SPRUE FORM AND METHOD OF PRECISION CASTING

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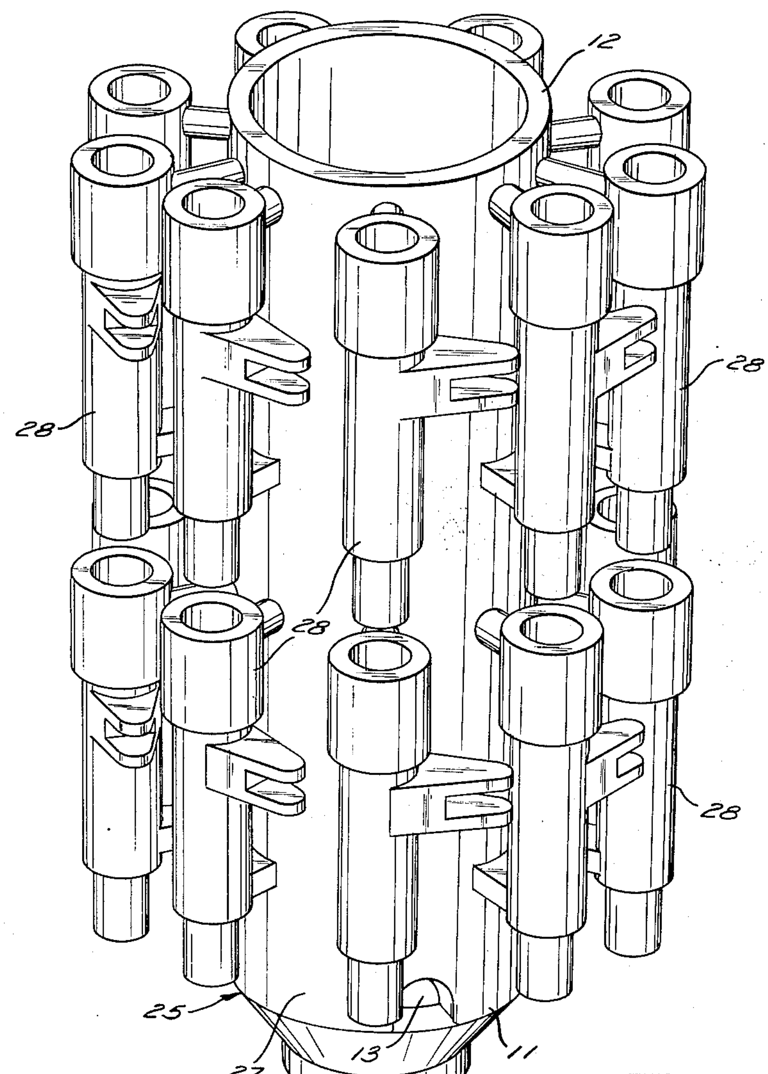

Fig. 1

INVENTOR.
CLAUDE H. WATTS
BY
WATTS, EDGERTON, PYLE, & FISHER
ATTORNEYS

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C. H. WATTS

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2 Sheets-Sheet 2

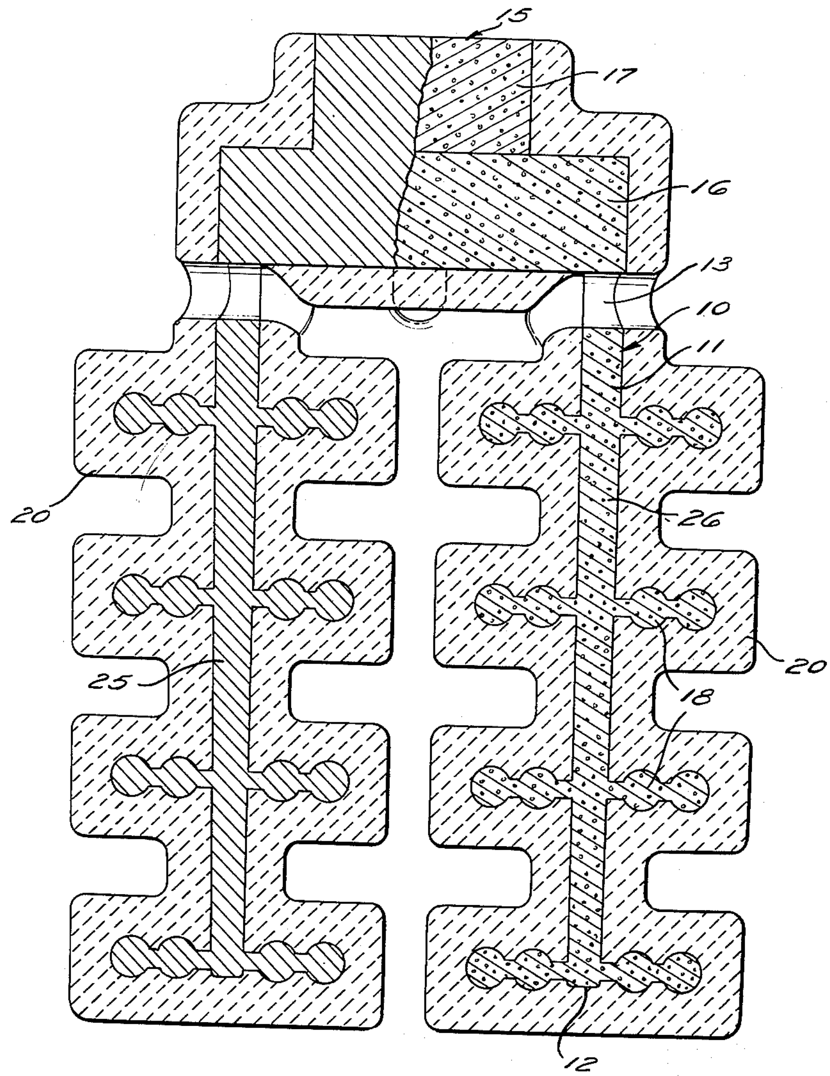

Fig. 2

INVENTOR.
CLAUDE H. WATTS
BY
WATTS, EDGERTON, PYLE & FISHER
ATTORNEYS

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SPRUE FORM AND METHOD OF PRECISION CASTING

Claude H. Watts, Lyndhurst, Ohio, assignor to Precision Metalsmiths, Inc.
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This invention relates to the art of making precision metal castings by the lost pattern method, generally referred to as "lost wax" method, and relates more specifically to an improved form and arrangement of sprue and pattern pieces to achieve an improved casting procedure and result.

The art of metal founding by the so-called "lost wax" process is quite well known in industry today and so requires very little in the way of description. However, a few brief comments in summary of this process are in order so as to include some of the more recent developments in the art to provide a full and complete disclosure on the present invention.

The method of manufacture consists of several fairly well defined steps which are as follows:

(1) A metal die is made by usual precision die making techniques.

(2) The die is used to produce either a wax or plastic pattern of the part that is required in metal. The pattern is usually produced by injection molding procedures.

(3) The wax or plastic patterns are then assembled to a runner system. This usually consists of a pouring cup and a large center tree, to which are attached the necessary gates to provide metal flow to the part being cast. This entire assembly which consists of the runner system and the patterns is variously referred to as a tree, a gating system or setup. The entire assembly is made of heat disposable material.

(4) The next step is to surround these patterns and this gating system with refractory slurry which may produce a mold either in the form of a solid mold or as more recently stressed, a ceramic shell. First, with reference to the solid mold, the setup may be surrounded or placed with a cylindrically shaped metal flask, open at both ends. Refractory investment material is then mixed into a slurry and poured into the flask and around the setup. The refractory slurry may be either vibrated into the flask and around the setup, or it may be vacuum invested, whichever is most suitable.

The most recent shell development includes the formation of a ceramic shell around the assembly of patterns to a runner system, by repeated dipping of the setup into a refractory slurry of the proper viscosity followed by draining so as to give uniform coverage, and then sprinkling coarse refractory grain onto this slurry. This gives a coat of ceramic material with refractory particles embedded in the surface. This coat is hardened, usually by air drying to evaporate the vehicle carrying the binder.

After the first coat is sufficiently dry and hard, the steps of dipping, draining, sprinkling on refractory, and drying are repeated until a ceramic shell about ¼" to ½" thick is formed around the assembly of patterns and runner system.

Both types of molds, that is the one formed by the solid mold technique and the shell mold as described above are heated in order to remove the pattern material of wax, plastic or other heat disposable pattern material. Final traces of organic materials are removed from the mold by firing to temperatures in the neighborhood of 1200° F. to 2000° F. according to the type metal to be later cast. After the pattern has been eliminated by firing, the mold is ready for casting.

After casting, the balance of the process includes cleanings, cut-off and gate removal, straightening and deburring where required, inspection and other operation such as X-ray examination.

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This invention is primarily concerned with the production of better castings where castings have been made successfully before, with making sound and economical feasible castings of sizes and shapes not before considered feasible, and to achieve both objects with far less waste material and, hence, with greater economy.

More specifically, this invention is concerned with a new and improved gating system for use in the steps of the process that are concerned with providing a means of pouring and directing the metal from the melting furnace through the pouring basin, into the gating system and finally into the part cavity.

One of the areas of primary concern in the art of metal casting is the ratio of gating system to finished part. This is true from an economic standpoint as well as a technical standpoint.

It is easily understood that it is most desirable to have a high proportion of metal parts cast in relation to the amount of metal required in the gating and runner system. In this connection it is common practice to refer to this relationship as a ratio of gating system to metal parts cast by weight. For example, if ten pounds of metal are used in a gating system to produce one pound of finished parts then the ratio is 10 to 1.

It is common practice in the foundry industry, which, of course, includes castings made by the process here described, to use massive gating systems in which the ratio of metal required to feed the finished castings is exceptionally high. It is an object of this invention to provide a gating system for precision metal casting in which the ratio is much lower.

It is well known in the art of metal casting that as molten metal cools, shrinkage or a reduction in volume takes place. This occurs in the liquid state, usually during solidification, and in the solid state.

One of the objects of this invention in providing a gating system is to supply molten metal to the pattern cavity until solidification is complete so as to produce a metallurgically sound casting.

Another object of this invention is to provide a gating system that will produce superior results metallurgically over what has been possible in the past by the old type gating systems.

Still another object is to provide a better arrangement of gate and pattern for use of the vacuum assist method of casting.

Another object of this invention is to provide a gating system that results in lower thermal gradients throughout the entire casting system, thus making possible a substantial improvement in cast results, such as more uniform Rockwell hardness values in the as-cast condition.

Greatly improved results with substantially lower rejects due to hot tear are obtained with the new improved gating system and, therefore, another object of this invention is to reduce the susceptibility of cast parts to hot tearing.

Another object is to provide a gating system with an increased area for attaching pattern gates in relation to the volume of the runner system. Substantial economies are being realized with this new gating system and these economies are the result of an increase in the number of patterns that can be attached to the new gating system. As a result, fewer number casting units are required to produce an equivalent number of pieces, and this has resulted in a savings in time and handling through every step of the operation.

Some of the advantages and improved results of this invention will be apparent to those skilled in the art after a study of this specification. Other advantages and improvements are not completely understood or explainable. For example, it has been possible in several practical applications to make a sound casting where the ratio of gate-to-part is less than 1 to 1. In other words, it is now possible, by this invention, to feed a part and make a sound casting with a gating system that, from a ratio standpoint, would have appeared inoperative to produce a sound casting.

The range in size and weight of the parts that are applicable to manufacture in accordance with this invention is from a fraction of an ounce to pieces measured in pounds.

As reference to the drawings and description following hereafter will show, the invention is embodied in a gating system which is essentially a thin wall having height and length dimensions far in exces of the thickness, and for practical purposes the wall is endless in the form of a tube, or possibly better described as a hollow cylinder. Because the central stem of a casting unit has heretofore been known as a "tree" this new form may also be referred to as a hollow tree.

As work progressed in exploring the various advantages of this hollow tree concept in comparison to other grating arrangements, additional advantages and benefits were discovered. For example, there has been noted a significant decrease in porosity in several specific instances, when parts were gated using the teaching of this invention instead of the old solid tree. The exact reason for this improvement is not definitely known. There is, however, a definite tendency to believe that the elimination of a massive center tree, with the resultant lowering of thermal gradients of gate metal to workpiece metal may in some way account for the improved results.

Similarly, it has been noted that some pieces that formerly required two to three separate gates to feed a part so as to produce acceptable castings can now be adequately fed to produce radiographically sound castings with only one gate.

It should be pointed out also that the most desirable ratio of gating system to casting by weight is not always attainable because of the design and configuration of the part. This is especially true for very small parts. In some instances it is impossible to attain a ratio lower than 5 to 1.

The foregoing general discussion and objects have been set forth to bring about a better understanding of the more specific discussion and description of the invention. Other objects and a fuller understanding of the invention will therefore be apparent as the invention is described and illustrated in the figures of the drawings in which:

FIGURE 1 is a perspective view of a cast unit made by the preferred embodiment of the invention, the unit of gating system and production pieces being as it appears after removing the shell; and,

FIGURE 2 is a longitudinal section of a unit having production piece nodes of another workpiece on both sides of the gate wall; one portion of the illustration cross sectioned as wax to show the condition prior to burning, and the other sectioned as metal to show the condition after casting.

For a full understanding and appreciation of the invention, reference is made to physical embodiments of the invention as carried out in actual practice. In the FIGURE 1, there is illustrated a perspective view of an actual production unit as it appears after having been cast in metal and then having the shell broken away to expose the solidified metal. The physical structure, however, is more readily understood by referring to the FIGURE 2. In FIGURE 2, a hollow tubular form of sprue, referred to by the reference character 10, is sectioned to indicate a wax member. Hereafter, this description will refer to wax as the sprue and pattern material and it will be understood that any heat disposable substance suitable for this type of operation will be included as acceptable material. Plastics are now widely used for some or all of these constructions, as an example. In the position shown in FIGURE 2, the unit is oriented as it will be used to pour the molten metal. The sprue 10 is tapered from a butt end 11 to a tip end 12 in order to provide a greater capacity at the butt end. This sprue 10 is cast or molded in a prepared die just as production piece patterns are molded. This sprue, of course, will serve as the runner or main gate for metal after the shell is made and the sprue removed by heat. Therefore, in order to provide a means for getting molten metal into the sprue 10, a sprue base 15 of the same or similar material is mounted at the butt end 11. In FIGURE 2, this sprue base is composed of a first and large disc shaped part 16, upon which is mounted a smaller disc shaped second part 17. The part 16 is mounted directly to the butt, and, hence, when the heat removes the disposable material, there will be a communication from the cavity which is created by the removal of the sprue base, and metal poured into the sprue base cavity will feed into the gating system created by the removal of the sprue 10.

Wax patterns 18 are mounted on the exterior surface of the sprue 10 in the conventional manner of mounting such patterns on the prior solid and massive trees. In FIGURE 2, the same patterns are shown mounted on the interior of the cylindrical form sprue 10 to bring forth the fact that it is possible in many instances to actually take advantage of both sides of the sprue wall in this embodiment and, hence, multiply the capacity of this arrangement even further.

After the patterns 18 are mounted, the completely assembled tree unit is then coated or invested as the particular chosen procedure may dictate. In either event, however, whenever the sprue 10 is made into cylindrical form as illustrated in FIGURE 2, it will readily be appreciated that the internal part of the sprue will act as a bottle turned upside down in water. For this reason, semi-circular ports 13 are molded into the butt end 11 in order to provide venting openings. These ports 13 do not interfere with the closed system from the cavity formed by the sprue base to the cavity formed by the sprue itself because all of the surfaces of the ports 13 are coated and closed by the same material encasing the balance of the structure. In the FIGURE 2, also, the structure is shown encased in a shell 20, indicating that the FIGURE 2 represents a dip-coated, shell mold rather than an invested type of enclosure. Furthermore, in FIGURE 2, one portion of the drawing is sectioned to represent wax 18 and, therefore, represents the condition of the assembly after being dipped with the shell forming material, whereas the balance of the drawing is sectioned to indicate metal 25, thus indicating the condition after the pattern material and sprue material has been driven off by suitable heat means, or other pattern removal processes, and the metal poured into the resultant cavity. This portion of the drawing represents the condition prior to breaking away of the shell 20 and exposing the type of structure shown in FIGURE 1.

Referring now to FIGURE 1, this metallic assembly resulting from a structure and process as discussed with respect to FIGURE 2 is an actual assembly of complex work pieces which have been successfully made by the structure and process herein set forth. The cavity created by removal of the wax sprue 10 in FIGURE 2 has now been replaced by a solidified metal and is indicated by the reference character 27. Workpieces 28 of a different form than illustrated in the more schematic view in FIGURE 2, indicate the fact that a considerable number of workpieces are successfully cast around the external surface of this cylindrical metal piece 27 and further, very graphically illustrates the fact of a most favorable ratio of metal in the piece 27 with respect to the metal in the desired workpieces 28. There are no internal pieces in FIGURE 1, although such could have been done if desired.

The discussion of the two figures of the drawing is relatively simple and easy to understand, but a full appreciation in order to make the full use of this invention must be gained by knowledges of the extraordinary advantages which have accrued from this development. Although these advantages have been set forth somewhat prior to the discussion of the physical embodiment, it will now be seen that this structure is the commercial embodiment which has achieved:

(1) A greater control of thermal gradients by reducing sprue volume with the use of the thin wall sprue. In the illustrated embodiment this has been achieved in a tubular or hollow cylinder construction.

(2) A greater number of parts per mold is obtained by increasing the diameter of the sprue without increasing the mass of metal in the sprue and having the sprue size related directly to, and governed by, the diameter and need for metal flow to workpieces put on the surface of the sprue, and

(3) A remarkably superior weight ratio of gating system to cast parts as low as ¼ to 1.

The advantage gained in area available for gating purposes in relation to the minimum volume of metal in the sprue can be conveniently expressed in ratio form. For example, the area in square inches of the hollow sprue shown in FIGURE 1 can be calculated. Similarly, the volume of the hollow sprue **12** can be calculated as cubic inches. In some instances it may be desirable to make use of the available area within the hollow sprue in which case the available gating area is almost doubled. In actual practice the ratio of gating area in square inches to volume of hollow sprue in cubic inches falls within the range of a low of 2 to 1 to a high of 10 to 1.

These ratios are calculated on the basis of outside surface only, and will be roughly double if both surface areas are considered. Further, these ratios are for most practical commercial sizes, and the extreme low ratio becomes less practical in small sizes. In fact, if the low ratio of 2 to 1 is used, it must be applied only to sprues over two inches in diameter, because at two inches, this ratio will produce a solid, rather than tubular, sprue. It has been found, as shown in the drawings, that the central passageway through the sprue must be large in proportion to the overall size of the sprue. The cross section area of the passageway will be at least one-third the cross section area of the sprue wall.

The ratio of 2 to 1 set forth above represents a sprue wall thickness of about the thickest practical dimension that will achieve the benefits of the present invention. On the other hand, it has been found that a wall thickness of about ⅛ of an inch or something less will be the thinnest practical wall that will deliver the benefits of the present invention. Accordingly, it may be seen that a ⅛ inch wall thickness will produce a ratio of about 10 to 1 and if one is to consider both the inside of the tubular sprue and the outside as being available for the securing and feeding of workpiece pods, then the ratio becomes about 20 to 1.

In order to test the present invention and push it to its greatest limits and, thus, determine what real benefit had been obtained, a series of extraordinary tests were performed wherein size and shape of cast pieces, together with location, were assembled upon a central sprue such as illustrated in the drawings. The conditions imposed were selected to be far beyond anything which had ever been commercially feasible by precision casters before this invention. Those who know and understand precision casting by the lost pattern process will appreciate and understand the following illustration of one such test.

The material used for the patterns, sprue, and ingates was wax with a candellia base fortified with polyethylene. The sprue was twelve inches long, five and one-half inhces outside diameter, with a wall thickness of one-half inch at the butt end **11**, tapering to one-quarter inch at the tip end.

Patterns in this setup consisted of 30 wax cubes varying in size from one and one-half inch on an edge to two and one-half inch on the edge. There were 10 cubes one and one-half inch, 15 cubes one and three-quarter inch, 8 cubes two inches and 6 cubes with an edge of two and one-half inch.

Round gates were used of three-quarter inch diameter by three-quarter inch long for the one and one-half inch cubes, seven-eighth diameter by three-quarter inch long for the one and three-quarter inch cubes, one inch diameter by seven-eighth inch length for the two inch cubes, and one and one-quarter inch diameter by one inch length for the two and one-half inch cubes. The vertical distance between centers of the gates at the point of attachment to the sprue was two and one-quarter inch for the one and one-half inch cube, two and three-eighth inch for the one and three-quarter inch cube, two and three-quarter inch for the two inch cube, and three and one-quarter inch for the two and one-half inch cube. Horizontally, the distance between the centers on the sprue was one and one-half inch for the one and one-half inch cube, one and five-eighth inch for the one and three-quarter inch cube, two inch for the two inch cube, two and one-eight inch for the two and one-half inch cube.

This assembly was encased in a ceramic shell mold, fired at 2000° F. for three hours prior to pouring and poured with a 17–4 pH type alloy.

After this casting was completed, each cast tube was examined visually. There was no evidence of dishing of the faces, the corners were well defined, and the details of the patterns were faithfully reproduced. Only a couple of the cubes had visual evidence of a pipe at the ingate sprue area, whereas it would be logical to predict that all would be bad.

Later X-ray and radiographic testing confirmed the evidence of a pipe at the gate. Some of the pipes were quite shallow and were not picked up on X-ray. Sectioned pieces chosen from castings that were radiographically sound and had the thinnest section of the sprue feeding them were macro etched and zygloed and found to be sound.

As indicated, this experiment and others of a similar nature have been carried out with the intention of pushing the feeding requirements of the cube castings beyond the apparent capability of this type of sprue system set forth as the invention herein. It was established that it is possible to feed a relatively heavy section, such as a two and one-half inch cube, through a relatively thin wall sprue section of one-quarter inch thickness. It has been definitely established, in the structure outline, that a gating system of this type having a wall thickness such that the ratio of area in square inches to volume in cubic inches is in the range from 3:1 to 10:1 so as to provide an arrangement that gives a ratio by weight of gating system to finish casting in the range of from ¼:1 to 5:1.

Although the invention has been described in its preferred form with a certain degree of particularity it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. In an apparatus for casting of molten metal by the lost pattern process, a gating system comprising a heat disposable sprue and a feeding cup for said sprue, said sprue having closely spaced opposed wall surfaces providing a ratio of surface area to volume in the range of from substantially 2:1 to 10:1, said sprue having a central axis with the wall surfaces spaced from and extending about said axis, one said wall surface thereby being an inner wall surface defining a passageway through said sprue, said passageway having a cross section area of at least one-third the cross section area of the sprue.

2. A mold having a gating system defined by closely spaced opposed wall surfaces, a pouring cup in communication with said gating system and a plurality of workpiece mold cavity pods carried by said sprue and extending from at least one said wall surface and in communication with said gating system said gating system defining a sprue form having a central axis with an inner wall surface spaced from and extending about said axis, the minimum volume ratio of said gating system to said workpiece cavities being about ¼ to 1, and said gating system having a minimum cross section of about one-eighth of an inch, said inner wall surface defining a passageway through said sprue, said passageway having a cross section area of at least one-third the cross section area of the sprue.

3. A mold, comprising, an inner and outer opposed wall surfaces defining a relatively narrow sprue passageway therebetween, said inner wall surface defining a passageway through said sprue having a central axis with said wall surfaces spaced from and extending about said axis, said passageway having a cross section area of at least one-third the cross section area of the sprue, a pouring cup in fluid communication with said sprue passageway to receive and direct fluid metal into said sprue passageway, a plurality of cavitated pods extending from at least one of said wall surfaces, said cavitated pods having a workpiece shaped cavity and a gate therein in communication with said sprue passageway, the area in square inches of the outer wall surface being related to the volume in cubic inches in said sprue passageway in a ratio of from 2:1 to 10:1, of said sprue to the volume of the total cavity area of said pods being in a range up to 1 to 4.

4. A mold comprising a heat disposable tubular sprue gating system, a pouring cup in communication with said sprue, the cross section of said sprue tapering from a large butt end at said pouring cup to smaller tip end, a plurality of molding cavities in communication with the surface area of said sprue, said sprue having closely spaced opposed walls providing a ratio of the surface area of said exterior of said walls to volume in the range of from substantially 2:1 to 10:1.

5. In the casting of molten metal as defined in claim 4, said molding cavities extending from both sides of the sprue wall, and said sprue together with the pouring cup and molding cavities being formed in a frangible shell.

6. In an apparatus for casting of molten metals by the lost pattern process, a gating system comprising heat disposable tubular sprue adapted to support heat disposable pattern clusters, said sprue having inner and outer wall surfaces defining a narrow sprue therebetween, said inner wall surface thereby defining a bore through said sprue, said bore having a cross section area of at least one-third the cross section area of the sprue.

References Cited in the file of this patent

UNITED STATES PATENTS

2,666,239 Farrell ---------- Jan. 19, 1954

OTHER REFERENCES

Precision Investment Castings, Edwin L. Cady, 1948, page 319 relied upon.

Investment Castings for Engineers, Rawson L. Wood and Davidlee Von Ludwig, 1952, page 131 relied upon.