Feb. 6, 1945. R. J. MILLER 2,368,719

TEMPERATURE CONTROL MOLD

Filed Dec. 17, 1942 3 Sheets-Sheet 1

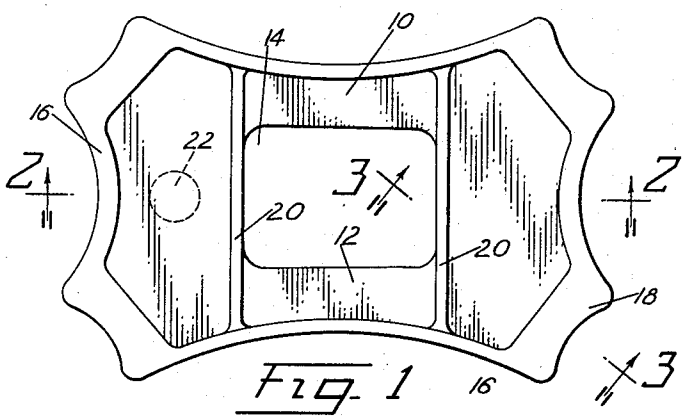

Fig. 1

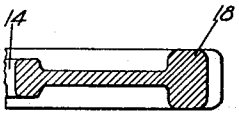

Fig. 3

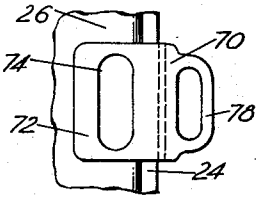

Fig. 6

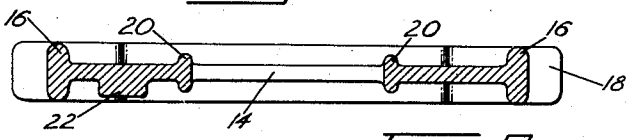

Fig. 2

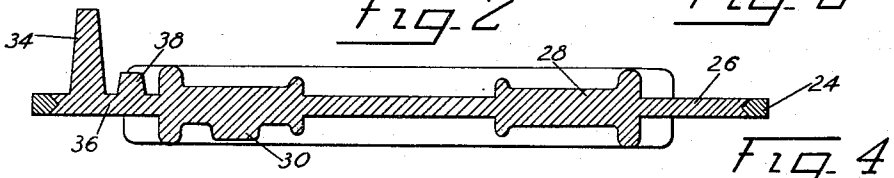

Fig. 4

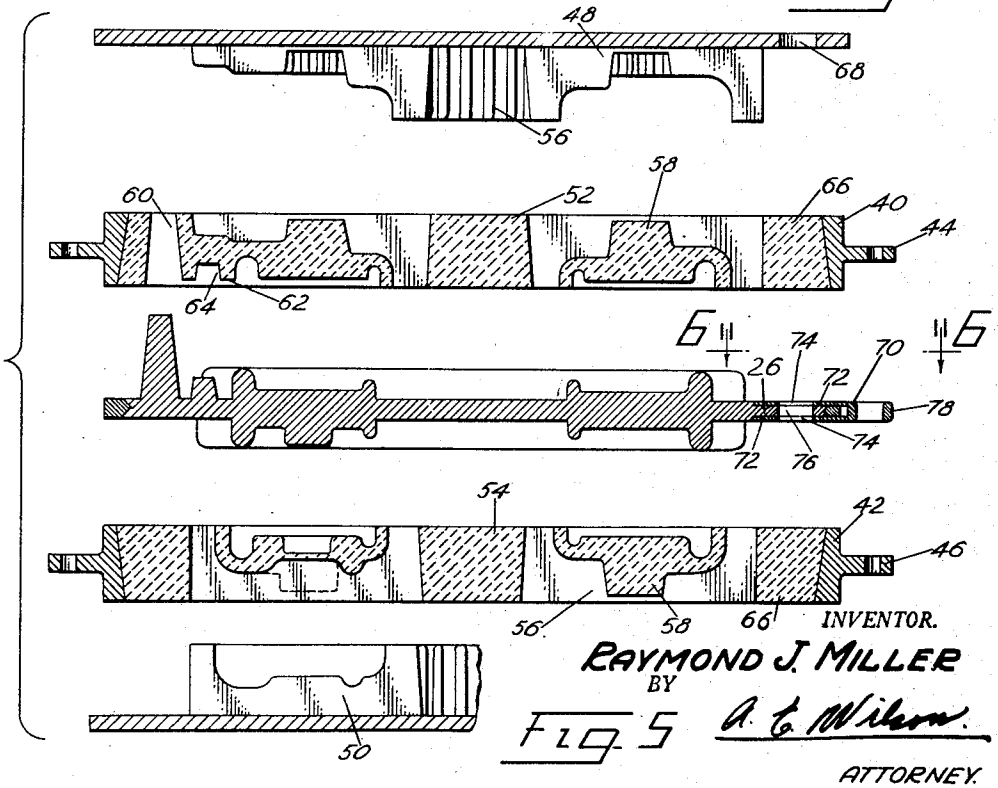

Fig. 5

INVENTOR.
RAYMOND J. MILLER
BY
A. C. Wilson
ATTORNEY.

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TEMPERATURE CONTROL MOLD

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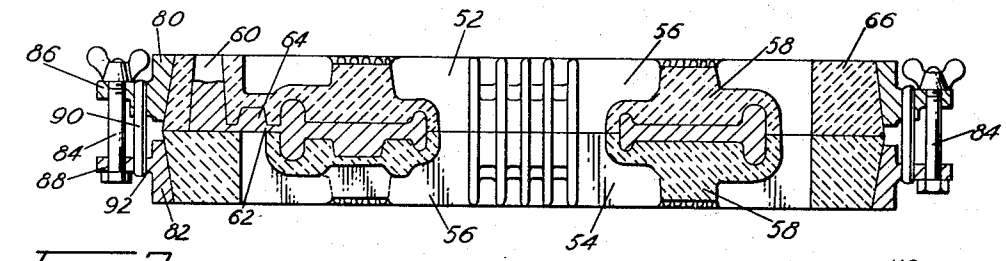

Fig. 7

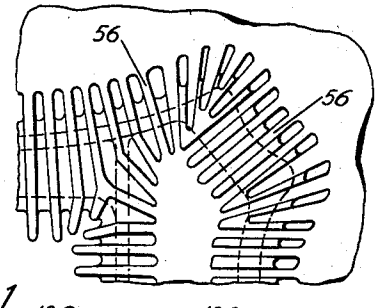

Fig. 8

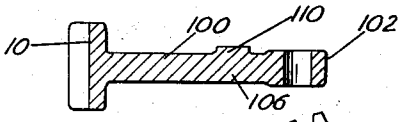

Fig. 10

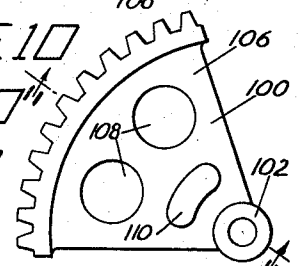

Fig. 9

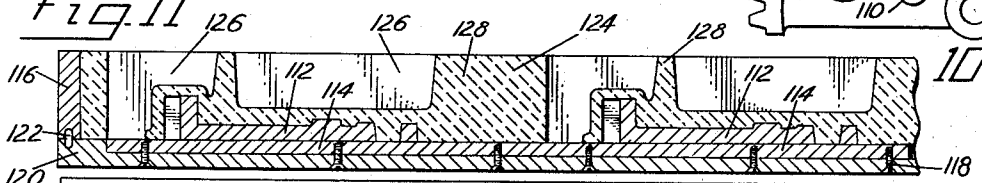

Fig. 11

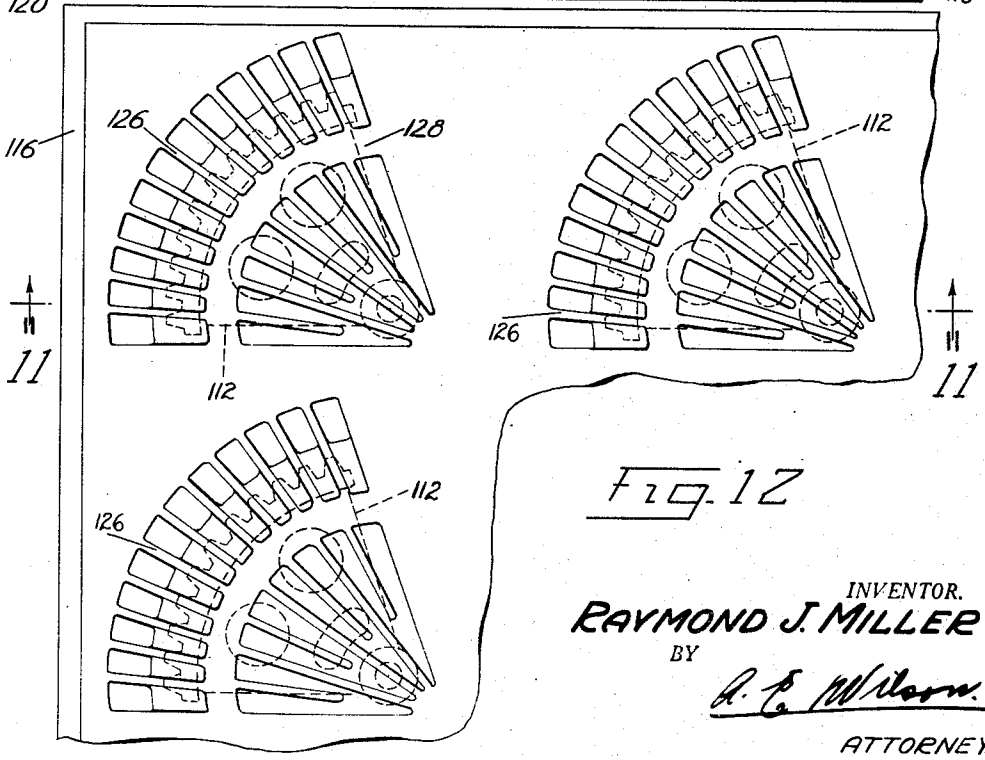

Fig. 12

INVENTOR.
RAYMOND J. MILLER
BY
R. E. Wilson
ATTORNEY.

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TEMPERATURE CONTROL MOLD

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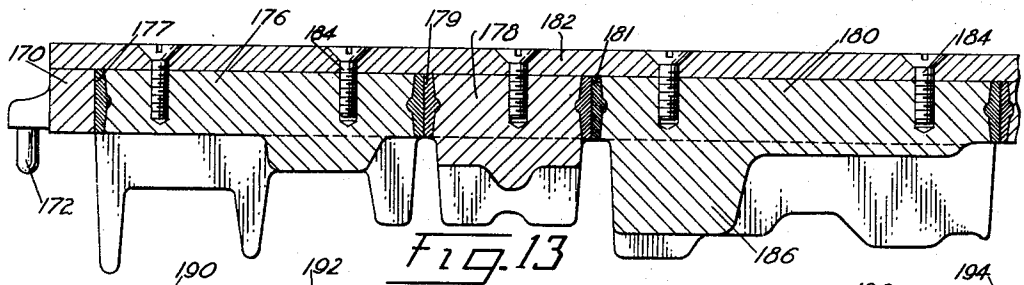

Fig. 13

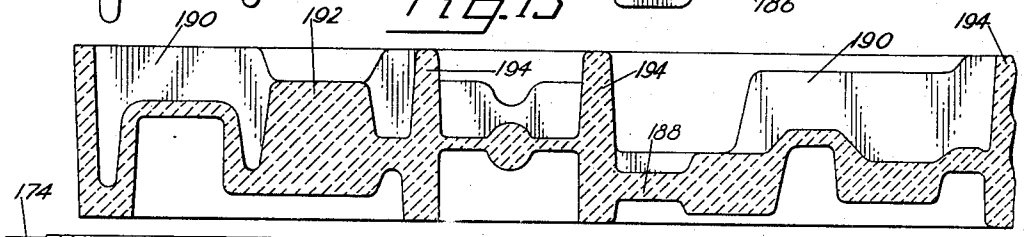

Fig. 15

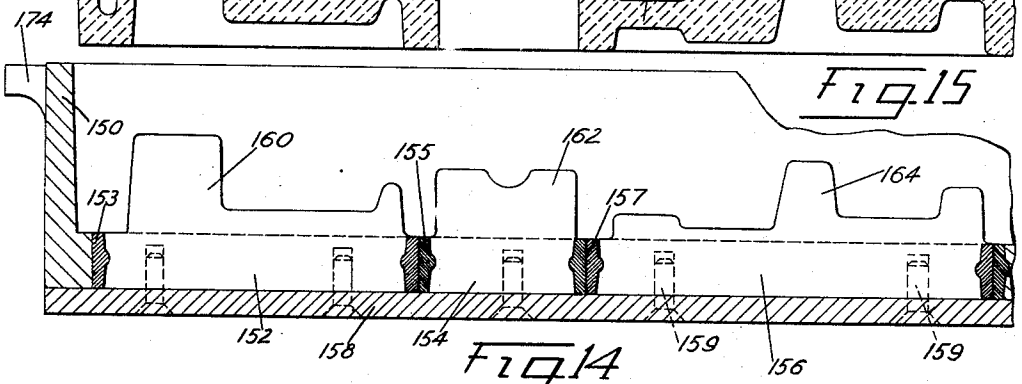

Fig. 14

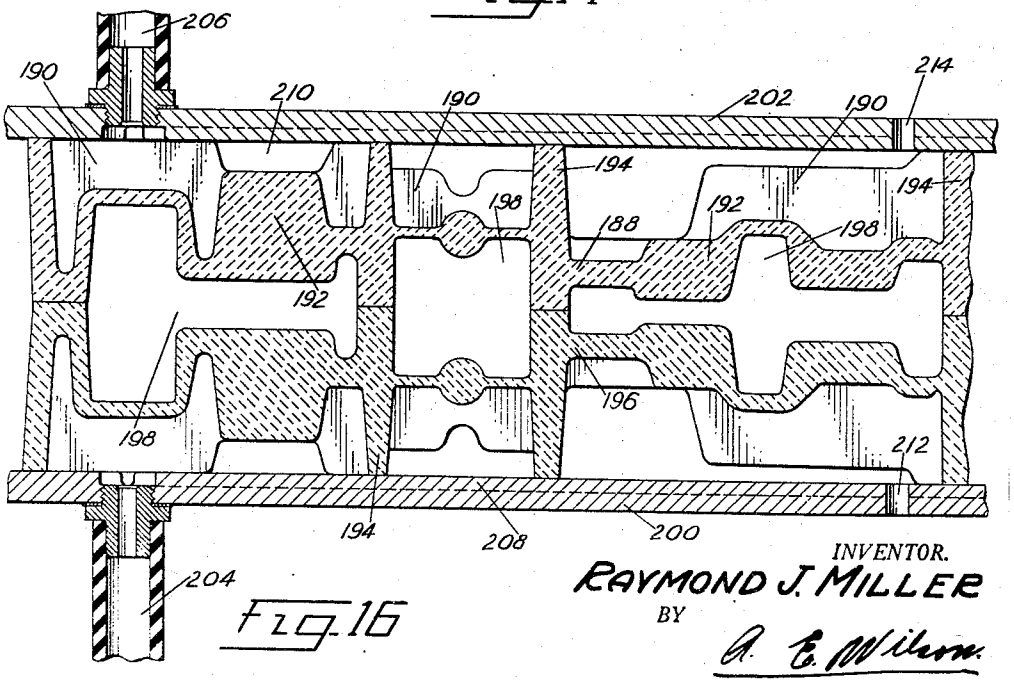

Fig. 16

INVENTOR.
RAYMOND J. MILLER
BY
A. E. Wilson
ATTORNEY.

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UNITED STATES PATENT OFFICE

2,368,719

TEMPERATURE CONTROL MOLD

Raymond J. Miller, Detroit, Mich., assignor to Miller Engineering Corporation, Detroit, Mich., a corporation of Michigan

Application December 17, 1942, Serial No. 469,307

11 Claims. (Cl. 22—113)

This invention relates to the art of casting, and more particularly to the formation of improved molds to control the dissipation of heat from molten alloy or metal to provide castings of uniform high quality free from shrinkage strains.

Molten alloy or metal is introduced into a mold, and when it solidifies a casting is produced conforming to the shape of the mold cavity. Solidification of molten alloy or metal is accompanied by shrinkage or a reduction in volume due to a contraction of the space between the molecules of the molten substance upon passing from the liquid to the solid state.

The period of time required for molten alloy or metal to solidify depends upon the rate of heat transfer, and the rate of heat transfer is dependent on the ratio of the area of the cooling surface of the mold and the volume of the casting. In the formation of castings having sections of varying contour, the light or thin sections have a greater ratio of surface area to volume in contact with the mold cavity than do heavier or thicker sections. Other factors being equal the light or thin sections cool more rapidly than do heavier or thicker sections, and the light sections will solidify while the heavier sections are still molten.

In the formation of castings a shrinkage compensating supply of molten alloy or metal is provided at the feeder. In castings having light or thin sections lying between heavier or thicker sections and the feeder, the light sections will solidify and form points of anchorage while the heavier sections remain molten. When the heavier or thicker sections solidify accompanied by shrinkage, they tend to draw alloy or metal from the already solidified thin or light sections. Shrinkage strains of considerable magnitude are thereupon introduced in the casting because of the isolation of the heavier or thicker sections from the shrinkage compensating supply of molten alloy or metal at the feeder to maintain the mold cavity completely filled.

It frequently happens that the supply of shrinkage compensating molten alloy or metal at the feeder will jell or solidify and form a point of anchorage while the alloy or metal in the mold cavity is still molten in form. When this happens shrinkage strains are introduced into the casting when the alloy or metal in the mold cavity solidifies.

The introduction of shrinkage strains in castings can be eliminated if the cooling of the molten alloy or metal can be controlled to such an extent that solidification takes place progressively from points remote from the feeder toward the feeder, and the supply of shrinkage compensating alloy or metal at the feeder be maintained in the molten state until the casting has solidified.

To accomplish this desirable method of controlling the cooling of castings, it is necessary that the rate of heat dissipation be accelerated from the heavier or thicker sections of the casting, and that the rate of heat transfer from the feeder and the light or thin sections lying between the feeder and heavier sections of the casting be retarded to maintain these light sections and the feeding in the molten state until the heavier sections have solidified.

The mold may be formed of many different types of materials, since all that is necessary is that the mold-forming substance be capable of conforming to and maintaining the shape of a pattern of the article to be formed to provide the mold cavity. Where the mold-forming substance is homogeneous throughout, the rate of heat dissipation by radiation from a mold varies almost in direct proportion to the external surface area of the mold to the unit volume of the casting to be formed, and the cooling effect of the mass of the mold by conduction is substantially in inverse proportion to the volume of the mold cavity at any point.

No readily usable means has heretofore been available to vary the rate of heat transfer from various portions of a casting to provide substantially uniform or progressive cooling of a casting. Difficulties have therefore been experienced in the casting of articles having sections of widely varying contour, since shrinkage stresses of considerable magnitude are developed and inferior castings result.

In the Capaco process of molding as disclosed in Patent No. 2,201,037, issued May 14, 1940, plaster is used as the mold-forming substance. The plaster is subjected to a drying operation whereby virtually all the moisture is dispelled. The resulting mold has a very smooth glass-like internal surface, and fine-grained homogeneous castings having smooth external surfaces are formed. These castings may generally be used without any machining work, since it is possible to hold them to very close tolerances. Until now it has been impossible to use this method of molding anything except relatively small articles where shrinkage strains caused by wide variation in sections would not be objectionable.

My copending applications, Serial No. 455,862,

filed August 24, 1942, and Serial No. 458,265, filed September 14, 1942, disclose methods of forming temperature control molds to provide progressive or substantially uniform cooling of castings having sections of varying contour. The flasks employed in the formation of the temperature control molds disclosed in said applications are more or less specialized in that a flask is selected to conform generally with the shape and contour of each article to be formed, and the temperature control mold is formed between a pattern of the article and a mold former associated with the flask.

This invention is directed to an improved method of forming temperature control molds from standard pattern and flask equipment. Where the article to be formed is of such size that more than a single pattern may be positioned in a standard flask, a plurality of casting cavities surrounded by suitable temperature control mold members may be formed in a single flask.

In the Capaco process of molding, a plurality of different patterns of varying size may be formed on a plurality of blocks of graduated sizes positioned in a single flask to form a die pattern. Molds having a plurality of casting cavities are formed from the die pattern by applying a gypsum compound to the die pattern. No provision has heretofore been made for controlling the rate of heat dissipation from molds formed from die patterns. This invention includes the formation of temperature control molds formed from die patterns to insure progressive solidification of each of a plurality of separate castings in molds formed from die patterns.

An object of this invention resides in the formation of temperature control molds in standard flasks to insure progressive solidification of castings formed in such molds.

Another object is to provide a temperature control mold having a plurality of casting cavities formed between pattern and mold contour-forming members associated with a flask of standard size.

A further object resides in the formation of temperature control molds formed from standard die patterns to provide progressive cooling toward the point of feed of each of a plurality of castings in die pattern-formed molds.

Yet another object of this invention is to provide an improved method of forming, in standard flasks, temperature-control molds having one or more mold cavities wherein the external surface area of the mold-forming substance is substantially proportionate to the volume of mold cavities throughout.

Another object resides in the development of a simplified method of forming temperature control molds in standard flasks whereby the heat transfer from one or more castings formed in the mold may be controlled to provide substantially progressive cooling towards the point of feed over the entire area of one or more castings being formed.

Still a further object of this invention is to provide a simplified method of controlling the rate of heat transfer from castings in mold cavities formed in standard flasks by contouring the body of the mold-forming substance to accelerate the rate of heat transfer from heavy or thick sections and to retard the transfer of heat from lighter or thinner sections of the castings to provide substantially uniform or progressive solidification of one or more castings formed in a single mold.

Another object is to provide plaster temperature control molds in standard flasks and having one or more similar or dissimilar mold cavities wherein the mold-forming substance has substantially constant volume throughout to permit moisture to escape uniformly over the entire mold surface to insure substantially uniform drying of the mold.

Yet a further object of this invention resides in the formation of plaster temperature control molds between standard die patterns and a mold contour former superimposed on the die pattern to provide a temperature control mold having a progressively decreasing ratio of external surface area to volume of mold cavity toward the point of feed of each casting cavity to form castings of uniform homogeneous structure free from shrinkage strains.

Still another object is to provide a simplified method of using standard pattern and flask equipment in conjunction with cooperating mold-forming members to provide temperature control molds having one or more casting cavities surrounded by mold-forming substance adapted to provide progressive cooling of the casting toward the point of feed either by radiation or conduction or the combination of radiation and conduction to provide castings having sections of varying cross-sectional area free from shrinkage strains.

Other objects and advantages of this invention will be apparent from the following detailed description considered in connection with the accompanying drawings, submitted for purposes of illustration only, and not intended to define the scope of the invention, reference being had for that purpose to the subjoined claims.

In the drawings wherein similar reference characters refer to similar parts throughout the several views:

Fig. 1 is a plan view of a unitary pattern of any article having sections of varying cross-sectional area to be formed by a casting operation.

Fig. 2 is a longitudinal sectional view taken substantially on the line 2—2 of Fig. 1 looking in the direction of the arrows.

Fig. 3 is a sectional view taken substantially on the line 3—3 of Fig. 1 looking in the direction of the arrows.

Fig. 4 is a longitudinal sectional view of a matched plate pattern formed from the pattern illustrated in Figs. 1 to 3 and having a frame shaped to fit a standard flask.

Fig. 5 is an exploded view of the matched plate pattern and the cope and drag temperature control molds formed in standard flasks between opposite sides of the pattern and the upper and lower temperature control mold-forming members.

Fig. 6 is a fragmentary plan view taken substantially on the line 6—6 of Fig. 5, looking in the direction of the arrows.

Fig. 7 is a longitudinal sectional view of the temperature control mold members illustrated in Fig. 5 being used to form a casting conforming to the shape and contour of the pattern illustrated in Figs. 1 and 3.

Fig. 8 is a fragmentary plan view of one of the temperature control molds illustrated in Figs. 6 and 7.

Fig. 9 is a plan view of a unitary pattern of a gear segment of such size that a mold having a plurality of casting cavities of the gear segment may be formed in a standard flask.

Fig. 10 is a sectional view taken substantially on the line 10—10 of Fig. 9 looking in the direction of the arrows.

Fig. 11 is a sectional view taken substantially on the line 11—11 of Fig. 12 looking in the direction of the arrows and showing the formation of a temperature control mold in a standard flask between a plurality of production pattern segments formed from the unitary pattern illustrated in Figs. 9 and 10, and a contour former to provide the mold with external surface area proportionate to the area of the mold cavities throughout.

Fig. 12 is a fragmentary plan view of the temperature control mold illustrated in Fig. 11.

Fig. 13 is a longitudinal sectional view of a temperature control mold former for a die pattern assembly.

Fig. 14 is a longitudinal sectional view of a die pattern.

Fig. 15 is a longitudinal sectional view of a mold formed from the temperature control former of Fig. 13 and the die pattern of Fig. 14.

Fig. 16 is a sectional view of assembled cope and drag temperature control molds assembled preparatory to forming castings.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Figs. 1 to 3 illustrate a unitary master pattern 10 of an elongated article having a thin, contoured, generally rectangular, flat plate 12 provided with an elongated aperture 14. The periphery of the plate 12 is provided with upwardly- and downwardly-extended flanges 16, and the corners of the article 10 are angularly disposed and provided with widened flanges 18. A pair of rigidifying flanges 20 extend across the flat plate 12 on opposite sides of the aperture 14 as illustrated. A downwardly-directed boss 22 projects from the lower surface of the plate 12 between the aperture 14 and one of the end flanges 16.

Production pattern equipment may be formed from the pattern 10 as disclosed in my previously issued Patent No. 2,348,086, issued May 2, 1944. The pattern 10 may be embedded in any suitable parting material such as molding clay, plaster, etc., up to its median plane. A female impression of the exposed portions of the pattern and the parting material may be formed in any suitable moldable substance such as alloys of the tin-bismuth-antimony base, such for example as an alloy consisting of 42% tin and 58% bismuth, possessing the characteristic of flowing and solidifying with negligible change of volume, or plaster. The assembly may then be inverted, the parting material removed, and a female impression formed of the portion of the pattern initially covered by the parting material, and the exposed surface of the first female impression.

These complementary female impressions may be separated, the pattern removed, and the impressions used in the formation of production patterns. The patterns formed from the female impressions may be either of the plate type wherein separated complementary pattern segments are carried by separate plates, or of the matched plate type wherein the complementary pattern segments are disposed on opposite sides of a single plate.

Where matched plate patterns are to be formed, the female impressions may be mounted on opposite sides of a pattern frame 24 illustrated in Fig. 4 and a pattern plate 26 having the complementary cope and drag pattern segments 28 and 30 respectively on opposite sides of the plate and suitable feeder, gate and riser chamber-forming members 34, 36, and 38 respectively, formed by a casting operation as more clearly illustrated in my copending application Serial No. 465,234, filed November 11, 1942.

The production pattern may be formed of any suitable moldable substance, such for example as white metal, an alloy of aluminum, the cerro alloys such as cerrobase, etc. If the substance of which the pattern is formed does not possess the characteristic of substantially constant volume upon solidification, suitable allowance should be made to compensate for the variation in volume.

In the formation of a temperature control mold, standard cope and drag flasks 40 and 42 having clamping brackets 44 and 46 respectively are positioned on opposite sides of the matched pattern plate 26 and are aligned therewith by suitable locator means. Temperature control mold-forming members 48 and 50 shaped to fit standard flasks are provided to shape the external surfaces of cope and drag temperature control molds 52 and 54 respectively formed between the cope and drag pattern members 28 and 30 and the cope and drag mold-forming members 48 and 50. The mold-forming members 48 and 50 have female impressions proportioned with reference to the volume of the mold cavity to provide the molds 52 and 54 with a progressively decreasing ratio of external surface area to the volume of the mold cavity toward the point of feed.

The temperature control molds 52 and 54 have fins 56 positioned adjacent and extending around the heavier or thicker sections such as the flanges 16, 18, and 20 to increase the external surface area of the mold adjacent these portions of the mold cavity to increase the heat-radiating capacity and accelerate the solidification of heavy or thick sections of the casting.

The molds 52 and 54 have thickened sections 58 adjacent light or thin sections of the mold cavity, such for example as adjacent the flat plate 12 of the pattern 10 to reduce the ratio of the external surface area to the volume of the mold cavity and retard the dissipation of heat by radiation. The increased mass of the mold-forming substance also retards the dissipation of heat because the cooling effect of the mass of the mold by conduction is substantially in inverse proportion to the volume of the mold cavity.

The temperature control molds 52 and 54 are so shaped that the cooling effect caused by radiation and conduction produces progressive solidification of the casting towards the feeder 60, controlled gate 62, and riser chamber 64 formed in the cope temperature control mold 52 by the feeder and riser-forming members 34 and 38 respectively of the pattern 26.

The light or thin sections of the casting and the supply of shrinkage compensating alloy or metal are thus maintained open until the heavier sections solidify, and progressive or substantially uniform solidification toward the point of feed occurs. The isolation of sections of molten alloy or metal from the feeder by solidified sections is thus avoided, and the introduction of shrinkage strains in the casting is prevented.

The temperature-control mold-forming members 48 and 50 have female impressions conforming with the desired external contour of the temperature control molds 52 and 54. These mold contour-forming members 48 and 50 may be made by a reproductive method from a master male model having the desired external contour of the temperature control mold in the manner set forth in my copending application Serial No. 455,862, filed August 24, 1942, and Serial No. 421,115, filed December 1, 1941.

Where the contour-forming members 48 or 50 have a plurality of symmetrical or identical sections or segments, a male pattern of only one of these alike segments or sections need be made. A female impression of this male pattern segment may be formed by a reproductive method in suitable material, such for example as one of the cerro alloys possessing the characteristic of accurately conforming to the contour of the pattern and solidifying with negligible change of volume, or plaster.

The necessary number of male impressions required to form a complete male pattern for the mold contour-forming members 48 or 50 may then be formed by a reproductive method from the single female impression. These male segments may be assembled and used in the formation of any desired number of temperature control-forming members 48 and 50 having female impressions of the desired external contour of the temperature control molds 52 and 54.

The temperature control mold-forming members 48 and 50 may be formed in any suitable moldable substance, preferably possessing the characteristic of solidifying with negligible variation in volume, such for example as the cerro alloys. Compensation may be made for change of volume in the event that the substance of which the mold-forming members 48 and 50 do not possess the characteristic of substantially constant volume upon change from liquid to the solid state.

The temperature control mold-forming members 48 and 50 may vary in shape and configuration through very wide limits. All that is necessary is that they meet with the pattern plate 26 with a sufficient degree of accuracy to confine the temperature control mold-forming substance to form the desired configuration. The outer contour of the temperature control mold serves no purpose other than to control the dissipation of heat and therefore need not be accurately formed.

After the pattern and temperature control mold-forming members have been formed they may be assembled with the flasks 40 and 42 in the relation illustrated in Fig. 5. Any suitable mold-forming substance 66, such for example as gypsum, may be introduced through an opening 68 in the cope mold-forming member 48 to fill the space between the female impression of the temperature control mold-forming member 48 and the surface of the pattern plate 26 and cope pattern members 28 to form the cope temperature control mold 52.

A drag mold-feeding member 70 associated with the pattern plate 26 and interposed between the cope and drag flasks 40 and 42 permits the mold-forming substance 66 to flow into the space between the drag mold-forming member 50 and the lower surface of the pattern plate 26 and the drag pattern 30 to form the drag temperature-control mold 54.

The feeding member 70 comprises a pair of flat sheets 72 positioned to lie on opposite sides of the pattern plate 26. If desired, a plurality of feeder members 70 positioned at spaced intervals may be employed. The sheets have apertures 74 adapted to align with an aperture 76 through the plate 26. After the mold-forming substance 66 has been introduced to form the cope and drag mold-forming members 52 and 54, and has attained a predetermined set such that the molds may be separated from the pattern and former members, a handle 78 is actuated to move the sheets 72 across the aperture 76 in the pattern plate 26 to cut the mold-forming substance 66 between the cope and drag molds 52 and 54.

Where plaster or gypsum or other low heat conducting material is used as the mold-forming substance 66, suitable strengthening and rigidifying ingredients such for example as asbestos fiber may be added to provide desirable physical properties. The substance 66 is preferably applied in a semiliquid or plastic state, and if desired may have somewhat of an excess of moisture. When the temperature control molds 52 and 54 have attained a predetermined set they may be separated from the pattern and cope and drag mold-forming members and subjected to a drying or curing operation to dispel moisture therefrom.

If desired the temperature-control molds 52 and 54 may be removed from the flakes 40 and 42 either before, during, or after being subjected to the drying or curing operation. The treated molds 52 and 54 may be positioned in cope and drag clamping flasks 80 and 82 assembled in the manner illustrated in Fig. 7 and used in the formation of castings.

It will be noted that the flasks 80 and 82 do not meet at the parting line between the cope and drag molds 52 and 54, but rather engage the tapered edges of the molds at points spaced from the median plane of the molds. Clamping pressure may therefore be exerted through clamping bolts 84 engaging brackets 86 and 88 of the cope and drag flasks 80 and 82 to hold the molds together during the pouring of the molten alloy or metal into the molds to form a casting. Guide pins 90 carried by the cope flask 80 may be provided to engage apertures 92 associated with the drag flask 82 to maintain alignment.

When the temperature-control molds have been formed and assembled in the manner illustrated in Fig. 7, molten alloy or metal may be introduced through the feeder 60 to fill the casting cavity. The temperature control molds dissipate heat at varying rates of rapidity from sections of varying contour of the casting to induce progressive solidification of the molten alloy or metal toward the feeder 60 to form a homogeneous casting free from shrinkage strains.

The embodiment of the invention illustrated in Figs. 9 to 12 is an adaptation of the invention to the formation of a plurality of castings in a single standard flask. This embodiment of the invention is illustrated as applied to the formation of temperature-control molds for forming a segmental gear 100 having a hub 102 connected to a gear segment 104 by a web 106. The web 106 is of considerably less cross-sectional area than the hub 102 and the geared segment 104 and is provided with a plurality of apertures 108 and a boss 110 of thickened cross section.

Production pattern equipment of the so-called plate type may be formed from the unitary master pattern in the manner disclosed above and in my copending application Serial No. 421,115, filed December 1, 1941.

The pattern segments 112 may be carried by plates 114 of suitable size and shape that a plu-

rality of pattern plates 114 may be positioned in a standard plate flask 116 and attached thereto by means of screws 118. The flask 116 preferably has a removable base plate 120 adapted to be aligned with the flask 116 by means of suitable dowel locators 122.

A temperature-control mold-forming member is shaped to fit the standard flask 116 and is provided for each of the cope and drag pattern and flask members to provide a cope and drag temperature-control mold 124 having heat-radiating fins 126 positioned to overlie the heavier or thicker sections of the mold cavity to accelerate the dissipation of heat from these sections. The mold-forming member has female surfaces shaped to cooperate with the pattern segments 112 to provide thickened mold sections 128 adjacent sections of light or thin section to retard the dissipation of heat from these sections of the casting as discussed above.

After the pattern and mold-forming members have been formed, they may be assembled, and the moldable substance introduced into the space between the former and pattern to provide the temperature control molds. Suitable locator means may be provided to align the cope and drag molds relative to each other preparatory to introducing the molten alloy or metal to form the casting.

It will be apparent that dissimilar pattern members carried by the pattern plates 114 of standard size may be provided in the flask 116 of standard size. A plurality of castings of such a size that a plurality of them may be formed in a single flask may thus be formed in temperature-control molds formed in a single standard size flask to provide homogeneous castings free from shrinkage strains.

Figs. 13 to 16 show the adaptation of this invention as applied to the formation of temperature-control molds from die patterns for use in the Capaco process of plaster molding.

Fig. 14 illustrates a die pattern formed of a standard flask 150 having a plurality of pattern-carrying blocks 152, 154, and 156 carried by frames 153, 155, and 157 respectively of accurate external dimensions secured to the base 158 by suitable screws 159. The space within the flask 150 may be filled with a plurality of pattern-carrying blocks of the same or different size. The size of the blocks may be graduated in multiples of a standard dimension so that the space within the flask 150 can be used to the greatest advantage.

The pattern-carrying blocks are formed to accurate external dimensions in three planes to insure proper alignment of the casting cavities formed in the cope and drag molds by the cope and drag pattern members. A pattern-carrying block may thus be selected to accommodate any size pattern member. The patterns 160, 162, and 164 may, for example, be carried by the blocks 152, 154, and 156 respectively. The pattern and pattern-carrying blocks of accurate external dimensions in three dimensions may be readily formed in the manner set forth in my copending application Serial No. 454,831, filed August 14, 1942.

A temperature-control mold-forming member 170 of the same external dimensions as the standard flask 150 may be superimposed on the flask 150 and accurately aligned therewith by suitable locator means 172 and 174 carried by the mold-forming member 170 and flask 150 respectively.

The space within the confines of the mold-forming member 170 may be divided to receive a plurality of blocks of graduated size corresponding with the sizes of the pattern-carrying blocks positioned in the flask 150. For example, blocks 176, 178, and 180 carried by frames 177, 179, and 181 respectively of accurate external dimensions corresponding in size with the frames of the blocks 152, 154, and 156 may be suitably attached to the plate 182 of the mold-forming member 170 by screws 184.

The blocks 176, 178, and 180 of the temperature control mold may be provided with depending impressions 186 to cooperate with the exposed surfaces of the patterns 160, 162, and 164 respectively, to provide therebetween a temperature control mold-forming cavity having external surface area and mass proportioned with reference to the casting cavity to provide substantially progressive cooling toward the point of feed of the molten alloy or metal introduced into the casting cavity formed by the pattern impressions 160, 162, and 164.

The assembled temperature control mold-forming member 170 is superimposed on the standard sized flask 150 of the die pattern assembly and is aligned therewith by means of the locator members 172 and 174. Any suitable mold-forming substance preferably of the low heat conducting type such for example as plaster is introduced into the flask 150 to fill the space between the blocks 176, 178, and 180 of the former 170 and the pattern impressions carried by the pattern blocks 152, 154, and 156 to form the temperature control mold 188.

It will be noted that the impressions 186 carried by the mold former 170 are shaped with reference to the pattern impressions to provide fins 190 on the temperature control mold 188 to accelerate the dissipation of heat from heavy sections of the casting cavities formed in the mold 188 by the pattern impressions 160, 162, and 164. The impressions 186 of the mold former 170 are also spaced with reference to the pattern impressions to provide mold-thickened sections 192 positioned to overlie lighter or thinner sections of the casting cavities to retard the dissipation of heat by radiation from light sections of the casting to be formed, and to reduce the cooling effect caused by conduction by proportionately increasing the mass of the mold-forming substance.

The impressions 186 of the mold-forming blocks 176, 178, and 180 are preferably shaped with reference to the pattern impressions 160, 162, and 164 that upstanding walls 194 are formed along the marginal edges of the pattern blocks 152, 154, and 156. The upstanding walls 194 may be engaged to hold cope and drag temperature control molds together at the time molten alloy or metal is introduced into the casting cavities to form castings.

It will be understood that suitable feeder passageways extend along the die pattern to connect with each mold cavity to permit the introduction of molten alloy or metal into the casting cavities. These feeder passageways may be formed in the mold by suitable feeder runners positioned on the die pattern at the time the mold-forming substance is introduced to form the mold.

The temperature control mold-forming members carried by the blocks 176, 178, and 180 may be formed by a reproductive method of any suitable material, such for example as the cerro alloys, on frames of accurate external dimensions

as set out in my copending application Serial No. 454,831, filed August 14, 1942.

When it is desired to change a pattern to form castings conforming to a different pattern, all that is necessary is to remove the pattern from the die pattern and the mold-forming member from the mold former, and replace them with pattern and mold-forming members of the new article to be cast. Great flexibility in the use of this equipment is thus insured to form variously-shaped articles efficiently and economically with no waste of space in the improved temperature control molds.

After the mold-forming substance has attained a predetermined set, the temperature control mold 188 may be removed from the mold former and die pattern members and subjected to a treating process such as a drying operation to prepare it to receive the molten alloy or metal to form castings.

After the formation of cope and drag temperature control molds 188 and 196 respectively, they may be assembled as illustrated in Fig. 16 to provide casting cavities 198.

The drag mold 196 may be positioned on a plate 200, and a plate 202 may be positioned on the cope mold 188. Suitable locator means may be employed to accurately locate the cope and drag molds 188 and 196 respectively to prevent misalignment of the casting cavities 198. Clamps may be provided to engage the plates 200 and 202 or a weight or other suitable pressure-applying means may be employed to prevent separation of the cope and drag molds when molten alloy or metal is introduced into the casting cavities to form castings.

If desired, directed air currents may be employed to facilitate cooling of all the temperature control molds disclosed herein to accelerate solidification of the molten alloy or metal. The temperature of the air may be controlled, and it may be directed over a portion only of a mold if desired to provide the progressive solidification of the castings. It will be apparent that the heat-dissipating characteristics of the entire temperature control mold may be substantially uniform throughout and that currents of air or other cooling fluid preferably controlled as to temperature may be directed over the mold towards the point of feed and the shrinkage compensating supply of molten alloy or metal to provide the desired progressive solidification of the castings.

Air or other fluid may be introduced into the space between the temperature control molds, and the plates 200 and 202 through suitable air inlet conduits 204 and 206 projecting through the plates 200 and 202 respectively. The inner surfaces of the plates 200 and 202 may be corrugated as illustrated at 208 and 210 respectively to permit the cooling medium to flow over the upstanding walls 194 to carry heat away from the temperature control mold associated with each casting cavity. The cooling fluid may be dispelled through outlets 212 and 214 extending through the plates 200 and 202 respectively preferably positioned at the opposite end of the molds, but illustrated as at the end of the third mold cavity.

I claim:

1. The method of forming cope and drag temperature control molds from a matched plate pattern and mold-forming members comprising interposing standard flasks between the matched plate pattern and mold-forming members, the mold-forming members being shaped with reference to pattern impressions carried by the matched plate pattern to provide a temperature control mold having progressively decreasing heat dissipating characteristics toward a feeder, introducing a mold-forming substance into the space between the cope mold-forming member and the cope pattern, the matched plate pattern having a controlled aperture to permit the mold-forming substance to be introduced into the space between the drag mold former and the drag pattern, severing the mold-forming substance at the controlled aperture in the matched plate pattern to separate the cope and drag temperature control molds, and separating the temperature control molds from the pattern and mold-forming members.

2. The method of forming cope and drag molds from a matched plate pattern having cope and drag pattern impressions and a controlled aperture extending through the pattern plate outside of the pattern impressions, assembling the matched plate pattern with cope and drag flasks, introducing mold-forming substance into the cope flask to fill the cope and drag flasks, severing the mold-forming substance at the controlled aperture in the pattern plate, and separating the cope and drag molds from the matched plate pattern.

3. A matched plate pattern having cope and drag pattern impressions, and a controlled aperture extending through the pattern plate outside of the pattern impressions comprising cutting means adjacent the aperture and aligned with the cope and drag surfaces of the pattern plate.

4. The method of forming non-permanent temperature control molds comprising superimposing a mold former on a die pattern including a flask having a plurality of removable pattern-carrying blocks of graduated sizes the mold former comprising a plate having a plurality of removable mold-forming members each shaped with reference to the pattern impression carried by its associated pattern-carrying block to provide a mold having heat dissipating characteristics substantially proportionate to the volume of the pattern impression throughout, and introducing a mold-forming substance of low heat conducting characteristics into the space between the pattern-carrying blocks and the mold-forming members.

5. A temperature control mold former comprising a die pattern including a flask having a plurality of removable pattern-carrying blocks, and a closure for the flask having a plurality of removable mold-forming members each shaped with reference to the pattern impression carried by its associated pattern block to provide a non-permanent mold formed of low heat conducting material having heat-dissipating characteristics substantially proportionate to the volume of the pattern impression throughout.

6. The method of forming non-permanent temperature control molds of low heat conducting material in standard flasks between pattern and mold-forming members to provide cope and drag molds having bevelled side walls and heat dissipating characteristics substantially proportionate to the mold cavity throughout, separating molds from the pattern and mold forming members, drying the molds, clamping cope and drag dried molds in casting flasks having guiding means and reversely bevelled side walls to engage the bevelled side walls of the molds to hold the molds in assembled relation, and introducing molten alloy

or metal into mold cavities to form substantially homogeneous castings.

7. A non-permanent temperature control mold formed of low heat conducting material comprising cope and drag sections formed in die patterns having a flask and a plurality of replaceable pattern carrying blocks of predetermined graduated sizes to provide a mold having a plurality of casting cavities each having sections of varying cross-sectional area and a single feeder for the introduction of molten alloy or metal into the casting cavities, the mold having progressively decreasing heat dissipating characteristics toward the feeder to insure progressive solidification of molten alloy or metal in each casting cavity toward the feeder to provide substantially homogeneous castings.

8. The method of casting comprising forming non-permanent cope and drag temperature control molds of low heat conducting material in die patterns including a flask and a plurality of replaceable pattern carrying blocks of predetermined graduated sizes and having a feeder and a plurality of casting cavities of varying cross-sectional area, the mold being of substantially uniform thickness between casting cavities and contoured adjacent casting cavities to provide heat dissipating characteristics substantially proportionate to the casting cavities throughout, assembling cope and drag temperature control molds between corrugated plates, introducing molten alloy or metal into the casting cavities, and directing cooling fluid through the corrugations of the plate towards the feeder to progressively cool the molds towards the feeder to provide substantially homogeneous castings.

9. The method of forming cope and drag molds from a matched plate pattern having cope and drag pattern impressions and a controlled aperture extending through the pattern plate outside of the pattern impressions, assembling the matched plate pattern with cope and drag flasks, introducing mold-forming substance into one of said flasks to fill the cope and drag flask, and separating the cope and drag molds from the pattern.

10. A temperature control mold former for a die pattern including a flask having a plurality of removable pattern carrying blocks of graduated sizes comprising a closure for the flask having a plurality of removable mold contouring members of similar graduated sizes, each of the mold contouring members being proportioned with respect to the pattern impression carried by its associated pattern carrying block to provide a non-permanent mold formed of low heat conducting material wherein the mass of the mold forming substance varies substantially in inverse proportion to the cross-sectional area of the pattern impression throughout.

11. A temperature control mold former for a die pattern including a flask having a plurality of removable pattern carrying blocks of graduated sizes comprising a closure for the flask having a plurality of removable mold contouring members of similar graduated sizes, each of the mold contouring members being proportioned with respect to the pattern impression carried by its associated pattern carrying block to provide a non-permanent mold formed of low heat conducting material wherein the cooling effect of the mass of the mold and its external surface area are proportioned throughout with respect to the cross-sectional area of the pattern impression to permit rapid dissipation of heat from heavy sections of the casting to be formed and to retard the dissipation of heat from light sections of the casting.

RAYMOND J. MILLER.