the mold-tool system (100) includes (and is not limited to) a heating assembly (102). The heating assembly (102) is configured to deliver heat to a heatable component (101). The heat delivered to the heatable component (101) by the heating assembly (102) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) by the heating assembly (102) is a combination of conductive heat and convective heat.

In general terms, referring to FIGS. 2 to 7, there is depicted a second example of the mold-tool system (100), in which the mold-tool system (100) includes (and is not limited to): (i) the heatable component (101), and (ii) the heating assembly (102). The heating assembly (102) is configured to deliver heat to the heatable component (101). The heat being delivered to the heatable component (101) by the heating assembly (102) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) by the heating assembly (102) is a combination of conductive heat and convective heat.

In general terms, referring to FIGS. 2 to 7, there is depicted a third example of the mold-tool

system (100), in which the molding system (900) has or includes the mold-tool system (100).

In general terms, referring to FIGS. 2 to 7, there is depicted a fourth example of the mold-tool system (100), in which a method is associated with operating the mold-tool system (100).

5 The method includes (and is not limited to): delivering heat to the heatable component (101) of the mold-tool system (100), in which the heat being delivered to the heatable component (101) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) is a combination of conductive heat and convective heat.

10 Referring now to FIG. 3, which depicts an option of the mold-tool system (100), wherein the heating assembly (102) includes (and is not limited to): an infrared assembly (104) configured to provide infrared-radiative heat to the heatable component (101). The heating assembly (102), such as an infrared heaters (by way of example), are non-contact heaters that provide heat to an object receiving the heat primarily through radiative-heat transfer  
15 across a gap; the gap exists between the heating assembly (102) and the heatable component (101) this is to receive the heat from the heating assembly (102). Aside from a heater support mechanism (configured to support and position the heating assembly (102), no contact of the heating assembly (102) to either the heatable component (101) or to the component supporting the heating assembly (102) is required (these may be, in fact, the same component). The support components may transfer some amount of heat (heat  
20 conduction) as a consequence of the mechanical coupling with the heating assembly (102), but the coupling mechanism is not intended to be a primary source of heat transfer between the heating assembly (102) and the heatable component (101) but rather heat transfer through the mechanical coupling is simply a result of the mechanical coupling, and may be  
25 minimized as much as possible.

Referring now to FIG. 4, which depicts an option of the mold-tool system (100), wherein the heating assembly (102) is partially connected to and partially decoupled from the heatable component (101). This partial coupling is a consequence of supporting the heating assembly  
30 (102) and not intended to be a primary source of heat transfer from the heating assembly (102) to the item receiving the heat. The primary source of heat transfer from the heating assembly (102) that is to be received by the object or item is radiative heat.

Referring now to FIG. 5, which depicts an option of the mold-tool system (100), wherein the  
35 heating assembly (102) is positioned, at least in part, in a void (106) being defined by the

heatable component (101). By supporting the heating assembly (102), such as an infrared heater, within the void (106) formed in the heatable component (101), all (or at least most) of the radiation emitted from the heating assembly (102) is directed, via the void (106), towards the heatable component (101). It will be appreciated that the support structure configured to maintain the heating assembly (102) in position in the void (106) may be minimized so as to reduce heat transfer along the support structure to the heatable component (101). This arrangement provides the advantage of improved heating efficiency. However, it will be appreciated that the support structure may provide a degree of mechanical coupling, and so heat transfer along the support structure may be minimized as much as possible.

Referring now to FIG. 6, which depicts an option of the mold-tool system (100), wherein the heating assembly (102) is connected to another component (110) that is located adjacent to the heatable component (101). This configuration reduces an amount of mechanical coupling between the heating assembly (102) and the heatable component (101), and any associated localized heat transfer to the heatable component (101) through the mechanical coupling, and then this arrangement provides for improved consistency of temperature associated with the heatable component (101). There may also be advantages from a usability, manufacturability, and serviceability point of view.

Referring now to FIG. 7, which depicts an option of the mold-tool system (100), in which the mold-tool system (100) further includes (and is not limited to) a reflector assembly (112). The reflector assembly (112) is for reflecting an amount of heat imparted from the heating assembly (102) to the heatable component (101). The reflector assembly (112) may be set apart from the heating assembly (102). The reflector assembly (112) improves heating efficiency by increasing amount of heat to be transferred from the heating assembly (102) to the heatable component (101). It is noted that the reflector assembly (112) may be used in the arrangements depicted in the other FIGS, such as FIGS. 4 and 6. Additionally, the reflector assembly (112) may also include a mechanism (not depicted) that is configured to support position of the heating assembly (102) relative to the heatable component (101).

#### **ADDITIONAL DESCRIPTION**

The following clauses are offered as further description of the examples of the mold-tool system (100): Clause (1): a mold-tool system (100), comprising: a heating assembly (102) being configured to deliver heat to a heatable component (101), the heat being delivered to the heatable component (101) by the heating assembly (102) is substantially radiative heat,

and the balance of the heat being delivered to the heatable component (101) by the heating assembly (102) is a combination of conductive heat and convective heat. Clause (2): a mold-tool system (100), comprising: a heatable component (101); and a heating assembly (102) being configured to deliver heat to the heatable component (101), the heat being delivered to the heatable component (101) by the heating assembly (102) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) by the heating assembly (102) is a combination of conductive heat and convective heat. Clause (3): the mold-tool system (100) of any clause described in this paragraph, wherein: the heating assembly (102) includes: an infrared assembly (104) configured to provide infrared-radiative heat to the heatable component (101). Clause (4): the mold-tool system (100) of any clause described in this paragraph, wherein: the heating assembly (102) is partially connected to and partially decoupled from the heatable component (101). Clause (5): the mold-tool system (100) of any clause described in this paragraph, wherein: the heating assembly (102) is positioned, at least in part, in a void (106) being defined by the heatable component (101). Clause (6): the mold-tool system (100) of any clause described in this paragraph, wherein: the heating assembly (102) is connected to another component (110) that is located adjacent to the heatable component (101). Clause (7): the mold-tool system (100) of any clause described in this paragraph, further comprising: a reflector assembly (112) for reflecting an amount of heat imparted from the heating assembly (102) to the heatable component (101). Clause (8): the mold-tool system (100) of any clause described in this paragraph, wherein: the reflector assembly (112) is set apart from the heating assembly (102). Clause (9): a molding system (900) having the mold-tool system (100) of any clause described in this paragraph. Clause (10): a runner assembly (916) having the mold-tool system (100) of any clause described in this paragraph. Clause (11): a method of operating the mold-tool system (100) of any clause described in this paragraph, comprising: delivering heat to a heatable component (101) of the mold-tool system (100), the heat being delivered to the heatable component (101) is substantially radiative heat, and the balance of the heat being delivered to the heatable component (101) is a combination of conductive heat and convective heat.

FIGS. 1 to 7 depict examples of the mold-tool system (100). It will be appreciated that the examples depicted in FIGS. 1 to 7 may be combined in any suitable permutation and combination well within the skill of persons of skill in the art. It will be appreciated that the assemblies and modules described above may be connected with each other as may be required to perform desired functions and tasks that are within the scope of persons of skill

in the art to make such combinations and permutations without having to describe each and every one of them in explicit terms. There is no particular assembly, components, or software code that is superior to any of the equivalents available to the art. There is no particular mode of practicing the inventions and/or examples of the invention that is superior to others, so long as the functions may be performed. It is believed that all the crucial aspects of the invention have been provided in this document. It is understood that the scope of the present invention is limited to the scope provided by the independent claim(s), and it is also understood that the scope of the present invention is not limited to: (i) the dependent claims, (ii) the detailed description of the non-limiting embodiments, (iii) the summary, (iv) the abstract, and/or (v) description provided outside of this document (that is, outside of the instant application as filed, as prosecuted, and/or as granted). It is understood, for the purposes of this document, the phrase "includes (and is not limited to)" is equivalent to the word "comprising". It is noted that the foregoing has outlined the non-limiting embodiments (examples). The description is made for particular non-limiting embodiments (examples). It is understood that the non-limiting embodiments are merely illustrative as examples.

**CLAIMS****WHAT IS CLAIMED IS:**

- 5     **1.** A mold-tool system (**100**), comprising:  
            a heating assembly (**102**) being configured to deliver heat to a heatable  
            component (**101**), the heat being delivered to the heatable component (**101**) by the  
            heating assembly (**102**) is substantially radiative heat, and the balance of the heat  
10             being delivered to the heatable component (**101**) by the heating assembly (**102**) is a  
            combination of conductive heat and convective heat.
- 2.** A mold-tool system (**100**), comprising:  
            a heatable component (**101**); and  
            a heating assembly (**102**) being configured to deliver heat to the heatable  
15             component (**101**), the heat being delivered to the heatable component (**101**) by the  
            heating assembly (**102**) is substantially radiative heat, and the balance of the heat  
            being delivered to the heatable component (**101**) by the heating assembly (**102**) is a  
            combination of conductive heat and convective heat.
- 20     **3.** The mold-tool system (**100**) of any preceding claim, wherein:  
            the heating assembly (**102**) includes:  
                an infrared assembly (**104**) configured to provide infrared-radiative heat  
                to the heatable component (**101**).
- 25     **4.** The mold-tool system (**100**) of any preceding claim, wherein:  
            the heating assembly (**102**) is partially connected to and partially decoupled  
            from the heatable component (**101**).
- 5.** The mold-tool system (**100**) of any preceding claim, wherein:  
30             the heating assembly (**102**) is positioned, at least in part, in a void (**106**) being  
            defined by the heatable component (**101**).
- 6.** The mold-tool system (**100**) of any preceding claim, wherein:  
            the heating assembly (**102**) is connected to another component (**110**) that is  
35             located adjacent to the heatable component (**101**).

7. The mold-tool system (**100**) any preceding claim, further comprising:  
a reflector assembly (**112**) for reflecting an amount of heat imparted from the  
heating assembly (**102**) to the heatable component (**101**).

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8. The mold-tool system (**100**) any preceding claim, wherein:  
the reflector assembly (**112**) is set apart from the heating assembly (**102**).

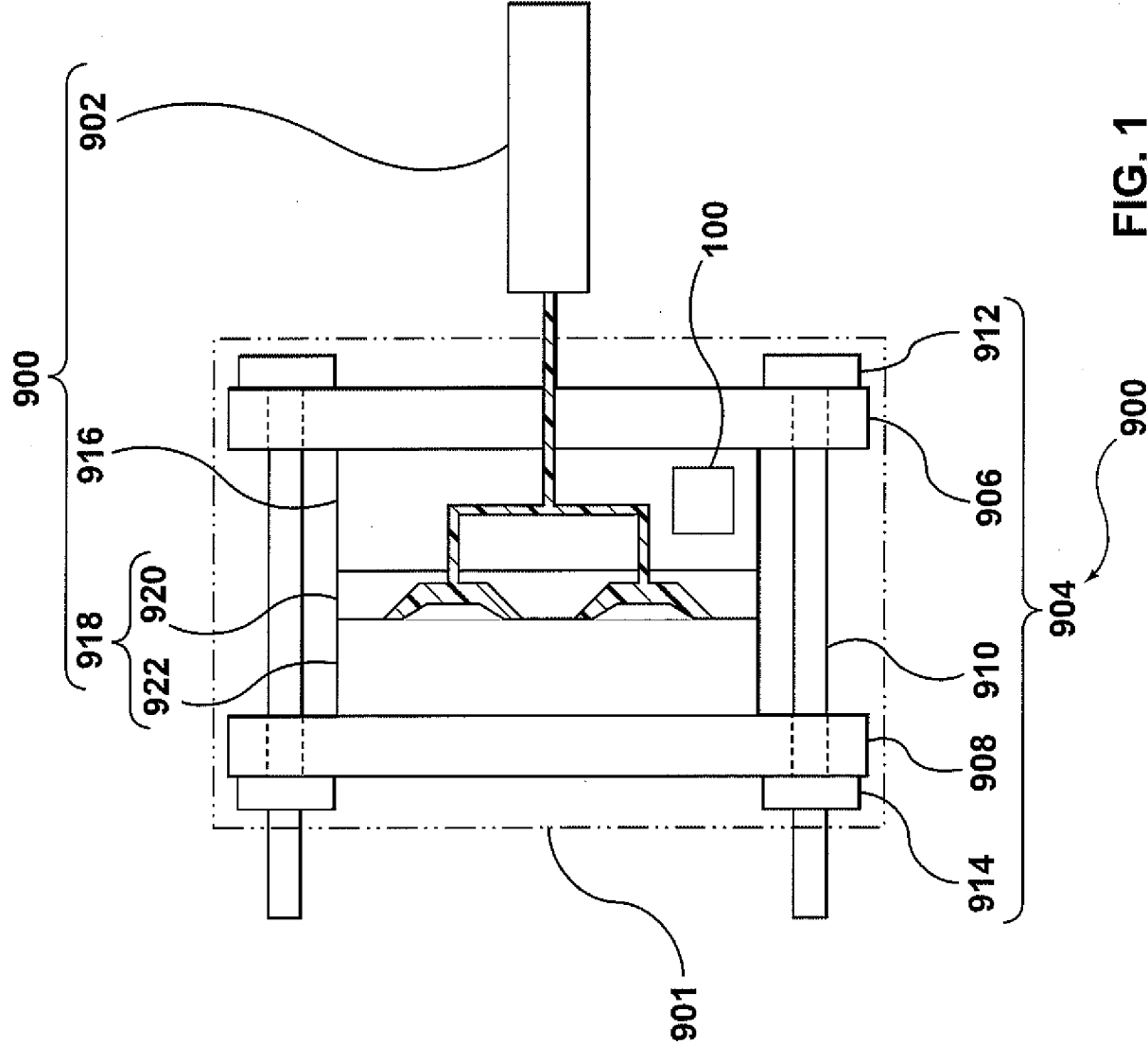
9. A molding system (**900**) having the mold-tool system (**100**) of any preceding claim.

10

10. A runner assembly (**916**) having the mold-tool system (**100**) of any preceding claim.

11. A method of operating a mold-tool system (**100**), comprising:  
delivering heat to a heatable component (**101**) of the mold-tool system (**100**),  
the heat being delivered to the heatable component (**101**) is substantially radiative  
heat, and the balance of the heat being delivered to the heatable component (**101**) is  
a combination of conductive heat and convective heat.

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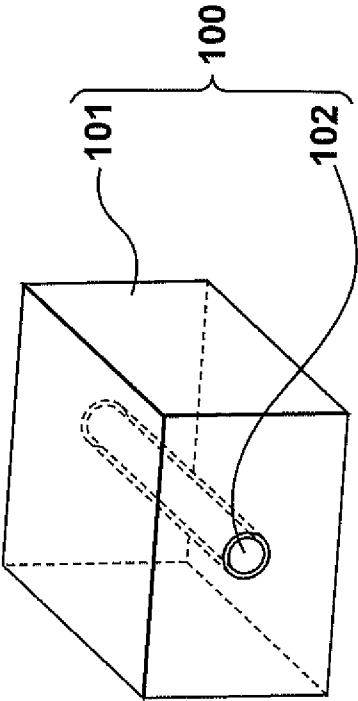


**FIG. 2**

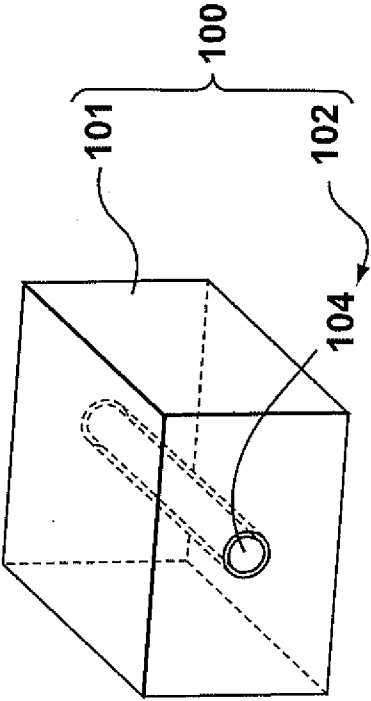


**FIG. 3**

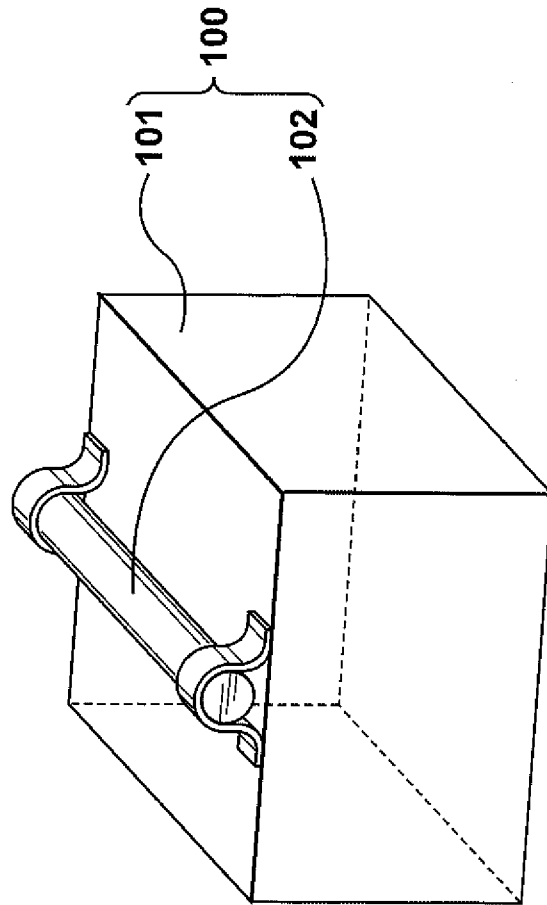


**FIG. 4**

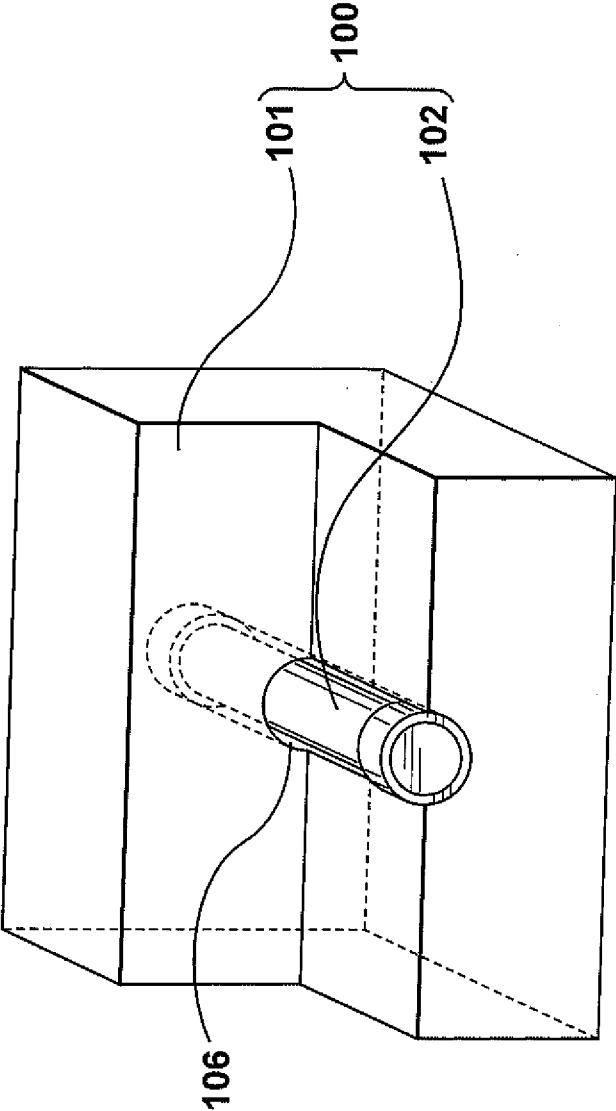
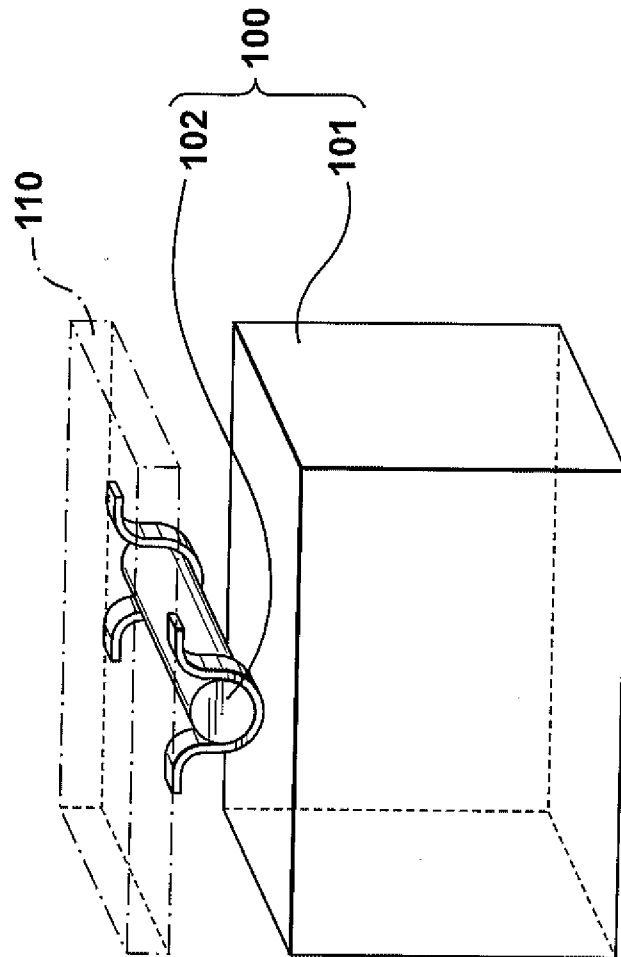


**FIG. 5**

**FIG. 6**

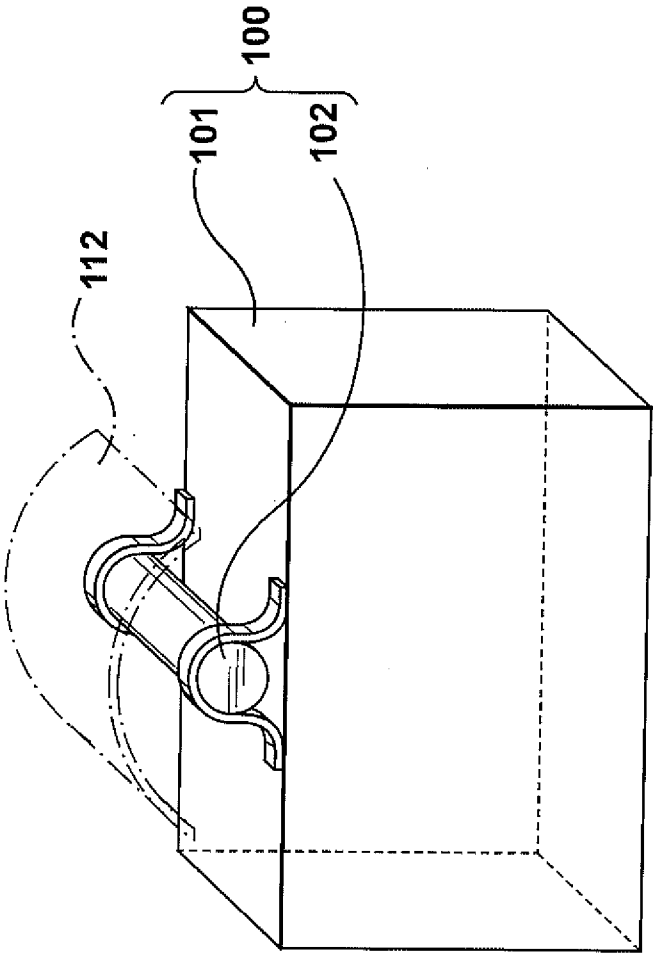


**FIG. 7**

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 12/37891

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B29C 45/26 (2012.01)

USPC - 425/174.4

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): B29C 45/26 (2012.01)

USPC: 425/174.4

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
USPC: 425/526, 547, 548, 407, DIG13, DIG245, DIG246; 264/402-404; 425/\$; 264/\$

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

Thomson Innovation; Google/Patents; Google/Scholar; EPO Espacenet

Search terms: Mold, mould, radiation, convection, conduction, temperature, heat, thermal, IR, infrared, supplement, add, extra, further, auxiliary, remaining, remainder, balance, residual, primary, principle, main, majority, most

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category*     | Citation of document, with indication, where appropriate, of the relevant passages                                  | Relevant to claim No.  |
|---------------|---------------------------------------------------------------------------------------------------------------------|------------------------|
| X<br>---<br>Y | US 7,824,165 B2 (DAVIE et al.) 02 November 2010 (02.11.2010), col 3, lns 52-61; col 6, lns 47-58; Figs. 1, 2, 3A, 4 | 1, 2, 11<br>-----<br>3 |
| Y             | US 3,491,170 A (ROE) 20 January 1970 (20.01.1970), col 6, lns 59-64                                                 | 3                      |
| A             | US 2004/0046290 A1 (KIM et al.) 11 March 2004 (11.03.2004), Claim 9                                                 | 1-3, 11                |
| A             | US 2011/0006460 A1 (VANDER WEL et al.) 13 January 2011 (13.01.2011), para [0049]                                    | 1-3, 11                |
| A             | US 3,675,905 A (PLACEK) 11 July 1972 (11.07.1972), col 7, lns 11-17                                                 | 1-3, 11                |

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

\* Special categories of cited documents:

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

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

31 July 2012 (31.07.2012)

Date of mailing of the international search report

13 AUG 2012

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents  
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300  
PCT OSP: 571-272-7774

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 12/37891

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-10  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.