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## (54) Die casting system machine configurations

Maschinenkonfigurationen für ein Druckgusssystem

Configurations de machine de système de moulage

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## Description

### BACKGROUND

**[0001]** This disclosure relates generally to casting, and more particularly to die casting system machine configurations.

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

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

**[0004]** EP 0 875 318 discloses a die casting system and a method of die casting a component with the features of the preamble to claims 1 and 6.

### SUMMARY

**[0005]** From one aspect, the present invention provides a die casting system in accordance with claim 1.

**[0006]** From another aspect, the present invention provides a method of die casting a component in accordance with claim 5.

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

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]**

Figure 1 illustrates an example die casting system.

Figure 2 illustrates an example machine configuration of a die casting system.

Figure 2B illustrates a positioning system of the example die casting system of Figure 2.

Figure 3 illustrates another example machine configuration of a die casting system.

Figure 3B illustrates an example shot tube plunger of the die casting system of Figure 3.

Figure 4 illustrates yet another example machine configuration of a die casting system.

Figure 5 schematically illustrates an example implementation of the die casting system machine configurations of Figure 3 and Figure 4.

### DETAILED DESCRIPTION

**[0009]** Figure 1 illustrates a die casting system 10 having a machine configuration 11. In this example, the die casting system 10 includes a horizontal machine configuration. The die casting system 10 includes a reusable die 12 having a plurality of die elements 14, 16 that function to cast a component 15. Although two die elements 14, 16 are depicted in Figure 1, it should be understood that the die 12 could include more or fewer die elements, as well as other parts and configurations.

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

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

**[0012]** The shot tube 24 receives a molten metal from a melting unit 25, such as a crucible, for forming the component 15. In this example, the molten metal is melted in the melting unit 25 at a location that is separate from the shot tube 24. However, this disclosure is not limited to melting units located separate from the other die casting system components.

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

**[0014]** The shot tube 24 receives a sufficient amount of molten material to fill the die cavity 20. The shot tube plunger 28 is actuated to inject the molten metal under pressure from the shot tube 24 into the die cavity 20 to cast the component 15. Although the casting of a single component is depicted, the die casting system could be configured to cast multiple components in a single shot (see Figures 3 and 4, for example).

**[0015]** Although not necessary, at least a portion of the die casting system 10 can be positioned within a vacuum chamber 34 that includes a vacuum source 35. A vacuum is applied in the vacuum chamber 34 via the vacuum source 35 to render a vacuum die casting process. The vacuum chamber 34 provides a non-reactive environment for the die casting system 10 that reduces reaction, contamination, or other conditions that could detrimentally affect the quality of the cast component 15, such as excess porosity of the die cast component that can occur as a result of exposure to oxygen. In one example, the vacuum chamber 34 is maintained at a pressure between $1x10^{-3}$ Torr and $1x10^{-4}$ Torr, although other pressures are contemplated. The actual pressure of the vacuum chamber 34 will vary based on the type of component 15 being cast, among other conditions and factors. In the illustrated example, the melting unit 25, the shot tube 24, and the die 12 are positioned within the vacuum chamber 34 during the die casting process such that the melting, injecting and solidifying of the metal are each performed under vacuum. In another example, the vacuum chamber 34 is backfilled with an inert gas, such as Argon, for example.

**[0016]** The machine configuration 11 of the die casting system 10 depicted in Figure 1 is illustrative only and could include more or less sections, parts and/or components. This disclosure extends to all forms of die casting, including but not limited to, horizontal systems, vertical systems, vacuum systems, or non-vacuum systems. Described below are additional machine configurations of die casting systems capable of casting components made from high melting temperature materials. The example machine configurations described below and depicted in Figures 2-5 maintain thermal control of the molten metal received by the die casting system components and thereby minimize thermal losses (i.e., heat of the molten metal) during injection. In addition, the example machine configurations extend part life and reduce the defects caused by transfer of the molten metal from a location separate from the die casting system components.

**[0017]** Figure 2 illustrates an example machine configuration 111 of a die casting system 110. In this disclosure, like reference numerals signify like features, and reference numerals identified in multiples of 100 signify slightly modified features. Moreover, selected features of one example embodiment may be combined with selected features of other example embodiments and still fall within the scope of this disclosure.

**[0018]** In this example, the die casting system 110 is positioned relative to a surface 40, such as a machine shop floor, for example. The surface 40 is substantially flat. The die casting system 110 is substantially similar to the die casting system 10 of Figure 1, except that the die casting system 110 is positioned at an angle $\alpha$ relative to the surface 40. That is, the machine configuration 111 includes an inclined positioning of the die casting system 110 relative to the surface 40.

**[0019]** In this example, the die 12, the shot tube 24 and the shot tube plunger 28 are each angled relative to the surface 40 at an angle $\alpha$. The machine configuration 111 therefore changes the orientation of the die casting system 110 relative to the surface 40 such that the surface area contact between molten metal and the interior of the shot tube 24 is reduced. Reduction of the surface area contact of the molten metal with the shot tube 24 minimizes thermal losses of the molten metal that can occur during injection, and reduces the thermal stresses acting upon the shot tube 24.

**[0020]** The depicted angle $\alpha$ is for illustrative purposes only and is not meant to limit this disclosure. In one example, the die casting system 110 is angled relative to the surface 40 at an angle of about 5° to about 85°. In another example, the die casting system 110 is angled relative to the surface 40 at an angle of about 30° to about 45°. In this disclosure, the term "about" is intended to include the defined ranges and any slight modifications thereof, such as within a range of accepted tolerances.

**[0021]** The die casting system 110 could be permanently inclined relative to the surface 40, such as by mounting the die casting system 110 to an inclined surface 41. In another example, as depicted in Figure 2B, the die casting system 110 includes a positioning system 42 that selectively inclines the die casting system 110 relative to the surface 40. In this example, the positioning system 42 includes cylinders 44 that are selectively actuable to position the die casting system 110 at a desired angle $\alpha$ relative to the surface 40. The positioning system 42 could include any appropriate hydraulic, pneumatic, electromechanical and/or other configurations for positioning the components of the die casting system 110 at a desired inclined angle $\alpha$.

**[0022]** Although not depicted, the die casting system 110 could be positioned within a vacuum chamber powered by a vacuum source to render a vacuum die casting system, or a die casting system 110 could be positioned within a chamber that is backfilled with an inert gas, such as Argon, for example.

**[0023]** Figure 3 illustrates another example machine configuration 211 for a die casting system 210. In this example, the machine configuration 211 of the die casting system 210 includes a vertical, bottom feed configuration. Although a vertical, bottom feed configuration is depicted, the advantages of this disclosure are applicable to other configurations including, but not limited to, horizontal, side feed and top feed configurations.

**[0024]** The die casting system 210 includes a die 212 having a plurality of die elements 214, 216 that define a die cavity 220. A shot tube 224 is in fluid communication with the die cavity 220. A gate 221 connects the shot tube 224 to the die cavity 220. A shot tube plunger 228 is received within the shot tube 224 and is moveable between a retracted and injected position (in the direction of arrow A) within the shot tube 224 by a mechanism 230.

**[0025]** The shot tube 224 includes an integrated melting unit 225 configured to heat a charge of material 237 from an interior position IP of the shot tube 224. In this example, the integrated melting unit 225 includes an induction coil 227 mounted about the shot tube 224. The induction coil 227 of the integrated melting unit 225 induces a current within the shot tube 224 to melt and/or superheat the charge of material 237 within the interior position IP of the shot tube 224. That is, the charge of material 237 can be either melted from inside of the shot tube 224, or can be melted separate from the shot tube 224 (such as in a crucible) and then transferred to the shot tube 224 and heated to a desired temperature inside of the shot tube 224. The induction coil 227 is powered by a power source 229 in a known manner.

**[0026]** The example shot tube 224, in accordance with the present invention includes a first sleeve 231 and a second sleeve 233. The first sleeve 231 is a graphite sleeve and the second sleeve 233 is a ceramic sleeve. The induction coil 227 is positioned around the second sleeve 233 to melt and/or heat a charge of material 237 (such as an ingot of a high melting temperature material) within the second sleeve 233. The charge of material 237 is transformed into molten metal and/or superheated once induced by the induction coil 227. The shot tube plunger 228 packs the molten metal into the first sleeve 231 of the shot tube 224. The first sleeve 231 is capable of withstanding the pressure of the packed molten metal.

**[0027]** Figure 3B depicts example features of the shot tube plunger 228. The shot tube plunger 228 could include a cooled copper plunger 250. In this example, the cooled copper plunger 250 includes cooling channels 251 that receive a coolant 253, such as water, from a coolant source 255. The coolant 253 is circulated through the coolant channels 251 to remove heat from the shot tube plunger 228 as a result of direct contact with the molten metal during injection.

**[0028]** As depicted in Figure 3, the die casting system 210 could be positioned within a vacuum chamber 234 that includes a vacuum source 235. A vacuum is applied in the vacuum chamber 234 via the vacuum source 235 to render a vacuum die casting process. In the illustrated example, each of the shot tube 224, the integrated melting unit 225 and the die 212 are positioned within the vacuum chamber 234 during the die casting process such that the melting, injecting and solidifying of the metal are all performed under vacuum. Although a vacuum chamber 234 is depicted in Figure 3, the die casting system 210 may also be utilized in non-vacuumed environments.

**[0029]** Figure 4 illustrates yet another example machine configuration 311 associated with a die casting machine 310. The die casting system 310 is substantially similar to the die casting system 210 of Figure 3. However, the example die casting system 310 includes a slightly modified integrated melting unit 325. In this example, the integrated melting unit 325 includes an induction skull melting system 327. That is, in this example machine configuration 311, the induction skull melting system 327 replaces the induction coil 227 depicted in Figure 3.

**[0030]** The die casting system 310 also includes a die 312 having a plurality of die elements 314, 316 that define a die cavity 320. A shot tube 324 is in fluid communication with the die cavity 320. A gate 321 connects the shot tube 324 to the die cavity 320. A shot tube plunger 328 is received within the shot tube 324 and is moveable between a retracted and injected position (in the direction of arrow A) within the shot tube 324 by a mechanism 230. Although not depicted, the die casting system 310 could be positioned within a vacuum chamber powered by a vacuum source to render a vacuum die casting system.

**[0031]** The induction skull melting system 327 of the integrated melting unit 325 includes wall segments 91 which are surrounded by an induction coil 93. In this example, the wall segments 91 are copper wall segments. The wall segments 91 and the induction coil 93 include cooling chambers 95 that receive a coolant, such as water, from a coolant source 97 to cool the wall segments 91 during contact with molten metal. A magnetic field is induced by the induction coil 93 and passes through the wall segments 91 to heat and melt the charge of material 337 to form molten metal.

**[0032]** The shot tube plunger 328 is moveable to pack the molten metal within a sleeve 331 of the shot tube 324 to prepare the molten metal to be injected into the die cavity 320. In this example, the shot tube plunger 328 is a copper shot tube plunger and could include cooling channels (similar to those depicted by Figure 3B) to cool the shot tube plunger 328 during contact with the molten metal.

**[0033]** Figure 5 schematically illustrates an example implementation 100 of the machine configurations 211, 311 of Figure 3 and Figure 4. The example implementation 100 schematically depicts a method of die casting a component 15. The component 15 could include an aeronautical component, such as an airfoil or vane, for example. However, the casting of non-aeronautical components is also contemplated as within the scope of this disclosure.

**[0034]** The example implementation 100 includes loading a charge of material 237, 337 within a shot tube 224, 324 of a die casting system 210, 310, which is depicted at step block 102. In one example, the charge of material 237, 337 is molten metal that is melted in a melting unit 25 (See Figure 1) separate from the die casting systems 210, 310 and poured into the shot tube 224, 324. In another example, the charge of material 237, 337 is a solid ingot of material that is positioned inside the shot tube 224, 324 prior to melting. The charge of material 237, 337 is a high melting temperature material.

**[0035]** Next, at step block 104, the charge of material 237, 337 is heated from a position inside of the shot tube 224, 324. The charge of material 237, 337 is heated with an integrated melting unit 225, 325. A skull 75 forms on an interface defined between the shot tube plunger 228, 328 and the molten metal to seal the shot tube 224, 324. Once the charge of material 237, 337 is either melted or achieves a desired temperature, the molten metal is advanced through the integrated melting unit 225, 325 at step block 106. During advancement, the shot tube plunger 228, 328 pushes on the skull 75 formed at step block 104. Formation and advancement of the skull 75 protects the shot tube 224, 324 from exposure to the molten metal and protects the molten metal from contamination.

**[0036]** At step block 108, the shot tube plunger 228, 328 crushes the skull 75 and the molten metal is rapidly injected into the die cavity 220, 320 of the die 212, 312. The molten metal solidifies within the die cavity 220, 320 to form the component 15 at step block 110. Finally, at step block 112, the die 212, 312 is opened and the component 15 is removed relative to the die 212, 312. The component 15 can be subjected to finishing operations once removed from the die 212, 312.

## Claims

**1.** A die casting system (200;300), comprising:

a die (212;312) comprising a plurality of die components (214,216;314,316) that define a die cavity (220;320);
a shot tube (224;324) in fluid communication with said die cavity (220;320), wherein said shot tube (224;324) includes an integrated melting unit (225;325) configured to heat a charge of material (237;337) from a position inside of said shot tube (224;324), wherein said integrated melting unit (225) includes an induction coil (227); and
a shot tube plunger (228;328) moveable within said shot tube (224;324) to communicate said charge of material (237;337) into said die cavity (220;320); **characterised in that**
said shot tube (224) includes a first sleeve (231) and a second sleeve (233) and said first sleeve (231) is a graphite sleeve and said second sleeve (233) is a ceramic sleeve.

**2.** The system as recited in any preceding claim, wherein said integrated melting unit (325) includes an induction skull melting system (327).

**3.** The system as recited in any preceding claim, wherein said shot tube plunger (228;328) includes a cooled copper shot tube plunger.

**4.** The system as recited in any preceding claim, wherein the die casting system (200;300) is a vertical die casting system (200;300).

**5.** A method of die casting a component, comprising the steps of:

(a) loading a charge of material (237;337) within a shot tube (224;324) of a die casting system (200;300);
(b) heating the charge of material (237;337) at a position inside said shot tube (224;324) with an integrated melting unit (225;325) associated with the shot tube (234;334) of the die casting system (200;300), wherein said integrated melting unit (225) includes an induction coil (227); and
(c) injecting the charge of material (237;337) into a die cavity (220;320) of the die casting system (200;300) to cast the component; **characterised in that**

said shot tube (224) includes a first sleeve (231) and a second sleeve (233) and said first sleeve (231) is a graphite sleeve and said second sleeve (233) is a ceramic sleeve.

**6.** The method as recited in claim 5, wherein the charge of material (237;337) is a molten metal and said step (a) includes the step of:
pouring the molten metal into the shot tube (224;324).

**7.** The method as recited in claim 6, wherein said step (b) includes the step of:
heating the molten metal to a desired temperature inside of the shot tube (224;324).

**8.** The method as recited in claim 5, wherein the charge of material is an ingot of material and said step (a) includes the step of:
positioning the solid ingot of material inside of the shot tube (224;324).

**9.** The method as recited in claim 8, wherein said step (b) includes the step of:
melting the solid ingot of material into a molten metal inside of the shot tube (224;324).

## Patentansprüche

**1.** Druckgusssystem (200; 300), umfassend:

eine Gussform (212; 312), die eine Vielzahl von Gussformkomponenten (214, 216; 314, 316) umfasst, die einen Gussformhohlraum (220; 320) definieren;
ein Einspritzrohr (224; 324) in Fluidkommunikation mit dem Gussformhohlraum (220; 320), wobei das Einspritzrohr (224; 324) eine integrierte Schmelzeinheit (225; 325) beinhaltet, die konfiguriert ist, um eine Beladung von Material (237;

337) von einer Position innerhalb des Einspritzrohres (224; 324) zu erwärmen, wobei die integrierte Schmelzeinheit (225) eine Induktionsspule (227) beinhaltet; und
einen Einspritzrohrkolben (228; 328), der innerhalb des Einspritzrohres (224; 324) bewegbar ist, um die Beladung von Material (237; 337) in den Gussformhohlraum (220; 320) zu kommunizieren; **dadurch gekennzeichnet, dass**
das Einspritzrohr (224) eine erste Hülse (231) und eine zweite Hülse (233) beinhaltet und die erste Hülse (231) eine Graphithülse ist und die zweite Hülse (233) eine Keramikhülse ist.

2. System nach einem vorhergehenden Anspruch, wobei die integrierte Schmelzeinheit (325) ein Induktions-Skull-Melting-System (327) beinhaltet.

3. System nach einem vorhergehenden Anspruch, wobei der Einspritzrohrkolben (228; 328) einen gekühlten Kupfereinspritzrohrkolben beinhaltet.

4. System nach einem vorhergehenden Anspruch, wobei das Druckgusssystem (200; 300) ein vertikales Druckgusssystem (200; 300) ist.

5. Verfahren zum Druckgießen einer Komponente, die folgenden Schritte umfassend:

(a) Laden einer Beladung von Material (237; 337) in ein Einspritzrohr (224; 324) eines Druckgusssystems (200; 300);
(b) Erwärmen der Beladung von Material (237; 337) an einer Position innerhalb des Einspritzrohres (224; 324) mit einer integrierten Schmelzeinheit (225; 325), die mit dem Einspritzrohr (234; 334) des Druckgusssystems (200; 300) verbunden ist, wobei die integrierte Schmelzeinheit (225) eine Induktionsspule (227) beinhaltet; und
(c) Einspritzen der Beladung von Material (237; 337) in einen Gussformhohlraum (220; 320) des Druckgusssystems (200; 300), um die Komponente zu gießen; **dadurch gekennzeichnet, dass**

das Einspritzrohr (224) eine erste Hülse (231) und eine zweite Hülse (233) beinhaltet und die erste Hülse (231) eine Graphithülse ist und die zweite Hülse (233) eine Keramikhülse ist.

6. Verfahren nach Anspruch 5, wobei die Beladung von Material (237; 337) ein geschmolzenes Metall ist und Schritt (a) den folgenden Schritt beinhaltet:
Gießen des geschmolzenen Metalls in das Einspritzrohr (224; 324) .

7. Verfahren nach Anspruch 6, wobei Schritt (b) den folgenden Schritt beinhaltet:
Erwärmen des geschmolzenen Metalls auf eine gewünschte Temperatur innerhalb des Einspritzrohres (224; 324).

8. Verfahren nach Anspruch 5, wobei die Beladung von Material ein Materialblock ist und Schritt (a) den folgenden Schritt beinhaltet:
Positionieren des festen Materialblocks innerhalb des Einspritzrohres (224; 324).

9. Verfahren nach Anspruch 8, wobei Schritt (b) den folgenden Schritt beinhaltet:
Schmelzen des festen Materialblocks zu einem geschmolzenen Metall innerhalb des Einspritzrohres (224; 324).

## Revendications

1. Système de moulage (200 ; 300), comprenant :

une filière (212 ; 312) comprenant une pluralité de composants de filière (214, 216 ; 314, 316) qui définissent une cavité de filière (220 ; 320) ;
un tube d'injection (224 ; 324) en communication fluidique avec ladite cavité de filière (220 ; 320), dans lequel ledit tube d'injection (224 ; 324) comporte une unité de fusion intégrée (225 ; 325) configurée pour chauffer une charge de matière (237 ; 337) à partir d'une position à l'intérieur dudit tube d'injection (224 ; 324), dans lequel ladite unité de fusion intégrée (225) comporte une bobine d'induction (227) ; et
un plongeur de tube d'injection (228 ; 328) mobile au sein dudit tube d'injection (224 ; 324) pour communiquer ladite charge de matière (237; 337) dans ladite cavité de filière (220 ; 320) ; **caractérisé en ce que**
ledit tube d'injection (224) comporte un premier manchon (231) et un second manchon (233) et ledit premier manchon (231) est un manchon en graphite et ledit second manchon (233) est un manchon en céramique.

2. Système selon une quelconque revendication précédente, dans lequel ladite unité de fusion intégrée (325) comporte un système de fusion à fond de moule refroidi par induction (327).

3. Système selon une quelconque revendication précédente, dans lequel ledit plongeur de tube d'injection (228 ; 328) comporte un plongeur de tube d'injection en cuivre refroidi.

4. Système selon une quelconque revendication précédente, dans lequel le système de moulage (200 ; 300) est un système de moulage vertical (200 ; 300).

**5.** Procédé de moulage d'un composant, comprenant les étapes consistant à :

(a) charger une charge de matière (237 ; 337) au sein d'un tube d'injection (224 ; 324) d'un système de moulage (200 ; 300) ;
(b) chauffer la charge de matière (237 ; 337) à une position à l'intérieur dudit tube d'injection (224 ; 324) avec une unité de fusion intégrée (225 ; 325) associée au tube d'injection (234 ; 334) du système de moulage (200 ; 300), dans lequel ladite unité de fusion intégrée (225) comporte une bobine d'induction (227) ; et
(c) injecter la charge de matière (237 ; 337) dans une cavité de filière (220 ; 320) du système de moulage (200 ; 300) pour couler le composant ;
**caractérisé en ce que**

ledit tube d'injection (224) comporte un premier manchon (231) et un second manchon (233) et ledit premier manchon (231) est un manchon en graphite et ledit second manchon (233) est un manchon en céramique.

**6.** Procédé selon la revendication 5, dans lequel la charge de matière (237 ; 337) est un métal fondu et ladite étape (a) comporte l'étape consistant à :
verser le métal fondu dans le tube d'injection (224 ; 324) .

**7.** Procédé selon la revendication 6, dans lequel ladite étape (b) comporte l'étape consistant à :
chauffer le métal fondu jusqu'à une température souhaitée à l'intérieur du tube d'injection (224 ; 324).

**8.** Procédé selon la revendication 5, dans lequel la charge de matière est un lingot de matière et ladite étape (a) comporte l'étape consistant à :
positionner le lingot plein de matière à l'intérieur du tube d'injection (224 ; 324).

**9.** Procédé selon la revendication 8, dans lequel ladite étape (b) comporte l'étape consistant à :
faire fondre le lingot plein de matière en un métal fondu à l'intérieur du tube d'injection (224 ; 324).

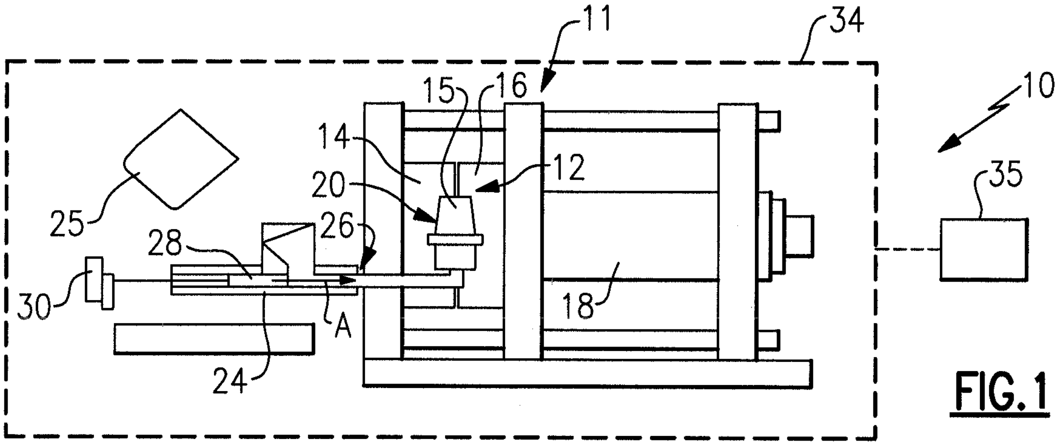


FIG.1

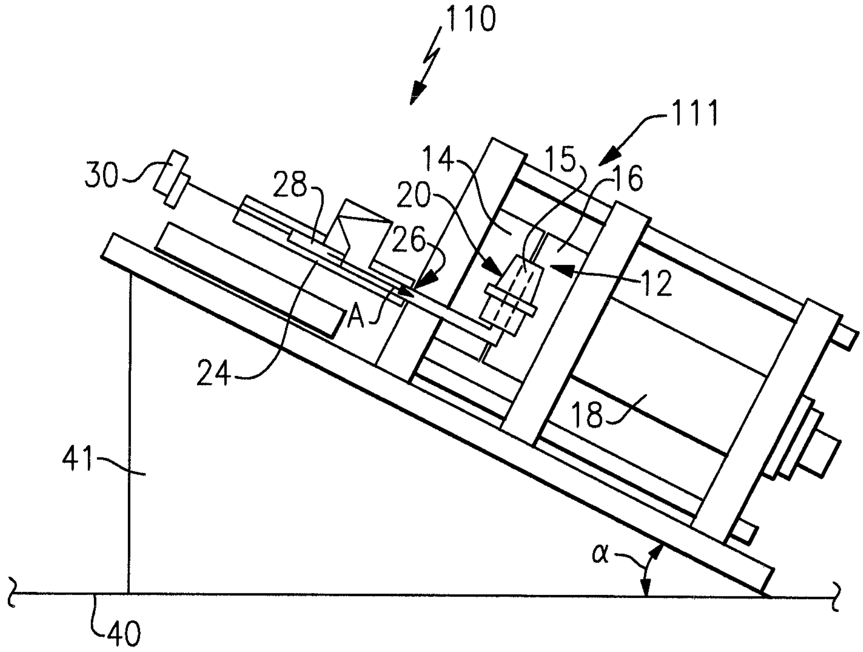


FIG.2

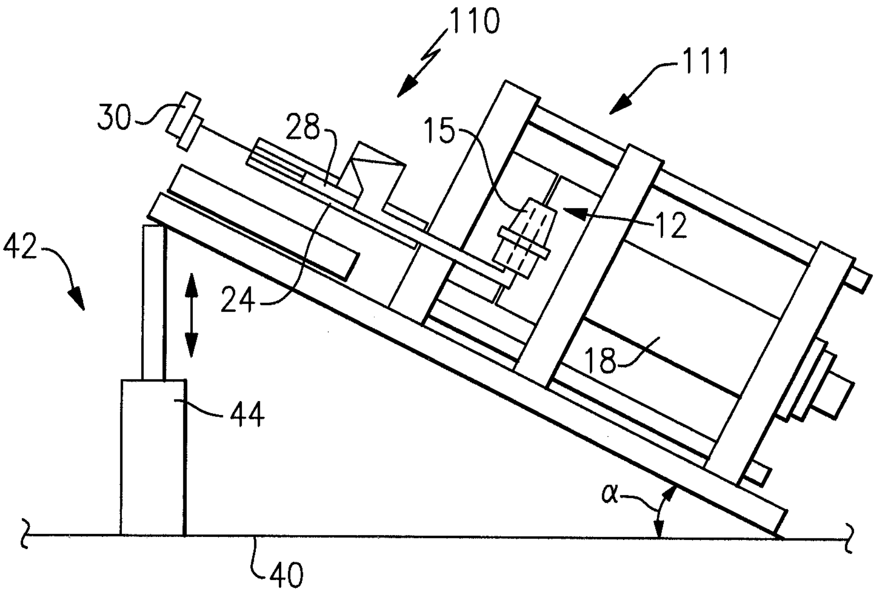


FIG.2B

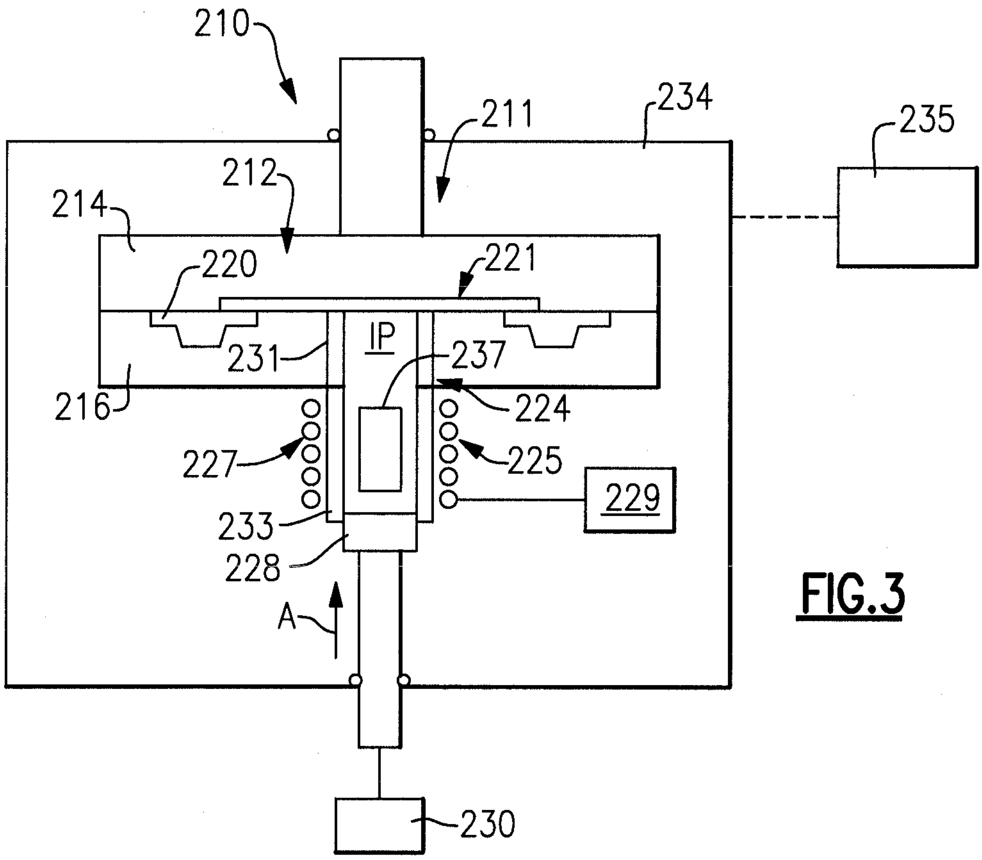
210
211
234
235
212
214
220
221
IP
231
237
216
224
227
225
229
233
228
A
230

FIG.3

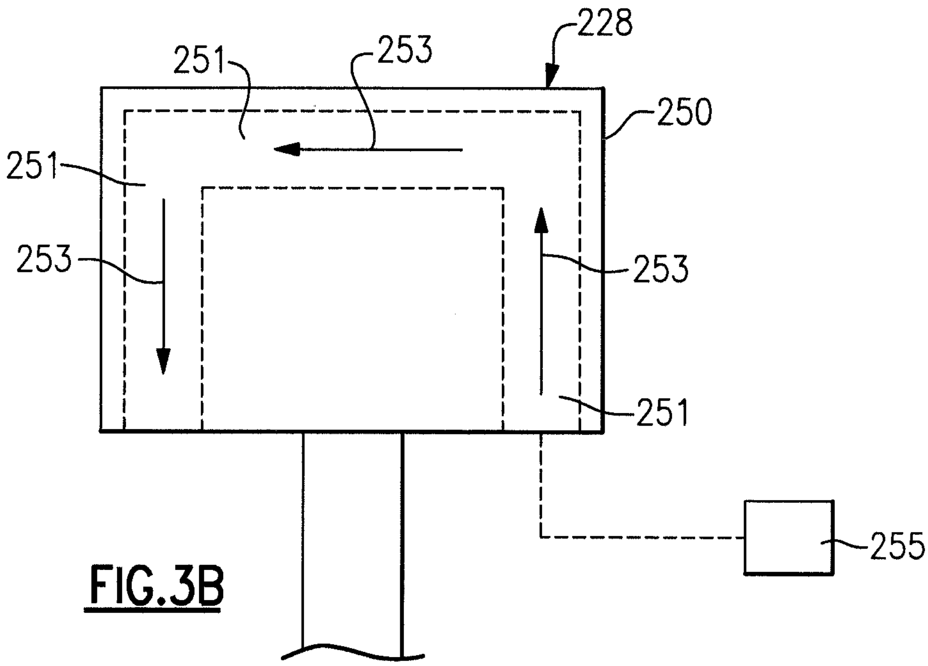
228
251
253
250
251
253
253
251
255

FIG.3B

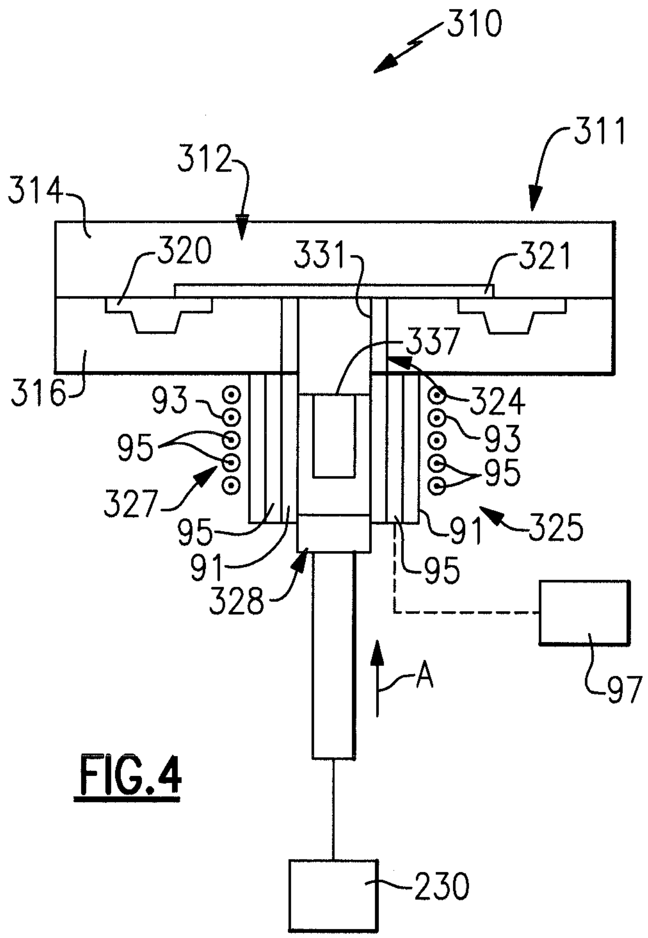
310
311
312
314
320
331
321
337
316
93
324
95
93
95
327
95
91
325
95
91
95
328
97
A
230

FIG.4

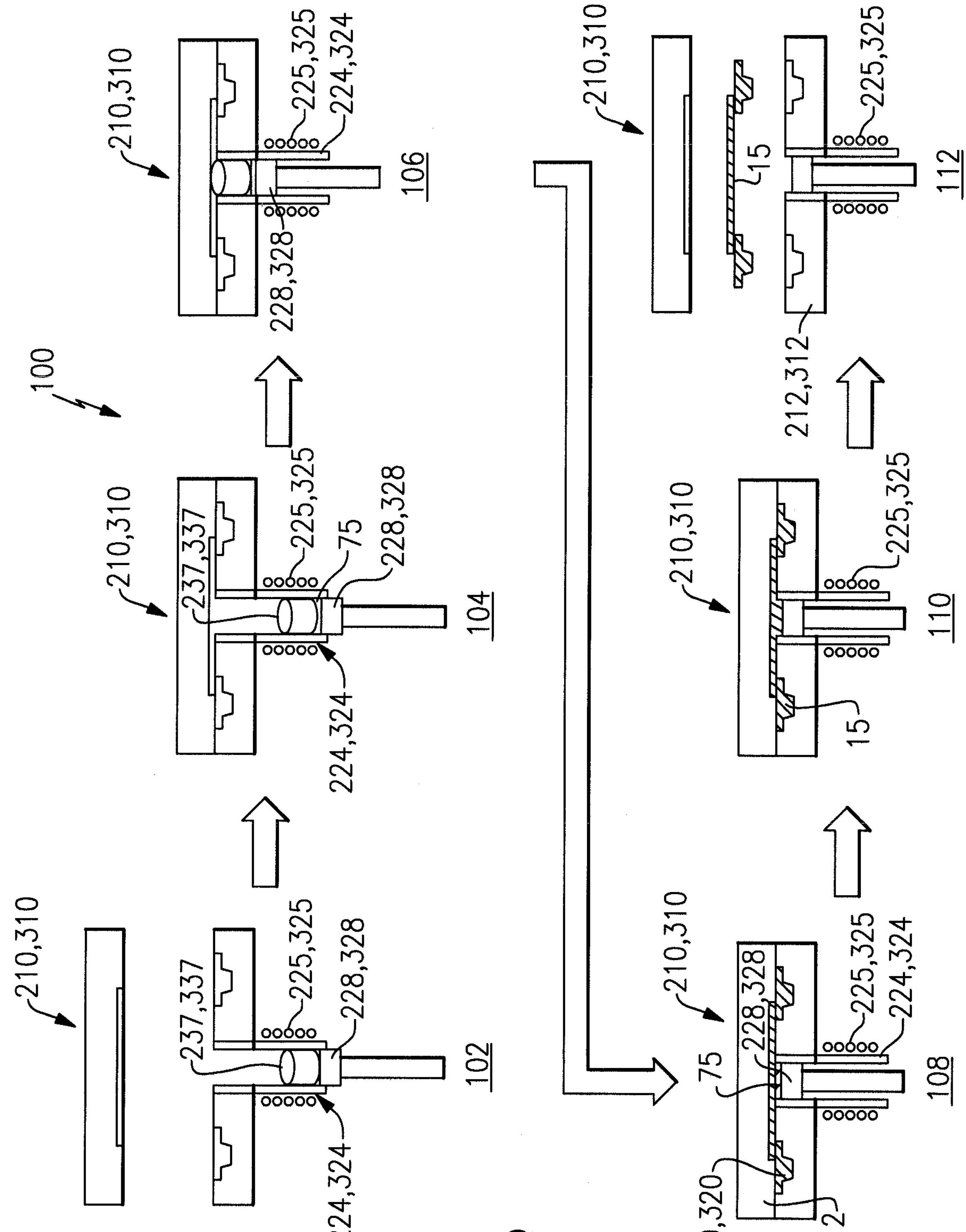
100
210,310
225,325
224,324
228,328
237,337
75
102
104
106
108
110
112
15
212,312
220,320

FIG.5

## REFERENCES CITED IN THE DESCRIPTION



### Patent documents cited in the description

- EP 0875318 A **[0004]**