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METHOD AND APPARATUS FOR PREDETERMINING GATE SYSTEMS

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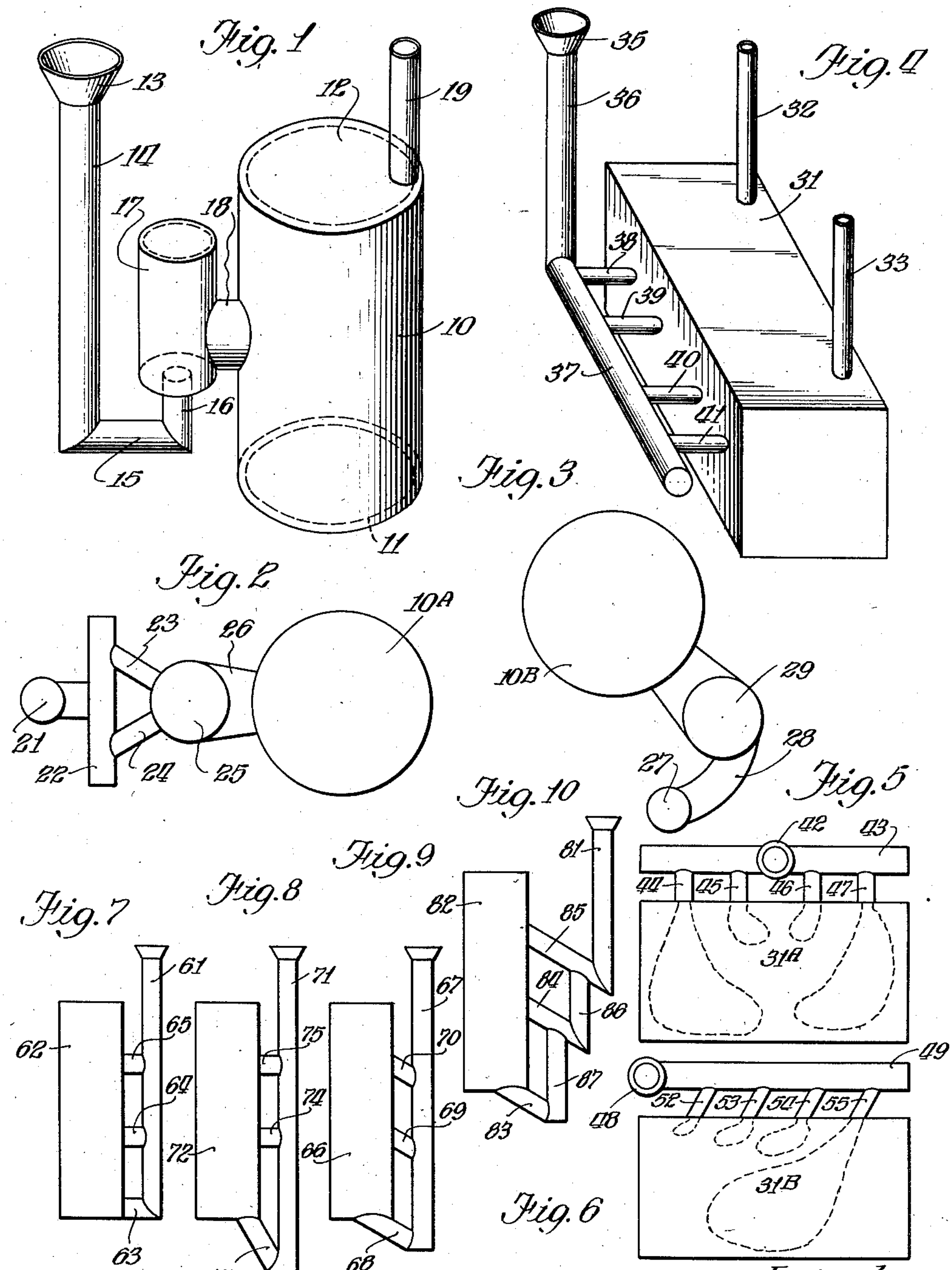

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METHOD AND APPARATUS FOR PREDETERMINING GATE SYSTEMS

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This invention relates to the production of metal castings and has specific reference to an apparatus for predetermining the most desirable system of gates and vents for pouring a casting of any known configuration, together with a method of employing the apparatus to effect a quick determination of the comparative characteristics of different gating systems.

It is the general aim of the invention to facilitate the proper design of systems of gates and vents in a mold, to improve the quality of the castings, reduce the percentage of defective castings, and increase the yield percentage. This involves control of turbulence, detection of zones unduly susceptible to erosion, adequate venting, and control of solidification and shrinkage. In pursuance of this general aim, it is a specific object of the invention to provide novel apparatus and a new method for predetermining the characteristics of flow of molten metal entering a mold through any proposed gating system, and to thereby facilitate designing the gate to a configuration of maximum efficiency.

A further object of the invention is to provide a method and means for determining and observing the characteristics of solidification, shrinkage and gas flow during the casting operation.

In introduction to this disclosure, it is believed pertinent to call attention to the fact that although metal casting is one of the oldest arts known to man, yet there has been, as a matter of fact, very little accurate knowledge heretofore known as to the characteristics of flow, solidification, shrinkage and gas formation within the interior of the molds. This situation exists, notwithstanding the long and intense activity in the art, which is actively practiced in almost every branch of industry; and the unfortunate consequence of this lack of knowledge is clearly demonstrated by the fact that although castings of almost every conceivable shape, design and size are in continuous commercial production in molds employing well-known and time-honored systems of venting and gating, yet the fact remains that a fairly large percentage of castings produced in even the most modern foundries are defective and must be discarded. Moreover, it is worthy of note that the effective yield of conventional casting practice is a compaartively low percentage. In fact, in most steel castings about 50% of the molten metal actually poured is required for the casting itself, the rest being waste solidifying in the risers, sprues, runners and vents of the mold. This is obviously disadvantageous from a cost standpoint, not only by reason of the wastage of metal in the production of the casting itself, but also because of the additional time required to clean and machine the finished product.

In short, it appears that although casting practices and techniques have been developed, recognized and extensively employed throughout long periods of years, and that seemingly logical theories of operation have been ascribed to the various conventional gating systems now generally employed, yet the fact that a significant percentage of defective pieces ordinarily always persists even in pieces cast according to techniques theoretically perfectly suited to their design leads to the belief that many of the commonly accepted theories of the functions of known types of gates and sprues are basically inaccurate and not in accord with the actual function that takes place.

In pursuance of this belief, the present disclosure proposes to provide a novel test apparatus, and to predetermine the optimum gating system for a casting of any given shape by a new method whereby the manner of functioning of any contemplated system of sprues, gates, runners and vents may be noted by actual observation rather than by theoretical deduction. This is accomplished by employing test apparatus having a plurality of different gating and venting systems which may be alternatively employed, in order that direct factual comparisons may be made between the functional characteristics of the different gating and venting systems contemplated for a casting of any specified configuration. Thus the most satisfactory expedients may be determined quickly and at minimum cost.

The objects of the present invention are accomplished by preparing one or more test units, each consisting of a substantially closed facsimile chamber, formed with its internal configuration corresponding to the shape of the casting to be made, and constructed of material which is transparent throughout, so that the flow of metal therein may be observed. This test chamber is provided with a series of proposed gate and vent systems, also of transparent material. These may be alternatively attached to a single test chamber if desired, but it is ordinarily more convenient to provide a set of identical test chambers, each provided with one proposed system of sprues, runners and vents to determine the relative advantages and shortcomings of each of several systems proposed. The functioning of the various types of gates may be visually observed by flowing molten metal into the internal cavities of the transparent test units and simultaneously observing the peculiarities of flow characteristic to each type of gate system proposed.

In determining the characteristics of flow, it is preferable to utilize a metal such as mercury which, while it possesses high specific gravity so that it "rolls" and performs in the manner characteristic of all molten metals, remains liquid at normal room temperatures and does not solidify in the cavity of the test units. The characteristics of solidification and shrinkage are more easily observed by employing a low melting point alloy such as Wood's metal, which may be introduced into the transparent test unit in a molten condition and allowed to solidify within the mold cavity, where the transparent walls permit the action of solidification to be closely observed. When either Wood's metal or mercury is employed, the flow of metal and the formation of gas pockets will give an indication of the most desirable locations for the vents, and as a further means of observing the outward flow of gas displaced from the mold with the introduction of the metal, a visible gas or smoke may be introduced into the mold prior to pouring the metal. When this is done, the movement of the gas may be visually observed as it is displaced by the incoming metal.

The precise configuration of the apparatus employed in practice in the teachings of this invention is determined in accordance with the shape and configuration of any casting for which a determination is to be made, and it will be understood that the facsimile test units as here contemplated are to be shaped and proportioned in accordance with the known dimensions of the desired casting. The drawings of the present application have been prepared, however, to give a simplified diagrammatic illustration of typical test sets prepared in the manner required for determination of optimum gating systems for simple geometrical forms such as cylindrical or rectangular shapes.

Referring now to drawings of the present specification in which typical test sets have been diagrammatically illustrated:

Figure 1 is a perspective view of a test unit designed for the study of the flow characteristics of a mold utilizing a "bottom gate underhead" as the inlet for the metal;

Figure 2 is a diagrammatic plan view of a test unit for a casting of the same shape, the test unit being provided with a metal inlet of the "fork-gate" type;

Figure 3 is a diagrammatic illustration of a cylindrical cavity as in Figures 1 and 2, wherein a metal inlet of the "90° angle whirl-gate" variety is employed;

Figure 4 is a perspective view of a test unit as would be employed to study the flow characteristics of a conventional 90° angle finger-gate employed in the production of a rectangular casting:

Figure 5 is a diagrammatic plan view of a test unit having a transparent cavity of the same shape as the unit of Figure 4, but arranged to be supplied with molten metal through a 90° angle finger-gate having its sprue located at the center of the runner rather than at the end;

Figure 6 is a diagrammatic plan view similar to Figure 5 but modified to employ fingers lying at an acute angle with respect to the runner;

Figures 7, 8, 9 and 10 are diagrammatic illustrations of four step-gates of conventional types ordinarily employed to produce a steady temperature gradient from the bottom of the casting to the top, yet accomplish this result without permitting spattering such as is characteristic with a top pouring mold.

In following the teachings of this disclosure, the first step of the procedure is to construct a facsimile test chamber of transparent material throughout. This test chamber should be shaped with its internal shape corresponding to the proportions and configurations of the casting under study. In the case of a simple geometric shape such as a cylinder, or rectangular block, this may be conveniently done by constructing the chamber of transparent plastic sheets or tubes fused or cemented together. For more complex shapes, the chamber may be cast of liquid plastic material, with a pattern employed to give the desired shape to the cavity. Satisfactory results may be obtained by utilizing glass, celluloid or similar materials for the chamber, but conveniently it is formed of one of the more recently developed transparent plastics such as acrylic resin or polystyrene. Suitable solid plastic compositions are widely distributed and sold commercially under the trade names of Plexiglas, Lucite, Tenite, etc., or liquid plastic material known in the trade as Plasticast or Castolite may be employed if the chamber is to be made by casting.

In the illustration of Figure 1, the chamber generally designated as **10** may consist of a tubular transparent sleeve having a flat transparent bottom closure **11** and a flat transparent top closure **12**. This test chamber is provided with a gate arrangement including a funnel **13** feeding through a sprue **14** having a horizontal runner **15** and upwardly extending ingate **16** terminating in a closed cylindrical riser **17**. The riser is connected to the cavity by an inlet **18** which enters the cavity of the chamber **10** at a point intermediate between the bottom **11** and top **12**. The test chamber is preferably provided with a vent tube **19** whereby air displaced by the incoming metal may be released.

In predetermining the best arrangement of gates and vents for a given geometric shape, it is contemplated that comparative tests may be made with gates of different configurations and designs, and while these tests may be conducted by alternately providing a single chamber with different gate structures, it is more conveniently accomplished by providing a plurality of identical facsimile test chambers, each having a different gate system, so that the functioning of the gate systems under contemplation may be compared by pouring the several cavities in immediate succession. Thus, for a casting of simple cylindrical shape, a typical test set may comprise a unit such as shown in Figure 1, together with units as shown in Figures 2 and 3, each having different gate systems. That is, in Figure 2 the facsimile chamber **10A** is shown as being provided with a sprue **21** terminating in a right angle runner **22** having a pair of converging fingers **23** and **24** entering a head or riser **25** connected to the cavity through an inlet **26**. Similarly, the facsimile chamber **10B** of Figure 3 is shown as provided with a sprue **27** having an ingate **28** entering the riser **29** at a 90° angle to the inlet connection from the riser to the cavity. Thus, by pouring molten metal into these identical chambers through gate systems of different design and configuration, the characteristics of flow of the metal passing through the gate systems and entering the cavity may be noted and the most desirable formation of gate determined.

It is an easy matter to note, by the turbulent condition of the moving metal, any points which would be subject to excessive erosion and to redesign the gate system to eliminate these and thus avoid the possibility of loose sand from the mold being drawn into the cavity. Similarly, any unwanted turbulence in the cavity may be noted and eliminated, or controlled turbulence may be introduced if desired in the cavity or risers as an aid in isolating slag carried by the incoming metal. The number and locations of vents may be seen by noting the formation of any air or gas pockets, and the efficiency of vents at proposed locations may be checked by subsequent pourings. Similarly, the minimum cubic capacity of the gate systems may be determined, so that adequate flow is assured without sprues, runners or risers of excessive size, so that the percentage of yield may be improved.

The results of tests conducted thus far with the apparatus indicate serious basic errors in what have heretofore been rather widely accepted principles of mold design, and raise serious doubt as to the soundness of some time-honored theories of gate function. It has been learned, for example, by comparative tests of the three gate arrangements shown that the systems of Figures 1, 2 and 3, which have heretofore been believed to be substantially equivalent, are not so in fact. In each of these systems, it has been previously theorized that the riser would act to reduce the velocity of the incoming metal substantially, and introduce it into the mold cavity with very low turbulence, but two of these systems do not in fact accomplish this object. On the contrary, with the systems of Figures 2 and 3 it has been observed that the metal spurts into the cavity with considerable violence and causes a turbulence not heretofore believed to exist with these systems, notwithstanding the fact that each of these gate systems has been conventionally employed in the foundry industry for years. In contrast to either of these, it has been learned that metal introduced through the gate system illustrated in Figure 1 expends the energy incident to its velocity of flow in the riser **17** and dribbles quietly into the cavity **10** in such a manner as to fill the cavity quickly, but without imparting noticeable turbulence to the metal.

A test set for casting of a rectangular block is illustrated in Figures 4, 5 and 6. In each of these cases the cavity of the facsimile chamber is of identical rectangular shape. The chambers may be formed of flat sheets of transparent plastic fused or cemented to each other to provide a substantially closed chamber **31**. Vents such as the vents **32** and **33** may be provided, and alternative gate systems attached to the different units to provide a comparison between different gating systems. In Figure 4 the inlet funnel **35** feeds a sprue **36** and runner **37** from which the metal enters the cavity of the chamber **31** through right angle fingers **38**, **39**, **40** and **41**. A somewhat similar arrangement is employed in Figure 5, except that the metal is introduced through a sprue **42** at the center of the runner **43** from whence it flows into the cavity **31A** through fingers **44**, **45**, **46** and **47**. In Figure 6 the arrangement of Figure 4 is modified by providing a sprue **48** to supply the runner **49** which supplies metal to the cavity **31B** through fingers **52**, **53**, **54** and **55**, each of which is positioned at an acute angle with respect to the runner **49**.

Multiple finger-gate systems of the types here shown have heretofore been interchangeably employed in an effort to accomplish uniformity of flow into the cavity of a mold. Tests have shown, however, that they do not accomplish this purpose, and that two or three of the fingers serve no useful purpose and may be eliminated to advantage. By direct observation, it is seen that metal introduced into the funnel **35** will flow into the cavity **31** primarily through the finger **41**, with progressively less flow from the fingers **40**, **39** and **38**. The flow through the finger **38** is so small as to introduce a serious risk of premature solidification. Similarly, with an arrangement such as Figure 5, the greatest initial flow takes place through the fingers **44** and **47**, notwithstanding that the fingers **45** and **46** present a shorter path. The same characteristic can be noted in the arrangement of Figure 6, wherein it is the finger **55** through which the major portion of the metal is introduced into the mold cavity.

It has long been conventinal practice to provide molds for certain types of castings with what are termed "step-gates" having several metal inlets positioned one above the other, and it has been widely theorized that the use of these gates permitted the metal to be introduced into the cavity without spattering and splashing by introducing it first at the lowermost level and then through the upper steps as the level of the molten metal in the cavity rises above the successive steps connecting with the down tube of the gate.

The four systems of step-gates illustrated in Figures 7 to 10 are all conventional and have heretofore been regarded as equivalents in foundry practice, but here again the teachings of the present invention disclose that the theories of operation heretofore ascribed to these structures are not in accordance with their actual functioning. In fact, it may be clearly seen by tests that of the four systems heretofore regarded as equivalent, only one accomplishes the intended purpose. In Figure 7, for example, it has always been assumed that metal would flow downwardly through the inlet **61** and into the cavity **62** first through the lower step **63** and then through the steps **64** and **65** as the level of molten metal in the cavity reached these heights. A careful observation of the apparatus, however, shows that the initial flow of the liquid through the steps **64** and **65** is not inward as would be commonly supposed, but is on the contrary an outward flow from the cavity of the casting to the tube **61**. The same result takes place with the arrangement illustrated in Figure 9, wherein the only inward flow to the cavity **66** is downwardly through the tube **67** and thence upwardly through the step **68**, and observation of the test units illustrates that when the level of metal reaches the steps **69** and **70**, the flow of metal is outwardly from the cavity to the tube rather than inwardly as heretofore supposed. The upper steps in these systems are, therefore, useless for the intended purpose.

With the arrangement of Figure 8, the desired result is obtained. In this instance, metal entering the down tube **71** flows first into the cavity **72** through the lowermost step **73**, and when the liquid level reaches the steps **74** and **75**, the flow is inwardly from the tube into the cavity. A peculiar effect which, so far as known to the applicant, has never before been recognized is characteristic of the conventional step-gate of Figure 10. With this gating arrangement it has heretofore been supposed that the metal entering the tube **81** would flow into the cavity **82** first through the lowermost step **83** and then through the steps **84** and **85** as the liquid level rises. By test, however, it can be demonstrated that this theoretical functioning of this type of step-gate is not in accordance with the facts, and that almost all of the liquid introduced through the tube **81** is projected upwardly through the upper step **85** and spurts into the top of the chamber with sufficient violence to cause great turbulence in the metal. Only a very small fraction of the metal introduced into the tube **81** dribbles downwardly through the tubes **86** and **87** to enter the cavity through the lower steps of the gate.

From the foregoing it will be seen that by the teachings of this invention, it has already been determined that many time-honored theories of gate functioning which have persisted throughout the years have been disproved, with the result that many of the seemingly inexplicable failures in casting which have heretofore perplexed foundrymen throughout industry may now be clearly understood. It follows that by utilization of the method of predetermination here disclosed an optimum system of gates for any contemplated cast shape may be arrived at, so that failure attributable to improper systems of gates and vents may be substantially eliminated. The contemplated method also makes it feasible to increase the yield percentage obtainable by ordinary casting procedures by eliminating any unnecessary sprues, risers, fingers or vents. This also effects an important secondary result in reducing the time required to clean and machine the rough castings. In addition to a predetermination of flow characteristics, the present method and apparatus serves as a means for predetermination of solidification and shrinkage characteristics. Thus by using an alloy such as Wood's metal, the molten metal may be allowed to solidify in the test units where these characteristics may be noted visually, and any modifications of the gate system required to produce the desired results will be clearly indicated.

Having thus described the invention, what I claim as new and desire to secure by United States Letters Patent is:

1. Apparatus for predetermining an optimum gating system for a mold comprising, in combination, a plurality of facsimile test units, each consisting of a substantially closed chamber having an internal configuration corresponding to the shape of the casting, said units each having gates of differing formation with alternate systems of sprues, fingers and risers; said chambers, sprues, fingers and risers being transparent throughout; whereby by pouring molten low-temperature metal into each of said chambers through the different gating systems the characteristics of flow and turbulence of the metal passing through the different gate systems may be compared.

2. Apparatus for predetermining an optimum gating system for a mold comprising, in combination, a facsimile test unit consisting of a substantially closed chamber having an internal configuration corresponding to the shape of the casting, with a system of sprues, fingers and vents communicating with said chamber, said chamber, sprues and fingers being formed of transparent plastic material throughout whereby by pouring molten low-temperature metal into said chamber through the sprues and fingers the characteristics of flow and turbulence of the metal may be observed.

3. The method of predetermining an optimum gating system for a mold for a metal casting of known configuration comprising the steps of preparing a plurality of facsimile test units, each consisting of a substantially closed transparent chamber having an internal configuration corresponding to the shape of the casting; providing each of said chambers with gates of differing formation having alternate systems of sprues and fingers; providing vents at a plurality of different alternate locations in said chambers, introducing visible gas into each of said chambers, pouring molten low-temperature metal into each of said chambers through the different gating systems, comparing the characteristics of flow and turbulence of the molten metal in the different test units and observing the flow and movement of the visible gas within the transparent chambers.

4. The method of predetermining an optimum gating system for a mold for a metal casting of known configuration comprising the steps of preparing a plurality of facsimile test units, each consisting of a substantially closed transparent chamber having an internal configuration corresponding to the shape of the casting; providing each of said chambers with gates of differing formation having alternate systems of sprues and fingers; providing vents in said chambers, pouring mercury into each of said chambers through the different gating systems, and comparing the characteristics of flow and turbulence of the metal in the different test units.

5. The method of predetermining an optimum gating system for a mold for a metal casting of known configuration comprising the steps of preparing a facsimile test unit consisting of a substantially closed transparent chamber having an internal configuration corresponding to the shape of the casting; providing said chamber with a gate system of sprues and fingers; providing a vent in said chamber, pouring molten low-temperature metal into said chamber through the system of sprues and fingers to observe the characteristics of flow and turbulence in the test unit, altering the size, shape and relative proportions of the sprues and fingers of the gate system and repeating the pouring step to achieve the flow characteristics desired.

6. The method of predetermining an optimum gating system for a mold for a metal casting of known configuration comprising the steps of preparing a facsimile test unit consisting of a substantially closed transparent chamber having an internal configuration corresponding to the shape of the casting; providing said chamber with a gate system of sprues and fingers; providing a vent in said chamber, and pouring mercury into said chamber through the system of sprues and fingers to observe the characteristics of flow and turbulence.

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