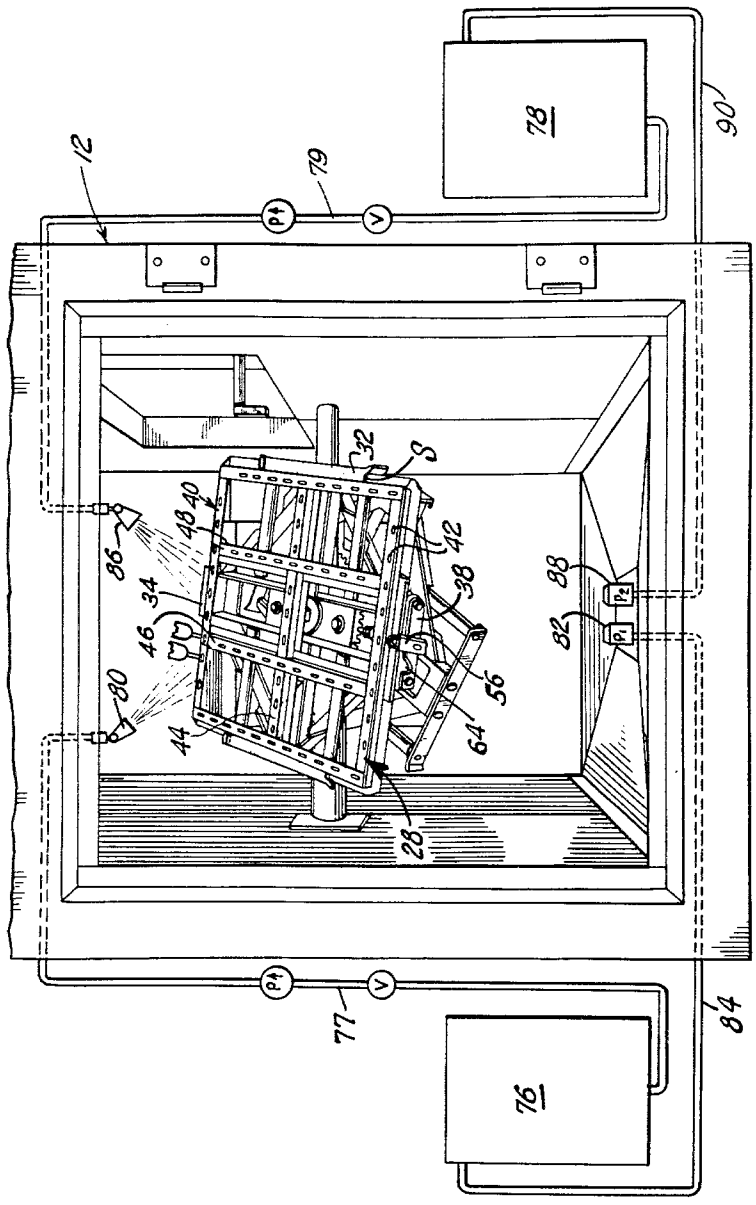
Feb. 8, 1966 E. B. BLUE ETAL 3,234,315

ROTATIONAL METHOD FOR CASTING HOLLOW BODIES INCLUDING SPRAYING OF A LIQUID HEAT TRANSFER MEDIUM

Original Filed March 9, 1962 4 Sheets-Sheet 1

Fig. 1.



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ROTATIONAL METHOD FOR CASTING HOLLOW BODIES INCLUDING SPRAYING OF A LIQUID HEAT TRANSFER MEDIUM

Original Filed March 9, 1962 4 Sheets-Sheet 2

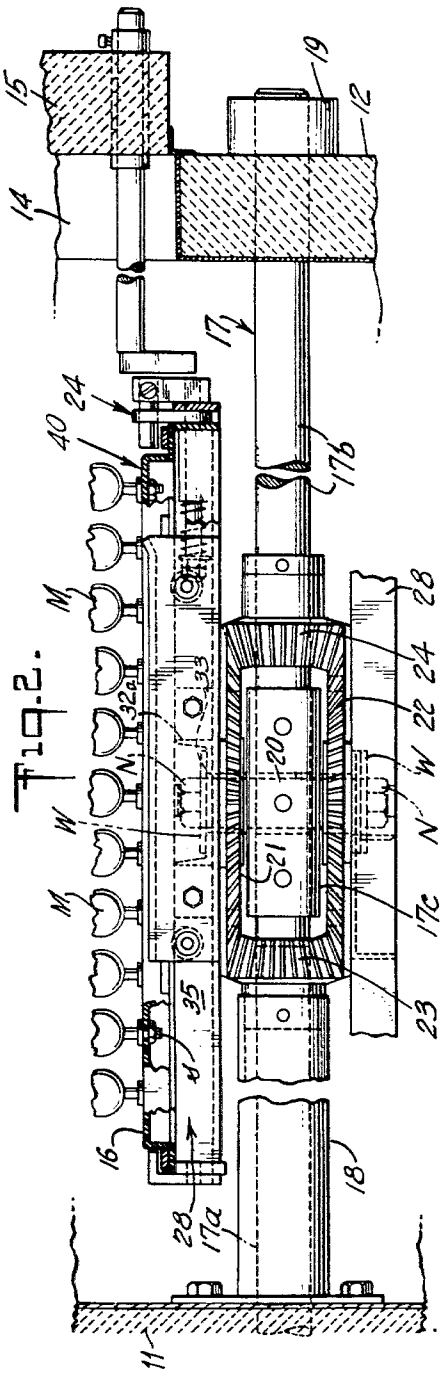


Fig. 2.

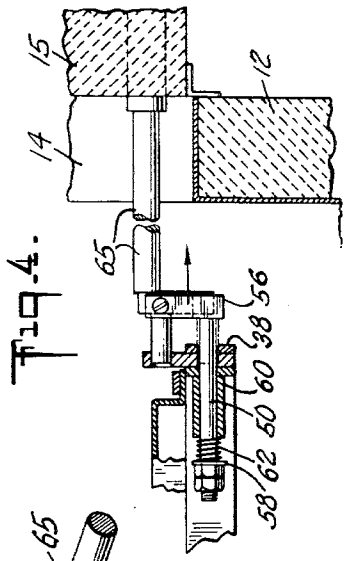


Fig. 4.

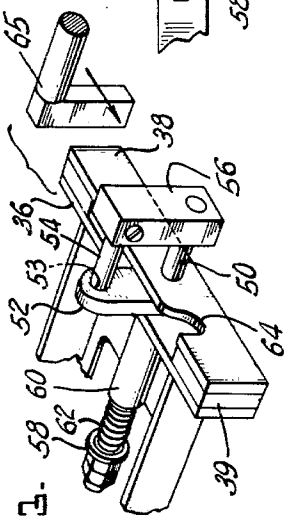
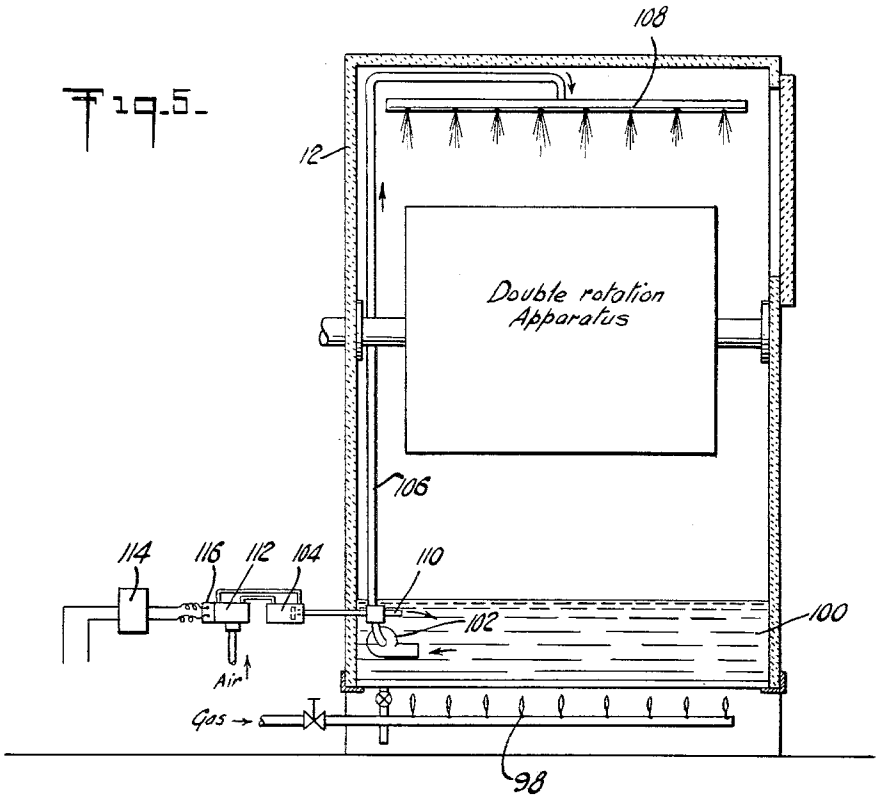


Fig. 3.

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Fig. 5



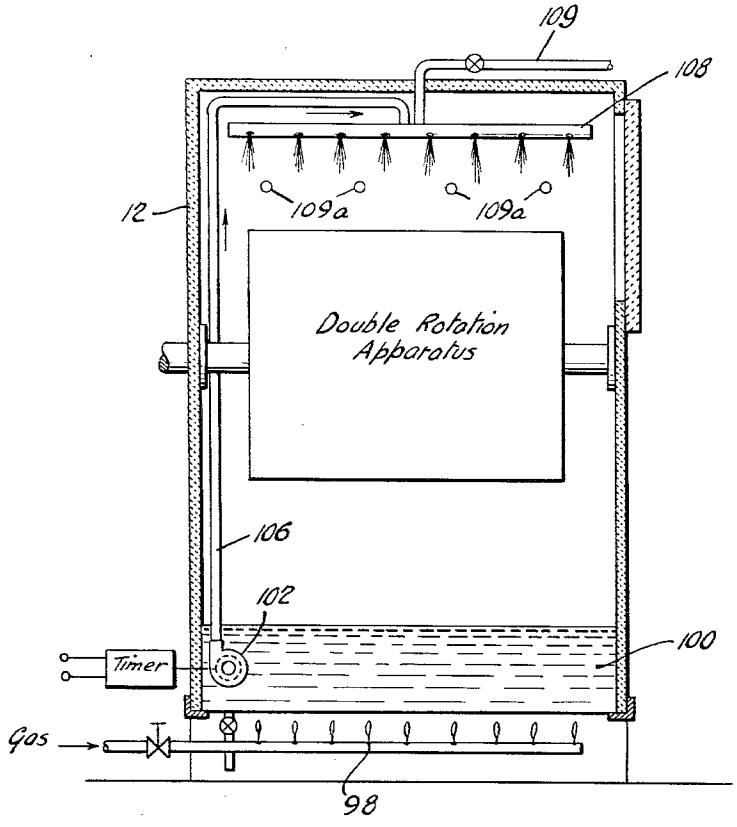
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ROTATIONAL METHOD FOR CASTING HOLLOW BODIES INCLUDING SPRAYING OF A LIQUID HEAT TRANSFER MEDIUM

Original Filed March 9, 1962 4 Sheets-Sheet 4

Fig. 6.



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Patented Feb. 8, 1966

3,234,315

ROTATIONAL METHOD FOR CASTING HOLLOW BODIES INCLUDING SPRAYING OF A LIQUID HEAT TRANSFER MEDIUM

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Original application Mar. 9, 1962, Ser. No. 178,749. Divided and this application Feb. 18, 1964, Ser. No. 346,588

4 Claims. (Cl. 264—310)

This invention relates to methods for casting of articles in hollow molds, and is a continuation-in-part of co-pending application Serial No. 72,907, filed December 1, 1960, and now abandoned, and a division of copending application Serial No. 178,749, filed March 9, 1962.

While this invention is not limited to any particular plastic resin casting composition, at the present time polyvinyl chloride compositions are usually employed and are mentioned herein as a specific application of the invention, but other casting compositions including polyethylene powders are also being used.

The terms "casting" and "molding" are used herein interchangeably.

Polyvinyl chloride compositions usually include stabilizers such, for example, as barium salts and cadmium salts. Because of the presence of stabilizers the vinyl plastisol remains stable up to 350° F., whereas, without a stabilizer the polyvinyl would degrade at temperatures between 300–350° F.

In the casting of articles in hollow molds the liquid casting composition is supplied into molds of the desired shape in an amount which, when distributed over the entire interior surface of a mold and transformed from liquid to solid phase will give a product of the desired thickness. If the molds are not heated uniformly the thickness of the casting will not be uniform. In order to cover the entire inner surface of the mold evenly with the casting composition, and to heat all of the casting compostion uniformly, it is customary to rotate the molds simultaneously through two different planes while the casting material is being heated and jelled and cured if a plastisol, or fused if initially in powder form. This double rotation of the molds stirs and distributes the casting material while it remains in liquid phase thus preventing a portion of the liquid from becoming overheated by remaining in contact with the inner surface of the mold, and also distributes the composition evenly over the entire inner surface of the mold so that when the material jells or fuses it will form an article coextensive with the inner surface of the mold.

The prior art methods are unsatisfactory because they are too time consuming, or produce articles which are unsatisfactory in quality, or have both of these objections. The chief difficulty in the prior art methods has been in the heating of the molds.

Heretofore, molds have been subjected to an atmosphere of steam while being rotated in two planes, but this is unsatisfactory since it subjects the outer surface of the molds to a temperature of substantially 212° F. Unless this operation is continued for a long time the interior of a mold is heated to a temperature somewhat less than the outside of the mold, and even for a composition

which is heat setting at a temperature below 212° F. the operation is inefficient because of the time consumed in heating the casting composition in the molds sufficiently to cause it to set. Superheated steam requires more expensive equipment, and steam is not an efficient heat transfer medium.

It has been proposed to heat the molds by immersing them in a body of heated liquid.

It has been customary to heat the molds by directing a stream of heated air against them, but even under the best conditions air is not an efficient heat transfer medium.

It is therefore an object of this invention to overcome the deficiencies of the prior art and obtain a better distribution of heat on the mold surfaces, and thereby to perform the molding operation in less time than has been heretofore required, while at the same time obtaining cast articles of uniform high quality.

The invention will best be understood if the following description is read in connection with the accompanying drawings in which:

FIGURE 1 is a front elevation looking into a treatment chamber;

FIGURE 2 is a front elevation detail view illustrating one form of double rotation means which may be employed including mold support and molds carrier means;

FIGURE 3 is a detail view showing in perspective means which may be employed for locking a mold carrier on its support;

FIGURE 4 is a side elevation of the locking means showing how it may be used in conjunction with a finger carried by a sliding panel to prevent starting of the apparatus unless the locking means is in locking position;

FIGURE 5 is a modification of FIGURE 1 showing apparatus preferred when using a liquefied salt as the heat transfer medium but not necessarily limited in use to any particular liquid heat transfer medium; and

FIGURE 6 is a view similar to FIGURE 5 but showing a second fluid conduit leading to the shower header means above the tank within the housing, or alternatively to other spray heads.

In practicing our method we supply the desired amount of casting composition into molds which are clean both on the inner and outer surfaces, and then move the molds into a heating chamber, where we direct against the entire surface of the molds a rain or shower of heat transfer medium so that the casting materials may be speedily fused or converted to a plastic stage while keeping the temperature of the heating medium within a range at which the rate of decomposition of the casting material is so low there will be no discoloration during the fusion cycle.

The terms "rain" and "shower" are used herein interchangeably.

We have had excellent heat transfer results using a heat transfer liquid having high specific heat, and a boiling point and flash point substantially above the molding temperature of the vinyl plastisol or other casting material, and heating it to a temperature substantially above the molding temperature and substantially below its boiling point, and directing a shower or rain of heat transfer liquid onto the entire outside surfaces of the molds while they are continuously rotating. After the heating operation, and before opening the molds, the heat transfer medium is washed off, using a liquid solvent for the heat

transfer medium. Desirably, to reduce cost, the mixture is collected and the heat transfer medium decanted for repeated use.

Examples of liquid heat transfer media having the above characteristics which we have used successfully are:

(1) A salt composition comprising:

	Percent
Potassium nitrate	10–50
Sodium nitrate	5–50

(2) A liquid hydrocarbon having one or more hydroxy groups, as for example,

Polyalkylene
Glycerine
Glycol
Polyethylene glycol
Chlorinated biphenol
An eutectic mixture of diphenyl and diphenyl-oxide

We have had particularly good results using a polyalkylene glycol which is commercially available under the trade designation "Ucon" 50HB280X (a product of Union Carbide Company), which is completely soluble in water at room temperature, i.e., within a range of 65–90° F., and becomes 80% insoluble in water when raised to a temperature of 160–180° F., and so separates from water within said temperature range and can easily be decanted and recovered.

We have found that a heated shower or rain of any of the above heated to at least 325° F. directed over the entire outer surfaces of the molds wets the mold surfaces, which results in very efficient heat transfer through the mold to the inner surfaces of the molds. Good results are obtained when the casting composition inside the molds is heated evenly to a temperature approximately within the range of 300–375° F. The temperature to which the heat transfer liquid should be heated in order to obtain the desired temperature within the molds depends upon the thickness of the molds and the material of which they are made, the composition of the casting material, the heat within the space through which the sprays are directed upon the molds, and the distance between the spray heads and the molds.

We have successfully used a liquid hydrocarbon heat transfer medium, supplied from a single tank or two tanks. When a heat transfer medium is supplied from a single tank, we prefer to start the molds rotating and to wet the molds for a short timed period to jell the plastisol, and then stop the flow of the medium and allow the molds to rotate for a timed interval before turning on the flow of the medium again to wet the molds for a longer timed period of time to effect the curing of the plastisol, and then to drain off the molds before removing them from the housing. For example, we have wetted the molds with a shower or rain of the liquid heat transfer medium for a period of eight seconds, and then turned off the shower and allowed the molds to continue to rotate without the shower for a half minute. We have then turned on the spray and wetted the molds for from 1 to 4 minutes to effect fusing of the gelled plastisol. The period between the two wetting steps seems to be beneficial in causing the plastisol to gell evenly over the entire inner surface of the molds.

If the liquid heat transfer medium is supplied from two tanks the liquid in one may be heated to a temperature desirable for the gelling step and the liquid in the other may be heated to a different temperature desirable for the curing step.

We have found that the molds commercially available at the present time are not always completely tight when closed and that if an oily heat transfer medium seeps into the mold interior it may cause some undesirable discoloration of the material in the mold if the contents of the mold are of a light color, and we prefer to use a liquefied salt medium where the contents of the molds have a light color. Because the salt reverts to its solid phase when its temperature is reduced it is desirable to collect and reheat it as soon as possible after its contact with the molds, and to reduce as much as possible the extent of its travel from its storage chamber to the shower or rain heads. When using a liquefied salt heat transfer medium we prefer to start the mold support means rotating for a short timed period and then turn on the rain of medium to wet the molds and heat them for a timed period long enough to cause both gelling and curing or fusing, of the casting composition, and then to drain off the molds within the housing, with or without a washing off step within the housing.

It will be understood that desirably time control means of any suitable kind are employed for each step of the operation. Timer means for the pump by which the heat transfer medium is supplied to the header **108** is shown in FIG. 6. The number of steps may vary. As indicated above it may be desirable to divide the operation into more steps when using a liquid hydrocarbon as the heat transfer medium than when using a liquefied salt.

Various means may be used for supporting the molds and moving them for even heating, and to distribute the casting material over the inside surface of the molds when the molds are not entirely filled and the resulting articles are hollow articles.

Very good results have been obtained employing biaxial rotation apparatus of the kind described in U.S. Patent No. 3,016,573 issued January 16, 1962. As shown herein in FIG. 2 the rotation apparatus is enclosed in a housing **12** having an access opening or window **14**, which may be opened and closed by sliding panel **15** through which mold carrier frames **40** may be inserted in a slideway S on a support member **28** and removed after the casting operation, and the apparatus is stopped while a mold carrier frame is being loaded into a support member or unloaded from it.

A desired amount of a selected plastisol is poured into one or more molds M (usually several are employed) of known kind, which are secured on a mold carrier frame **40**. The individual molds are closed and the frame is slid through the window **14** into the slideway S of a support member **28**. The locking means is then positioned to hold the carrier frame on the support during the time the double rotation apparatus is operating, and the power means (not shown) is actuated. When a casting operation is completed, the locking means is released and the mold carrier frame **40** is slid out of the slideway S on its support means and withdrawn through the window. The molds M are then cooled and opened and the cast products are withdrawn. The molds are then cleaned if required, in readiness for being refilled and employed again as described.

A drive shaft **17** (FIGURE 2) extends through wall **11** of housing **12** and is rotated by any suitable means such as an electric motor (not shown). Drive shaft **17** comprises a first part **17***a* which enters the housing through the sleeve **18**, and a second part **17***b* which extends through a bearing **19** provided in the wall of housing **12**. The shaft parts **17***a* and **17***b* are aligned with their inner ends spaced apart. Bridging the space between the shaft parts and interconnecting them is the collar means **17***c*. A cross support shaft **20**, which is a double headed bolt, extends at a right angle to shaft **17**, between the opposed ends of shaft parts **17***a* and **17***b*, and through the collar **17***c* to which it is secured in any suitable way as by welding.

A first pair of gears **21** and **22** are mounted for rotation on cross shaft **20** on opposite sides of shaft **17**. On the inner end of stationary bearing sleeve **18** a bevel gear **23** is mounted. Gear **23** is stationary and with bevel gear **24**, which is loosely mounted on shaft **17**, forms a second pair of bevel gears which mesh with gears **21** and **22**. When the drive shaft **17** and cross shaft **20** are revolving

around the axis of the drive shaft the gears **21** and **22** are caused to travel on and around the stationary gears **23** and they are thus also rotated around the axis of cross shaft **20**. If desired gears **22** and **24** may be eliminated and a counterbalancing disc used in place of gear **22** and keyed to cross shaft **20**.

The support members **28** are mounted on the outer surfaces of gears **21** and **22** (or on gear **21** and a counterbalancing disc used in place of gear **22**), respectively and may be integral with said gears or fixed to them in any suitable way, as for example by welding. Accordingly, when shaft **17** is rotated the support members **28** are caused to rotate simultaneously around the axis of shaft **17** and the axis of cross shaft **20**.

Each of the support members **28** is an open frame member with means **32** (FIGURE 1) along its side edges defining a slideway S and with the 2-sided angle stop member **34** (FIGURE 1) along its rear edge. Its front edge is defined by the cross pieces **36** and **38** (FIG. 3) which form part of a lock and stop assembly (FIGURE 2). Members **28** each comprise the crossed channel members **32***a* and **35**. A bore or hole **33** extends through the portions of **32***a* and **35** which cross one another, and the double headed bolt **20** projects through this aperture. Washers W are provided around ends of member **20** on the outer surface of the support members respectively, and are held in place by the nuts N which are screwed onto the ends of bolt **20** respectively.

Member **34** serves as a stop against which an end of a mold carrier **40** abuts when it is in "home" position in a slideway S on a support.

Each mold carrier **40** comprises a rectangular frame. The horizontally extended perimeter of each mold carrier is perforated with a number of small apertures **42** (FIGURE 1), the purpose of which is to receive the threaded stems respectively, of molds, such for example as the molds M shown in FIG. 2.

In order that a single carrier may support a greater number of molds cross pieces such as **44**, **46** and **48** (FIGURE 1) may be provided each having a number of said openings or perforations **42**. It will be understood that the molds employed may vary considerably in size and shape, and the perforations **42** are only illustrative of many possible means which can be used to engage and positively hold the molds on air pervious carrier while they are subjected to double rotation.

Cross pieces **36** and **38** at the front end of a support member are spaced apart by the spacing blocks **39** (FIGURE 3) leaving a space from within which there projects outwardly a locking guide member **52** which is mounted on the rotatable shaft **50** which extends through said cross pieces **36** and **38**. In locking guide member **52** the hole **53** is provided to receive and act as a bearing for the locking finger **54** which projects rearwardly from the lock-and-stop member **56** which is mounted on the rotatable shaft **50** in front of cross piece **38**. Around the rear end of rotatable shaft **50**, between the flange **58** thereon and the rear end of sleeve **60** which surrounds shaft **50** just to the rear of cross piece **36**, is a spring **62** which tends to retract shaft **50** and therefore cause locking finger **54** to pass into and through the bearing **53** in locking guide member **52** when rod **50** has been rotated to bring member **56** into upright position. With member **56** in upright position and finger **54** extending through bearing **53** a fixed stop is provided on the front end of the mold carrier support which prevents the inadvertent dislodgement of a mold carrier from its support as will be more fully explained. However, when shaft **50** is pulled forwardly against the force of spring **62**, thereby withdrawing finger **54** from the bearing **53**, and, the said members **54** and **56** and bearing hole **53** are rotated counter-clockwise through approximately 90°, the finger **54** will be received in the re-entry slot **64** in cross piece **38**, with its free end abutting against the cross piece **36** and therefore positioning lock-and-stop member **56** further outwardly from cross piece **38** than is the case when finger **54** is inserted through the bearing **53** in the locking guide member **52**. In this unlocked position of lock-and-stop member **56**, it is positioned in the path of movement of a finger member **65** which is carried on the inner surface of the sliding window panel **15**, and prevents the panel **15** from being closed and thereby completing an electric circuit (not shown), for energizing the power means for actuating the drive shaft **17**.

As shown herein, FIG. 1, there are two tanks (or reservoirs) **76** and **78** in which a liquid heating medium may be stored and heated to the desired temperature by any suitable means. From tank **76** a supply pipe **77** leads into housing **12** and to a header or spray head **80**. A pump **82** and return pipe **84** are provided for returning liquid medium from the housing to tank **76**. From tank **78** a supply pipe **79** leads into the housing **12** and to the header or spray head **86**. A pump **88** and return pipe **90** are provided for returning liquid medium to tank **78**.

After the molds have been charged and loaded onto the double rotation apparatus, they are preferably but not necessarily rotated for a short period at room temperature during which time the plastisol, which is in liquid phase, wets and is distributed over the entire inner surface of the molds.

A shower or rain of the liquid heat transfer medium having a temperature sufficient to heat the contents of the mold and cause it to gell is introduced into the housing, as for example from a first tank **76**, and directed against the molds while the molds are rotated to distribute the plastisol over the entire inner surface of the molds. Because of the efficient heat transfer accomplished by use of a liquid heat transfer medium of the kind described herein, the rate of gellation of the plastisol may be controlled more exactly than has been possible with the heat transfer media previously employed. This results in a more uniform film or layer of the casting material being deposited over the inner surface of the mold.

After the casting material is gelled, a shower of a liquid heat transfer medium having a temperature sufficient to heat the contents of the mold to cure it is introduced into the housing, as for example, from a second tank **78**, and directed against the molds. By the use of a liquid heat transfer medium of the kind described herein, the speed with which the plastisol or casting material can be cured after the gellation step has been completed in much faster, and more easily controlled, than by the use of hot air at the same temperature.

After each of the steps of heating the molds by means of a rain or shower of liquid heat transfer medium as described above, it is desirable, although not essential, to discontinue the shower while continuing the movement of the molds for a short interval prior to the next step. During each of these intervals the recovery of the liquid heat transfer medium employed may be continued and substantially completed by draining it from the treatment chamber and returning it to the appropriate tank.

In FIG. 5 heat transfer heating and circulating apparatus is shown which is preferred when using a liquefied salt as the heat transfer medium. A tank **100** is provided within the treatment chamber **12** below the double rotation apparatus. It is heated, as by gas jets **98**, to keep the salts from reverting to solid phase and also to heat the heat transfer medium to the desired temperature. Within the tank **100** is a pump **102** which sucks in the liquefied salt and, depending upon the position of slide valve **104**, either delivers the liquefied salt through pipe **106** to the perforate header **108**, from which it is rained down on molds supported on the double rotation means, or returns it through orifice **110** directly into the tank **100**. The slide valve **104** may be actuated by an air valve **112** controlled by an electric circuit including a timer **114** and a solenoid valve **116**.

Obviously only a single supply tank and its pump and return pipe need be used when the same temperature is

employed for effecting both the gelling and the curing of the plastisol. Timer and slide valve control means such as is shown in FIG. 5 may of course be used with either or both of the tanks **76** and **78**.

After the material in the molds has been gelled and cured, the molds are washed with water or other solvent for the heat transfer medium employed, and cooled, after which the molds are opened and the cast products are removed. The wash water or other solvent may be collected and the heat transfer medium it contains separated and recycled. In the case of polyethylene powders the phases of liquefying and adhering to the mold surface, and partially hardening, correspond to the phases of gelling and curing a plastisol.

When using a liquefied salt as the heating medium in apparatus of the kind shown in FIG. 5 the salt may desirably be washed from the outer surfaces of the molds, preferably with water, and returned to tank **100** while the molds are within housing **12**. In this way the salt is conserved and the water or other washing agent employed for washing does not substantially dilute the liquefied salt since the water is soon evaporated from the heated tank **100**.

Washing the salt or other heat transfer medium off the molds while they are within housing **12** has an added advantage when polyethylene plastic resin powder is used as the molding composition since the washing step can also be used to lower somewhat the temperature of the plastic resin within the molds which facilitates the setting of the plastic resin.

For washing or partially cooling the molds while they are within housing **12** a conduit **109** for water or other suitable liquid is shown (FIG. 6) connected to the header **108**, and may be opened by suitable valve means preferably automatically to provide a washing and attempering rain when pump **102** is idle. A conduit **109** may be connected to heads **109***a* if orifices differing in size or location from those of header **108** are desired.

Providing a rain of water or other suitable liquid on the molds to wash them off within the housing is desirable when using a liquefied salt as the heat transfer medium for otherwise the salt left on the surface of the molds may revert to solid form before the molds have been removed from the housing and washed.

With the method disclosed herein the heat transfer to the casting material in the molds is accomplished so rapidly that when stabilizers and plasticizers are employed the amount may be substantially reduced. Since these materials are expensive, this results in a substantial reduction in the cost of raw materials.

A correlated advantage is that when plastisols are used they may be more easily formulated for casting in the manner, and with the use of a heat transfer medium of the kind described above.

One of the chief advantages of the methods disclosed herein is in the more precise temperature control provided during the gellation, or fusing in the case of powders, of the casting material. Many casting compositions go through many physical changes as temperatures are increased. Non-uniformity in the temperature imparted to the casting material in a mold results in non-uniformity in the time required for distribution and deposit of the material over the inner surface of the mold.

It is desirable to have all casting compositions deposit at the same rate. In the past when using a casting material such as a polyvinyl plastisol it has been left to the supplier of the material to change the gellation rate through the use of slow or fast acting plasticizers to conform to relatively fixed heating conditions. With the more exact control of the temperature of the casting material in the mold obtainable with the apparatus which is the subject of this divisional application and is described above, it is possible to make all plastisols deposit at substantially the same rate by raising or lowering the temperature of the heat transfer medium, as may be required. The ability to more exactly transfer heat to the casting material in a mold and thus better controls its temperature also has the advantage that the supplier of plastisols may choose plasticizers on a basis other than whether they are fast or slow gelling. For example, he may choose them on a basis of cost and storage life at room temperature. It happens that plasticizers of very slow gellation (175°–195° F. gel point) normally have by far the best storage life at room temperature. Under the fixed or less exactly controlled heat transfer conditions of the prior art, it has not been considered possible to use these plasticizers. Now, by means of the apparatus described above, it is possible to use any of a large number of different type plastisols, including those of very slow gellation.

By using a method of the kind described above, fused plastisol articles of improved quality may be produced at significantly lower temperatures and shorter fusion cycles and lower compounding costs.

For example, in casting a plastic hobby horse which is from 35 to 40 inches long it is necessary to use more plastisol when using hot air as the heat transfer medium than when using a liquid shower as provided herein. This is because it is necessary to make the walls defining the hobby horse thicker than necessary in the wider portions of the mold in order to obtain sufficient gellation and curing of the plastisol at the hocks and other thinner portions of the mold. In casting the hobby horse we have found there are the following significant differences:

	Liquid Shower Transfer Medium	Hot Air Transfer Medium
Temperature Range	350°–450° F.	550°–650° F.
Cold Rotation	30 seconds	30 seconds.
Gellation of total distribution at about 200° F.	1–1½ minutes	2–5 minutes.
Fusion after gellation at about 350° F.	1 minute	2–10 minutes.

We have found in the manufacture of the hobby horse with a hot air transfer medium that the total time for cold rotation plus the periods of gellation and curring after gellation require from 9 to 14 minutes and only about 4 minutes when using a liquid shower heat transfer medium of the kind disclosed above. At a temperature of from 150° F. lower the liquid transfer medium produces curing 50% to 60% faster. There is a raw material saving on the order of 10% due to better distribution of the plastisol.

Furthermore, the lower temperature used with a liquid shower heat transfer medium is easier on the molds and mold carries and results in a prolongation of their useful life. The lower temperature also extends the useful life of the cast product which, because of being exposed only to the lower temperatures, retains its physical properties and original color for a substantially longer period of time.

There has thus been disclosed a method for casting articles from heat setting materials in which the above mentioned objects are accomplished in a thoroughly practical manner.

What is claimed is:

1. The method of casting a hollow article from a plastic resin casting composition, which method comprises

partially filling a hollow mold of heat-conductive composition with said plastic composition,

closing said mold,

continuously washing the outer surface of said mold with a liquid heating medium heated to a temperature above 325° F. by spraying said heating medium thereon

while biaxially rotating said mold to provide substantially uniform transfer of substantially the total heat energy required to cure said plastic composition, from the heating medium to the mold surface,

thereby quickly distributing said plastic composition over the interior surface of said mold and heating said plastic composition quickly and substantially uniformly to a temperature of at least 300° F. to rapidly cure said plastic composition without substantial degradation or discoloration,

cooling said plastic composition and

removing the resulting hollow article from the mold.

2. The process of claim 1 in which the plastic added to the mold is a vinyl plastisol.

3. The process of claim 1 in which the plastic added to the mold is a polyethylene powder.

4. The process of claim 1 in which the heating medium is

water soluble, and

in which the cooling is accomplished by spraying said mold with water at a temperature lower than the temperature of the mold surface.

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