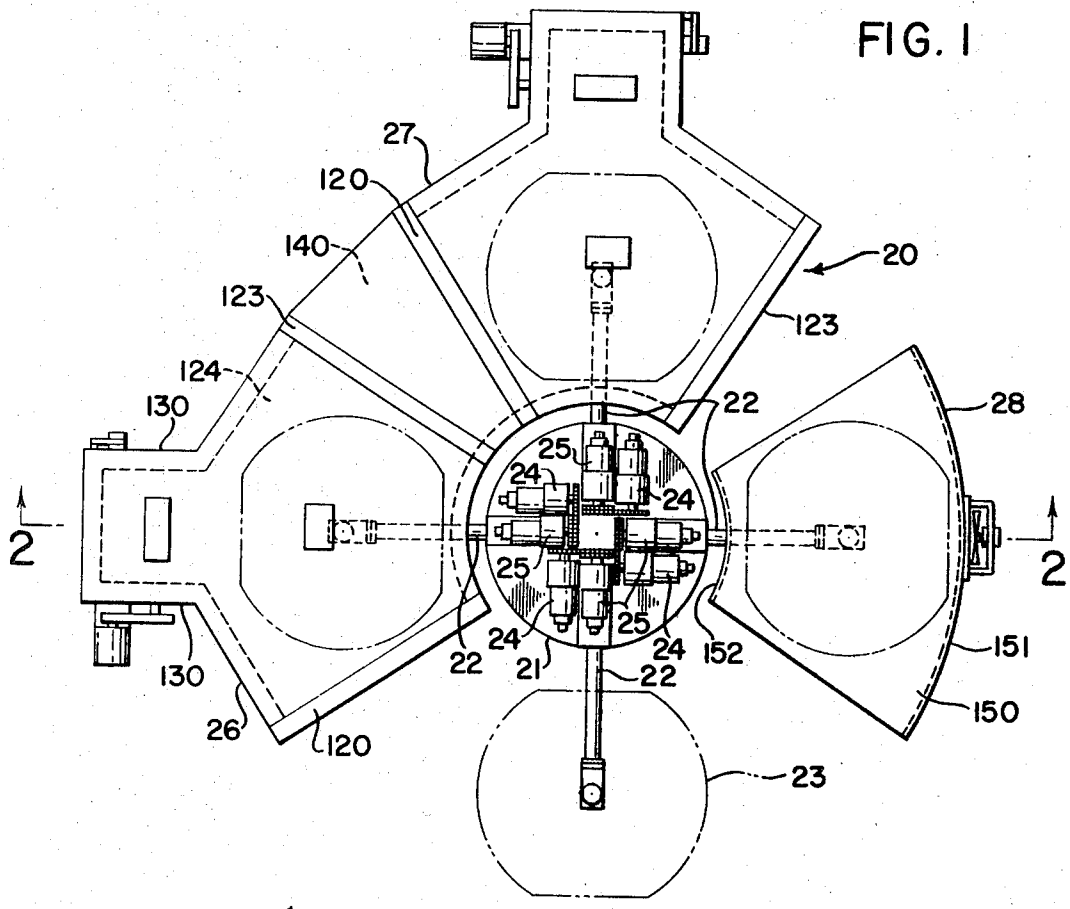
Dec. 29, 1970 E. J. VON DER HEIDE 3,550,206

ROTATIONAL CASTING APPARATUS

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FIG. 1



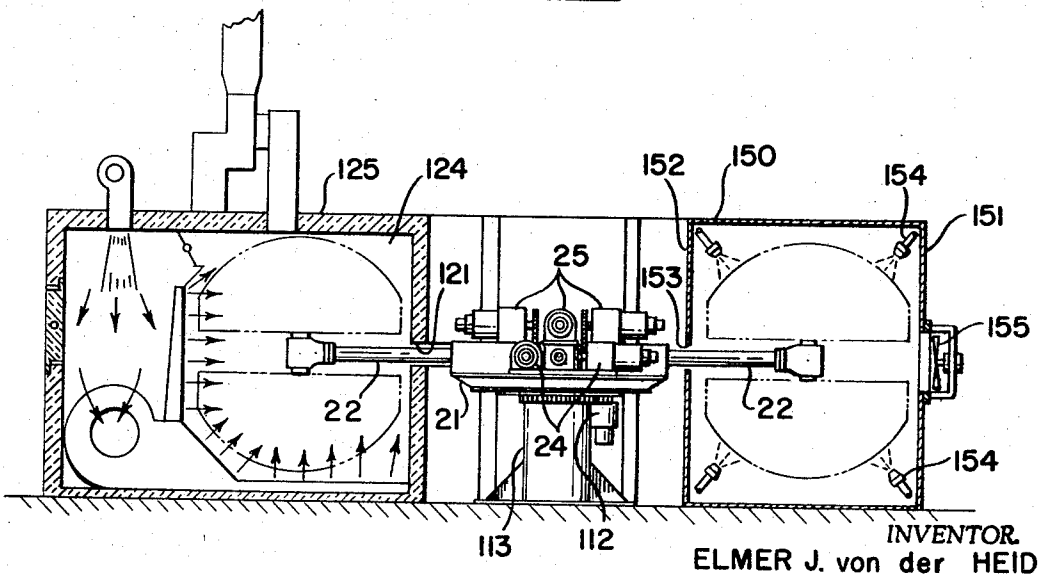


FIG. 2

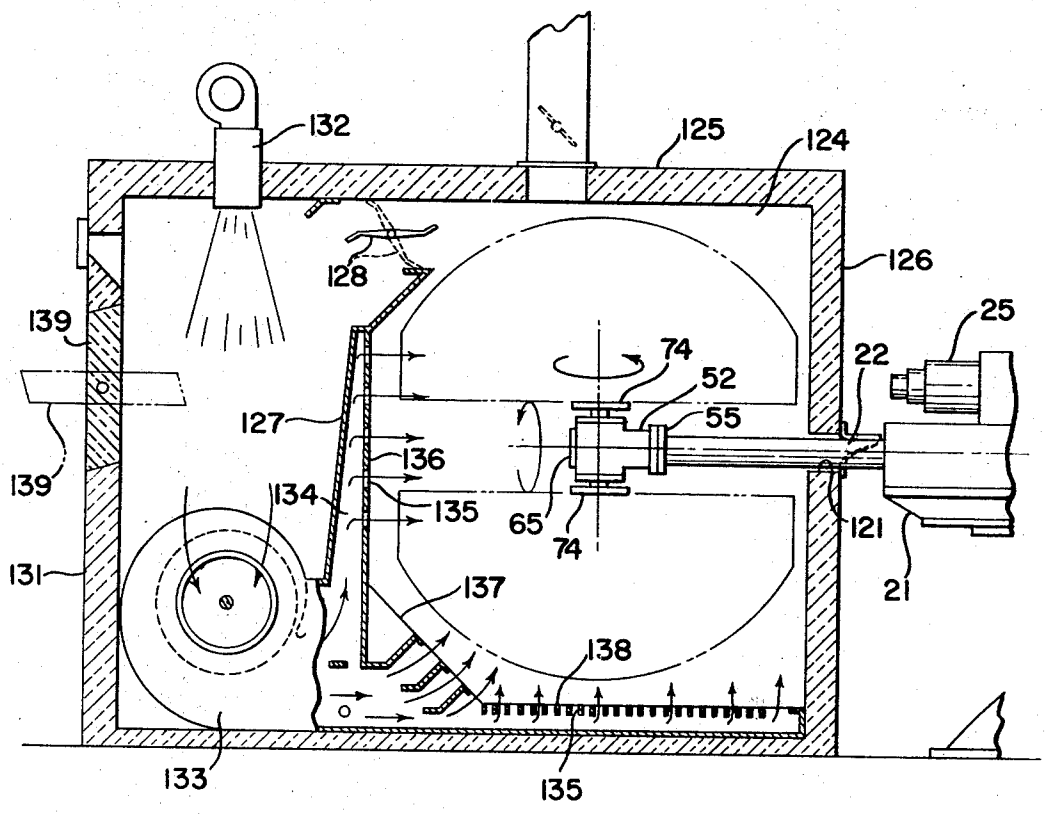
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ROTATIONAL CASTING APPARATUS

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FIG. 3



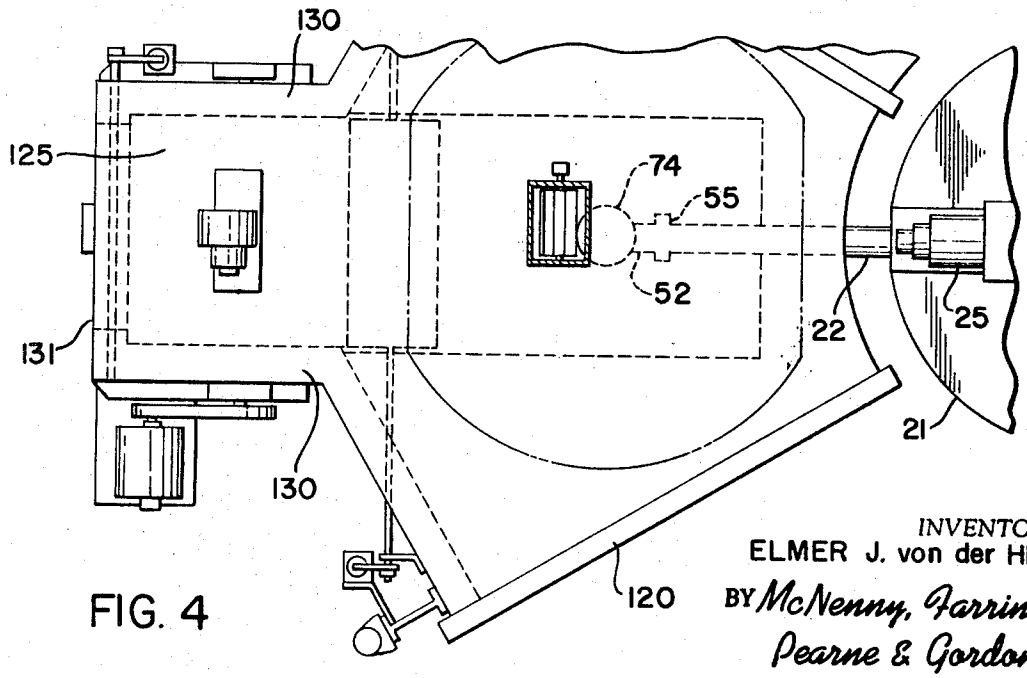


FIG. 4

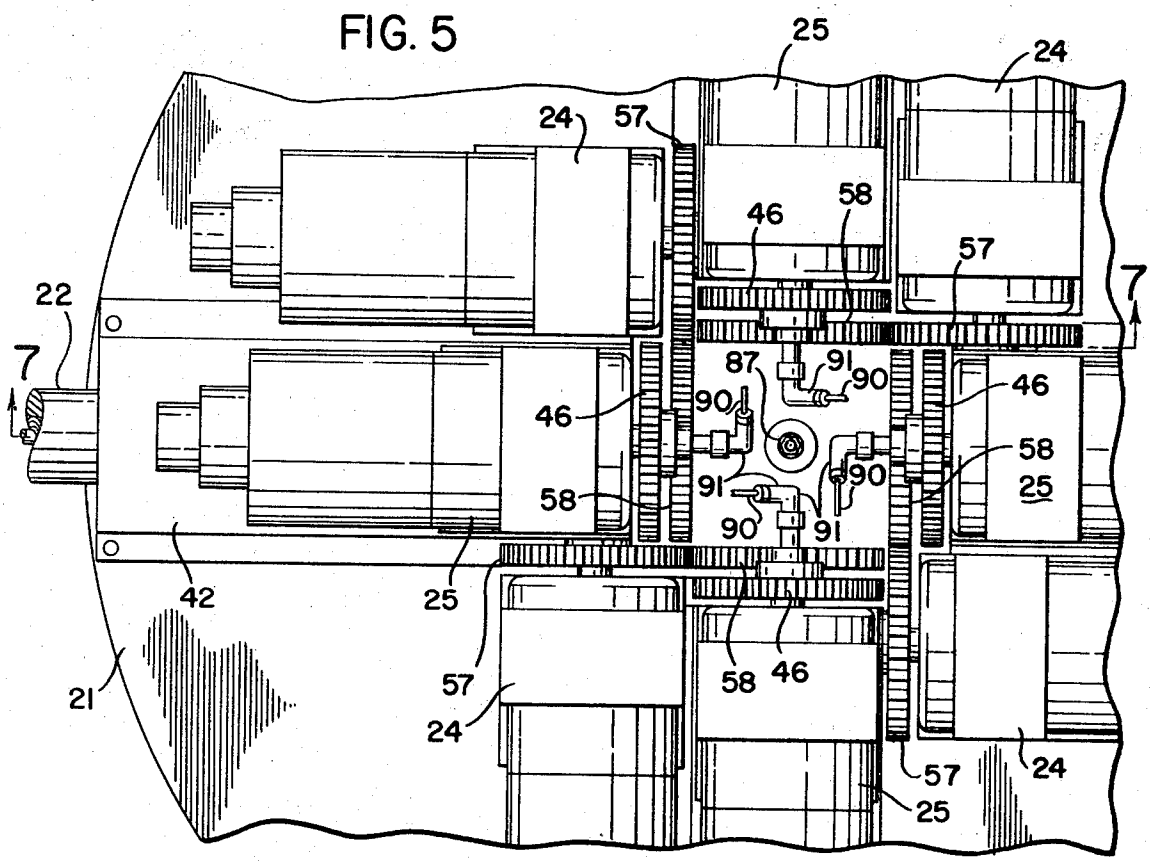
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FIG. 5



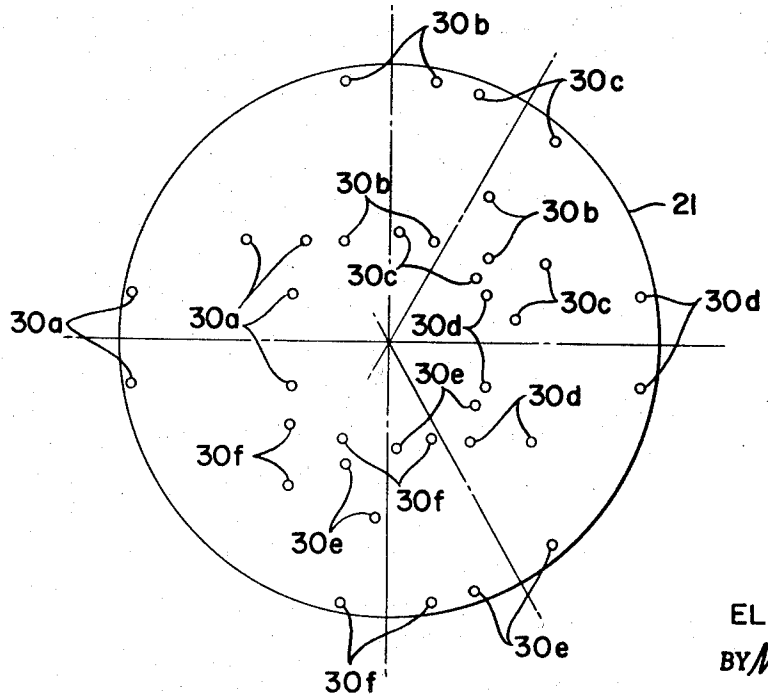


FIG. 6

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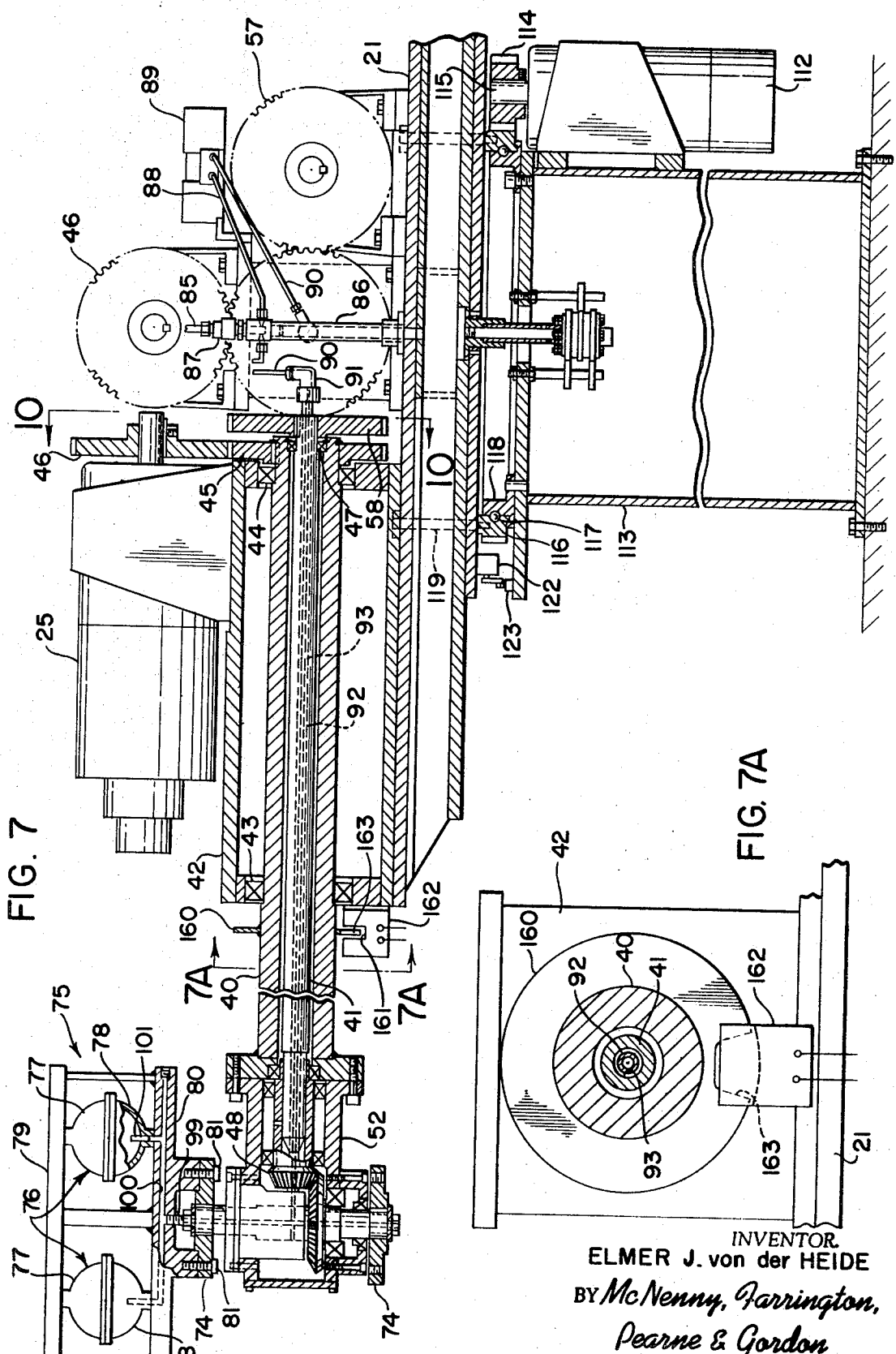


FIG. 7

FIG. 7A

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FIG. 8

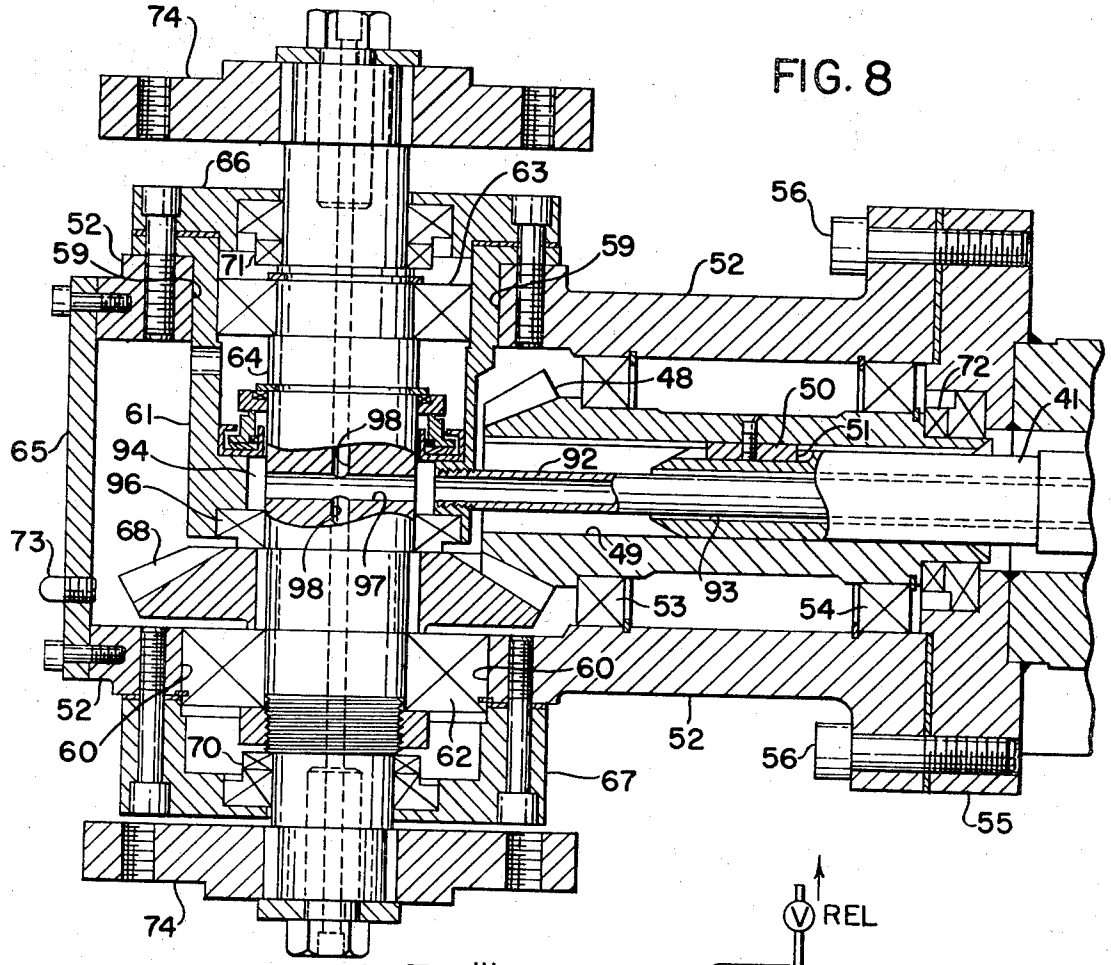
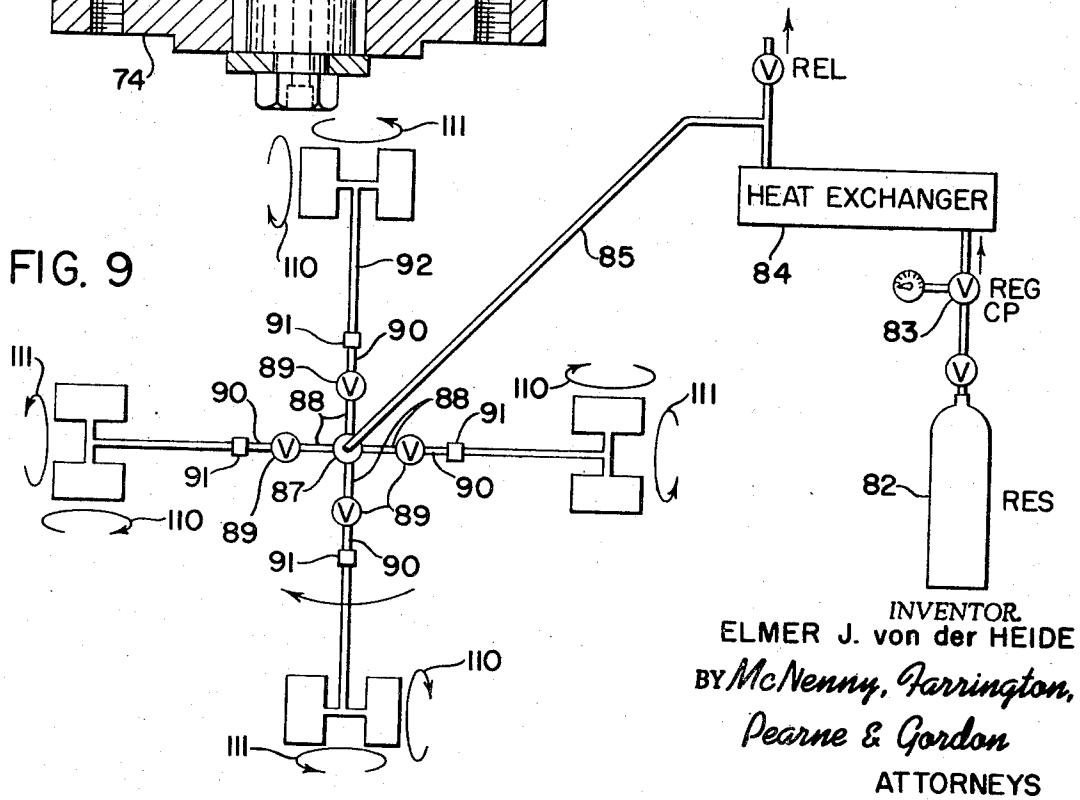


FIG. 9



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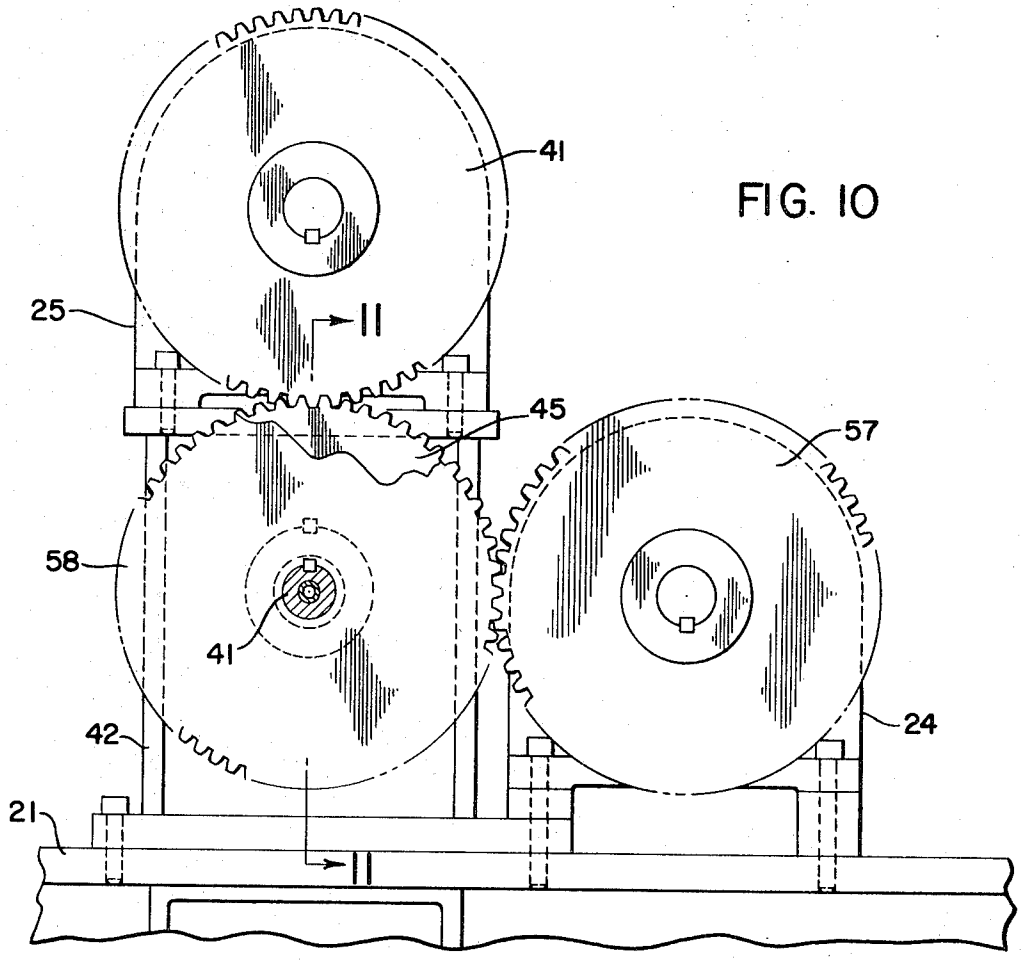


FIG. 10

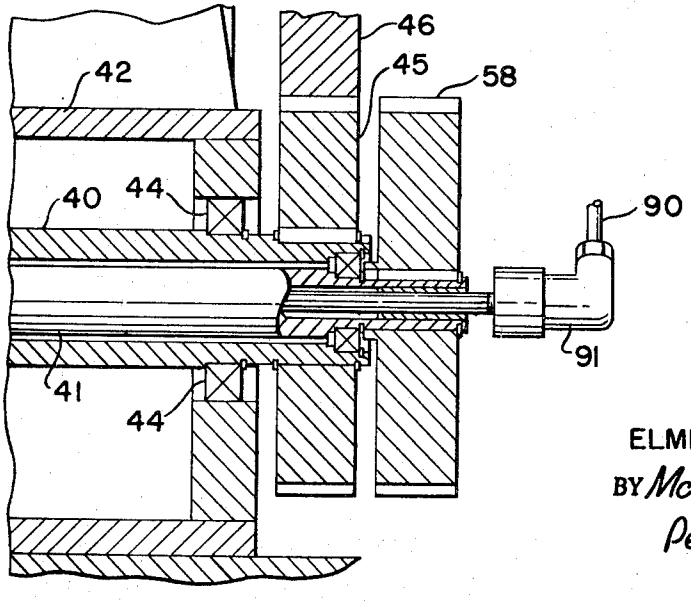


FIG. 11

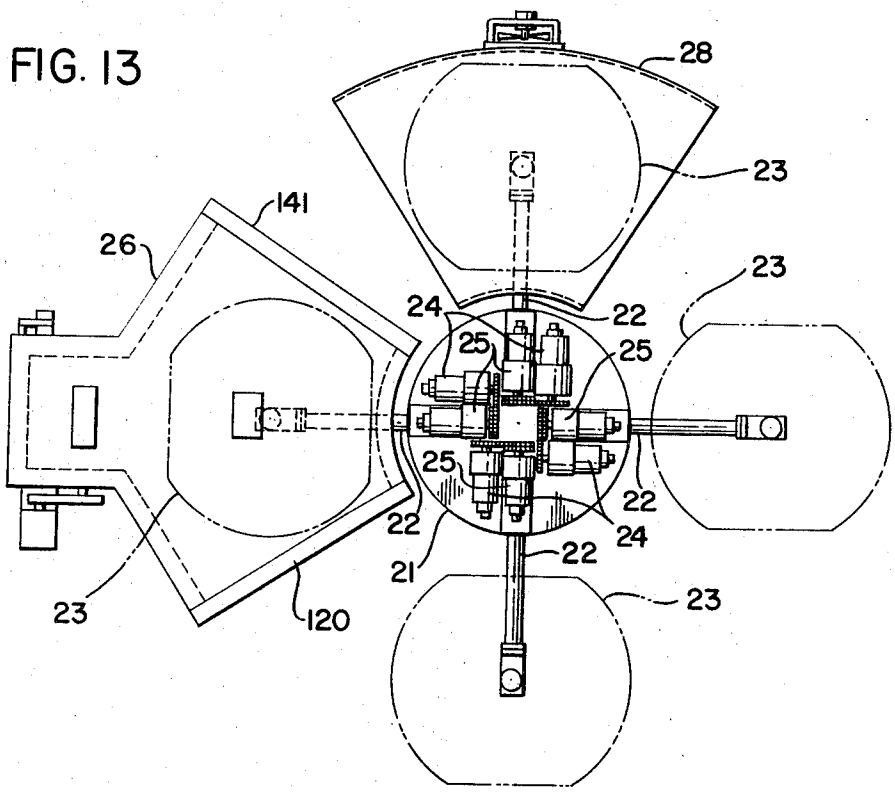
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FIG. 13



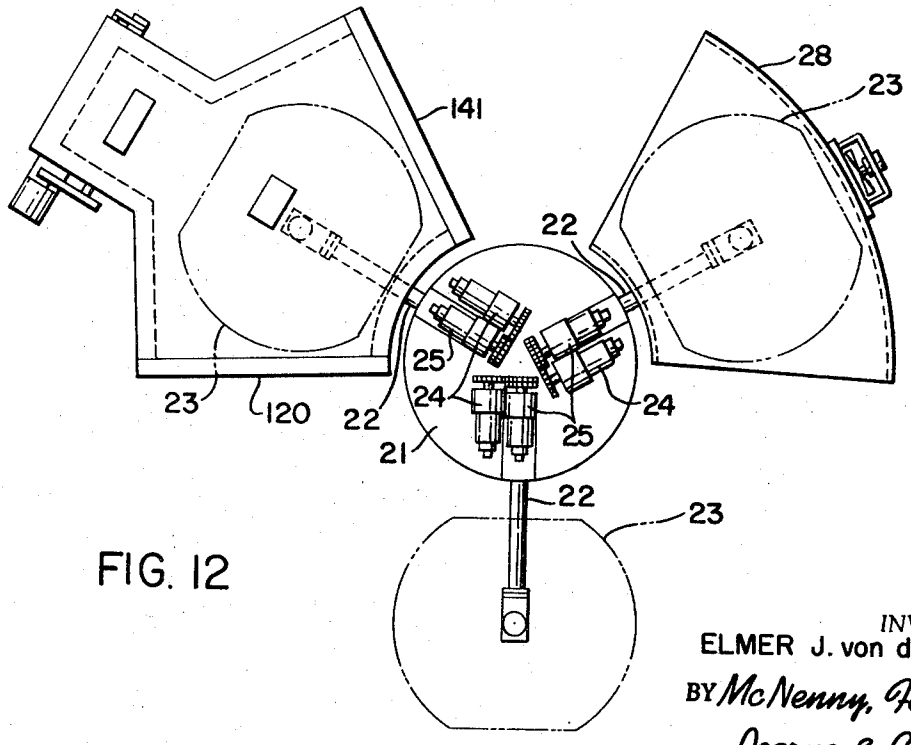


FIG. 12

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United States Patent Office 3,550,206 Patented Dec. 29, 1970

3,550,206

ROTATIONAL CASTING APPARATUS

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Filed Apr. 11, 1968, Ser. No. 720,700
Int. Cl. B29c 5/04
U.S. Cl. 18—26 19 Claims

ABSTRACT OF THE DISCLOSURE

A machine and method for rotationally molding or casting thermoplastic or thermosetting resinous compositions. The machine includes a rotatable turret on which at least one mold-rotating spindle and a pair of motor drives therefor are mounted as a removable unit with the spindle projecting radially outwardly from the turret. The spindle includes means for removably mounting a pair of molds on the outer end thereof for simultaneous rotation about a pair of perpendicular axes at the same or different speeds as determined by the speeds of the motor drives, which are independently variable. The turret has provision for mounting additional spindle and motor drive units thereon with equi-angular spacing of the spindles about the turret to satisfy varying output and/or process requirements. The machine further includes treating stations through which the molds on the spindle or spindles are successively indexed. The number, type, and location of the treating stations may be varied to suit a number of different molding processes. Inert gas may be fed into each mold cavity, and maintained therein at a predetermined positive pressure during any predetermined portion of the mold processing cycle after loading and closing the molds and until they are to be opened for removal of the molded or cast article. Separate ovens with independent temperature controls may be provided at successive stations. Cooling at a cooling station is two stage, first with a wet steam spray and second with a liquid coolant spray.

BACKGROUND OF THE INVENTION

Various machines and methods have been proposed for forming hollow articles by rotationally casting or molding liquid or particulate (solid) thermoplastic and thermosetting resins, such as vinyl plastisols, particulate polyethylene, polypropylene, and the like, and numerous other classes of resins. Hereinafter, the term "molding" will be used generically to include "casting." The machines developed for such molding operations employ molds comprising cooperating hollow mold sections which, when closed, define the external surface of one or more articles to be molded. A measured amount of resinous molding material in liquid or fusible solid form is placed within each mold cavity, and the mold is closed and rotated about a plurality of axes to cause the molding material to be distributed over and coat the interior of the mold cavity. While being rotated for that purpose, the mold is subjected to heat to convert the molding material to a settable fluid condition. In either case, the mold is then cooled and opened for removal of the finished article.

Prior art molding machines have usually been designed to perform a particular molding process or technique, depending upon the particular plastic material and size of the articles to be molded. For example, if the material

to be molded is a vinyl plastisol, a suitable molding machine would be provided with a conveyor mechanism (such as an indexing table or a loop conveyor) which successively conveys the mold from a mold loading station to an oven which heats the vinyl plastisol to a temperature sufficient to gel the plastisol while the mold is rotating and then to a cooling station where the molds are cooled by spraying water thereon to solidify the resin, sometimes while continuing the mold rotation. If the plastic is a particulate thermoplastic, the sequence of steps is the same, but the oven heats the molds to a temperature sufficient to liquefy the solid plastic.

Such molding operations have been performed heretofore with turret-type machines having a mold carrying spindles radially extending from an indexing table. The mold carrying spindles are indexed through treating stations, such as ovens, cooling chambers, and loading and unloading stations. However, such machines have generally been provided by the manufacturers with the required number of spindles, molds, and processing stations for operation according to a predetermined process and time cycle with little flexibility. Thus, when a plastic molder had fluctuating or radically differing production requirements, he often found it uneconomical to operate a large volume rotational casting machine during periods of low production or to apply a low volume machine to a high volume molding operation, or he often was unable to adjust a machine to vary the processing conditions as required by different molding jobs. Since most prior art rotational molding machines cannot readily be modified to accommodate such varying production requirements, the plastic molder faced obvious problems in equipping his plant and using his equipment efficiently and economically.

SUMMARY OF THE INVENTION

The machines and processes of the present invention enable a plastic molder to modify the machine and/or the method or process performed by the machine to suit drastically different plastic molding operations and widely varying production requirements with a high degree of process control.

According to this invention, a molding machine includes a rotating turret having one or more mold carrying spindles and motor drives therefor with each spindle and its motor drives being mounted as a separate unit on an indexing table. Each spindle has an outer, hollow, rotatable shaft or sleeve which both supports and rotates a mold or group of molds about a first axis and a second shaft within the outer sleeve which drives the mold or molds about a second axis angularly related to the first axis without being required to perform a mold supporting function. Separate motor drives are provided for each spindle for independently driving the outer sleeve and inner shaft thereof throughout the molding and cooling operations. The outer sleeve of each spindle is mounted within and supported by bearings which are removably attached to the indexing table, so that the drive means for the outer sleeve and inner shaft of the spindle are wholly independent of the spindle supporting bearings and perform no spindle supporting function.

A molding machine according to this invention may be easily modified by relatively unskilled plant personnel to perform different molding operations by adding, removing, and/or rearranging the positions of mold carry-

ing spindles, oven, and/or cooling chambers. A plastic molder may, therefore, initially acquire a machine having, for example, only one mold carrying spindle, one oven, and one cooling chamber for pilot operations, and thereafter add on to his machine as production requirements increase. Moreover, he may rearrange mold carrying spindles, oven, and/or cooling chambers to perform different plastic molding operations with the same molding machine and/or obtain the desired production rate with optimum efficiency and quality control.

Thus, the present invention provides a versatile and inexpensive molding machine which will accommodate a wide variety of production techniques and volume requirements for plastic molding operations.

The invention further contemplates a molding machine and method which controls degradation of the resin being molded at elevated temperature and also controls shrinkage and distortion of the molded articles during cooling. To this end, the apparatus includes means for feeding inert gases into molds to scavenge air from the molds, which might tend to oxidize and degrade the resin at elevated temperatures, and to maintain a predetermined inert gas pressure inside the articles being molded until they have been cooled for removal from the molds. The latter function not only serves to control shrinkage and distortion but, also, prevents excessive pressure build-up in the molds during the heating cycle while avoiding the use of conventional mold vents and the problem of preventing a cooling liquid from entering the molds through such vents during the cooling operation. In accordance with this aspect of the invention, there is provided a gas passageway from inside a mold to and along a spindle axis to a point adjacent a spindle support location. One end of the passageway opens inside the mold and inside the article being molded therein and the opposite end of the passageway opens adjacent the spindle support.

With or without employing an inert gas supply and pressure relief system for controlling mold pressures and minimizing shrinkage and distortion, the shrinkage and distortion can also be reduced by controlling the cooling of the molds. It has been customary in the past to cool the molds by spraying them with water or other liquid coolant, sometimes after a preliminary quench by blasting the molds with air at room temperature. Such techniques usually cause differential shrinkage and product distortion, since a part only of the mold that is inevitably first contacted by the water spray cools faster than the remaining part of the mold. According to this invention, the molds may be initially cooled by wet steam, uniformly and rapidly, to a point only slightly below the setting temperature of the plastic. Although the wet steam is hotter than the water heretofore sprayed on the molds, the steam movement and scrubbing effect of the wet steam on the mold surface, together with the greater ease of contacting the entire outer surface of the mold substantially simultaneously with the cooling medium, combine to give a more rapid initial cooling with greater uniformity so as to avoid differential shrinkage. The preliminary steam quench may then be followed by a water spray cooling step to reduce the temperature of the molds to a convenient handling temperature and an air blast to dry the molds. The apparatus of the invention permits the use of any other desired sequence of air, steam, and water cooling steps.

DESCRIPTION OF VIEWS OF THE DRAWINGS

FIG. 1 is a partly schematic plan view of a rotational molding machine in accordance with this invention.

FIG. 2 is a cross-sectional view of the machine of FIG. 1, the plane of the section being indicated by the line **2—2** in FIG. 1.

FIG. 3 is an enlarged, fragmentary, cross-sectional view similar to FIG. 1, showing in somewhat more detail a heating oven employed in the machine and the flow of heating fluid relative to molds within the oven.

FIG. 4 is a fragmentary plan view of the oven shown in FIG. 3.

FIG. 5 is an enlarged plan view of the drive means for each mold carrying spindle illustrated in FIG. 1.

FIG. 6 is a plan view of an indexing table upon which different numbers of mold carrying spindles may be mounted in accordance with this invention.

FIG. 7 is an enlarged, fragmentary, cross-sectional view of the same machine, the plane of the section being indicated by the line **7—7** in FIG. 5.

FIG. 7A is a fragmentary transverse section of the machine taken as indicated by the line **7A—7A** in FIG. 7 and showing a control switch assembly for the power circuit to a spindle driving motor.

FIG. 8 is an enlarged cross-sectional view of the mold carrying end of the spindle illustrated in FIG. 7, showing that portion in greater detail.

FIG. 9 is a schematic plan view of a fluid supply system for the mold cavities.

FIG. 10 is an enlarged fragmentary, elevational view of the same machine, the view being taken as indicated by the line **10—10** in FIG. 7.

FIG. 11 is a fragmentary cross-sectional view of the same machine, the plane of the section being indicated by the line **11—11** in FIG. 10.

FIG. 12 is a partly schematic plan view of a rotational casting machine having three mold carrying spindles and treating stations according to a further aspect of this invention.

FIG. 13 is a partly schematic plan view of another rotational casting machine having four mold carrying spindles and treating stations according to a still further aspect of this invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to FIGS. 1 and 2, a rotational casting machine **20** according to one aspect of the present invention includes an intermittently driven turntable **21** upon which four radially projecting, mold carrying spindles **22** are removably mounted. Each spindle **22** carries a mold or group of molds at the outer end thereof. In the drawings, the mold or mold group is generally indicated by phantom outline **23**, which outline also delineates the envelope traced by the mold or group of molds during their rotation about two axes. Such biaxial rotation, as will be explained in greater detail, is provided by independent drive means for each axis of each spindle **22**. For this purpose, each spindle **22** is provided with first and second drive motors **24** and **25**.

The machine illustrated in FIGS. 1 and 2 is provided with four treating or process stations for performing a two-stage heating operation and a single-stage cooling operation. To this end, there is provided a first oven **26**, a second oven **27**, and a cooling chamber **28** at successive stations, the fourth station being employed to empty and reload the molds. As further explained below, the two ovens **26** and **27** may be connected by a shroud to conserve heat and avoid chilling the molds while being indexed from the first oven to the second oven.

The character and arrangement of the four stations illustrated in FIGS. 1 and 2 are suitable, for example, for the rotational molding of vinyl plastisols. When using such a molding composition, the sequence of operations would involve loading the molds at a first station (the lowermost station illustrated in FIG. 1, heating the rotating molds at a second station in the oven **26** to gel the material being molded, continued heating of the molds at a third station in the oven **27** to complete the molding of the resin (with or without further raising its temperature) while continuing to rotate the molds, cooling the molds at a fourth station in the cooling chamber **28** to solidify and cool the molded articles while still continuing the mold rotation, and then unloading and reloading the molds at the first station.

The machine shown in FIGS. 1 and 2 may also be

employed to mold any of a variety of liquid, thermosetting resin compositions. for example, various phenolic or melamine resins, dispersions of acrylonitrile-butadiene-styrene resins, and the like may be cured during the molding operation to a final, thermoset condition. Similarly, meltable solid or liquid resin mixtures, or mixtures of resins and cross-linking agents, may be heated during the molding operation to effect a cross-linking of the resin molecules and produce thermoset, molded, plastic end products. In such cases, the heating of the rotating molds successively in the ovens **26** and **27** at the second and third stations may be regulated as required by the particular resin or resin mixtures charged to the molds at the first station. The molded and solidified articles would then be cooled by cooling the molds in the cooling chamber **28** at the fourth station and would be unloaded from the molds at the unloading and reloading station. Obviously, if desired, a single oven **26** at the second station could be followed by two cooling chambers or by a single elongated cooling chamber at the third and fourth stations.

Most of the above processes may also be carried out in the single oven machines of FIGS. 12 and 13, the only procedural change required in some cases being that of repeatedly raising and lowering the oven temperature for holding a particular molding composition at a plurality of curing temperatures for predetermined time periods.

As may be seen in FIG. 13, the same four-spindle molding machine may readily be modified to employ a single oven **26** at one station, a cooling chamber **28** at the next station, and separate unloading and loading operations at the other two stations. This is advantageous in molding operations that involve mold loading and unloading steps that are slow and cannot both be performed at a single station within the predetermined time period allocated for each dwell of the mold assemblies at the successive stations. This may occur, for example, when each mold involves a number of cavities, each containing complex arrangements of inserts.

Alternatively, as may be seen in FIG. 12, a three-spindle molding machine may be assembled on the same indexing table **21** and employ the single oven **26** and the cooling chamber **28** by placing the single oven and cooling chamber one-hundred twenty degrees apart. As still further alternatives, only two spindles or only one spindle may be used on the indexing table with the station arrangement of FIG. 1, FIG 12, or FIG. 13.

A plastic molder may begin pilot plant operations using a single mold carrying spindle **22** and associated drive motors **24** and **25** and mounting them on an indexing table **21** for movement through the stations of any FIGS. 1, 12, or 13. This may be done with a modest investment in equipment. As the table **21** is indexed, the mold assembly on the single spindle **22** will successively move from station to station according to the particular cycle determined for molding a particular article while using the particular station arrangement selected.

To increase production as business may require, the plastic molder may first acquire only one or more additional spindles **22** and add them to the original table **21** while using the same station arrangement as before or a modified station arrangement. If he started with the three-station arrangement of FIG. 12, for example and requires four spindles **22** to meet production requirements, he may simply rearrange the oven **26** and cooling chamber **28** as shown in FIG. 13. Alternatively, by also adding a second oven unit **27**, he may convert his machine to one having the dual oven arrangement of FIG. 1. Obviously, by reversing such evolution of the machine, the high capacity machine of FIG. 1 may be turned into an efficient low capacity machine.

It should be appreciated from the foregoing that this invention permits a plastic molder to modify his machine according to production requirements, both as regards production volume and processing operations, to perform a wide variety of different plastic molding operations with the basic machine elements of this invention.

To facilitate the kinds of conversions just described, the turntable **21** may be provided with a plurality of sets of mounting holes **30***a*, **30***b*, **30***c*, **30***d*, **30***e*, and **30***f*, arranged as shown in FIG. **6** so the turntable **21** may carry from one to four spindles **22**. One set of holes **30***a* **30***b*, **30***c*, **30***d*, **30***e*, or **30***f* may be employed to mount a single spindle; any two opposite sets of holes **30***a* and **30***d* or **30***b* and **30***f* may be employed to mount two spindles; the three sets of holes **30***a*, **30***c*, and **30***e* may be employed to mount three spindles; and the four sets of holes **30***a*, **30***b*, **30***d*, and **30***f* may be employed to mount four spindles.

Referring now to the details of the spindle and mold assemblies and drives therefor as shown in FIGS. 5 and 7–11, the spindle **22** is a unit which include a hollow outer sleeve **40** and an inner shaft **41**. The outer sleeve **40** extends through a supporting bearing box or spindle housing **42** and has a substantial portion of its length contained within the box and supported by bearings **43** and **44** at each end thereof. One end of the sleeve **40** extends radially inwardly beyond the bearing **44** and is provided with a spur gear **45** which is keyed to the sleeve **40**. The spur gear **45** is driven by a spur gear **46** which is keyed to the output shaft of the drive motor **25**. The drive motor **25** is mounted on top of the box **42** to conserve space.

The inner shaft **41** is mounted within the hollow sleeve **40** for independent axial rotation relative thereto by a bearing **47** at the radially inward end thereof. The radially outward end of the shaft **41** is keyed to the hub of a bevel gear **48**. As may be seen most clearly in FIG. 8, the bevel gear **48** and its hub have a bore **49** which receives the radially outer end of the shaft **41** and is provided with a key **50** which cooperates with a slot **51** in the shaft **41**. The bevel gear **48** is rotatably mounted within a gear box or housing **52** by bearings **53** and **54**. The housing **52** is removably secured to a flanged end portion **55** of the outer sleeve **40** by bolts **56**. The housing **52** is thereby rotated with the outer sleeve **40**, and the bevel gear **48** is driven by the inner shaft **41** relative to the outer sleeve **40** and the housing **52**.

The inner shaft **41** and its bevel gear **48** are driven by the motor **24** through a spur gear **57** connected to the drive shaft of the motor **24** and a cooperating spur gear **58** which is keyed to a projecting end of the shaft **41**.

The housing **52** is provided with axially aligned, transverse bores **59** and **60**, which are respectively provided with an inner housing member **61** and a bearing **62**. Another bearing **63** is mounted within the inner housing member **61**. A cross shaft **64** is rotatably mounted with respect to the housing **52** by the bearings **62** and **63** and projects in both directions beyond the bores **59** and **60** for the attachment of mold assemblies as described below. The housing **52** is closed at its outer end by a plate **65**, at one side by a cap **66**, and at its diametrically opposite side by a cap **67**. As shown (FIG. 8) the shaft **64** projects in opposite directions through the caps **66** and **67** and is journaled therein.

A bevel gear **68** is keyed to the shaft **64** within the housing **52** and is driven by the bevel gear **48** so that the shaft **64** is driven about its axis relative to the housing **52** by the drive motor **24**.

The bearings **62**, **63**, **53**, and **54** and the bevel gears **48** and **68** are enclosed and sealed in a chamber defined by the housing **52** and housing member **61**, by oil seals **70** and **71** on the shaft **64**, and by an oil seal **72** between the bevel gear **48** and the flange **55**. That chamber forms a lubricant reservoir so that those bearings and bevel gears are immersed in lubricant, which may be admitted through a plug **73** in the end plate **65**.

Each end of the transverse shaft **64** is provided with a mold mounting plate **74**. A suitable mold or mold assembly **75** (FIG. 7) is mounted on each of the plates **74** (only one such assembly being shown). The mold assembly **75** may include a plurality of subassemblies **76** de-

fining separate mold cavities, each cavity being formed by two separable mold section **77** and **78**. Each mold section **77** is mounted on a frame **79**, and each mold section **78** is mounted on a frame **80**. The frame **79** and its mold sections **77** may be removed from the frame **80** and its mold sections **78** by uncoupling suitable quick-disconnect clamps (not shown). The frame **80** is attached to its mold mounting plate **74** by a plurality of bolts **81**.

Each spindle **22** and its mold assembly **75** is provided with means for feeding inert gas into each mold cavity to purge air therefrom which might tend to oxidize and degrade the resin being cast. To this end, there is provided a source of pressurized inert gas, such as the reservoir **82** (FIG. 9). The reservoir **82** delivers its inert gas through a constant pressure regulating valve **83**, a heat exchanger **84**, and a supply line **85** to a distributor manifold **86** (FIG. 7) which is connected to the supply line **85** by a rotatable coupling **87**. The manifold **86** is fixed to the table **21** and has a plurality of branch conduits **88** which are respectively connected to a corresponding plurality of on-off valves **89**. The valves **89** are successively turned on by a cam operated switch **122** which engages a cam **123** (FIG. 7) as the spindle **22** is indexed from the mold loading position. One of the valves **89** is provided for each spindle **22**, and each valve **89** has an outlet conduit **90** connected to its spindle **22** by a rotatable coupling **91**.

Each rotatable coupling **91** is in fluid communication with the radially inner end of a delivery tube **92** which extends through an axial bore **93** in the shaft **41**. The tube **92** is suitably journaled in the bore **93** for independent rotation relative to the shaft **41**. The outer end of the tube **92** is threadedly engaged with and, therefore, driven by the housing member **61** that rotates with the outer sleeve **40**. The tube **92** communicates with a chamber **94** within the housing member **61** that surrounds the transverse shaft **64** therein, opposite ends of the chamber **94** being closed by seals **95** and **96** acting between the shaft **64** and the member housing member **61**. The chamber **94** is, in turn, in fluid communication with a transverse bore **97** and an axial bore **98** in the shaft **64**.

The axial bore **98** is coupled at **99** (FIG. 7) to a passageway **100** in the frame **80**, and the passageway **100**, in turn, communicates with the cavity of each mold subassembly **76** through a tube **101** that projects well into the mold cavity to near the center thereof so that its open end will not be covered or plugged with resin during the molding operation.

After a measured amount of resin material to be molded is deposited in each mold cavity at the mold loading station and those molds are closed, the valve **89** on the associated spindle **22** is opened upon indexing of the table **21** and actuation of the switch **122** thereon to admit presurized inert gas to the closed mold. The inert gas pressure causes leakage of the molds at their parting planes and scavenges air from the molds which would otherwise tend to oxidize and degrade certain molding resins when heated. When liquefied resin has coated the interior of the molds as a result of their rotation in the oven **26**, the resin seals the molds against further leakage at their parting planes, and the inert gas pressure established by the regulating valve **83** is maintained inside the articles being molded during the balance of the molding and mold cooling operations.

The gas supply to the molds on a given spindle is cut off as the molds are moved from the cooling chamber toward the unloading station by further indexing of the table **21**. This may be done by means of another appropriately located cam (not shown), like the cam **123**, for again actuating the switch **122**. For this purpose, the switch **122** may be a step switch or the like for alternately closing, opening, and closing a circuit on successive operations.

By setting the valve **83** to establish and maintain a predetermined positive gas pressure in the molds, shrinkage and distortion of the molded articles during the cooling step (when a partial vacuum inside the hollow articles would otherwise be created) can be materially reduced and more nearly perfect products can be made with greater consistency and less scrap loss. Generally, that predetermined gas pressure should be from around 2 p.s.i. gauge up to as high as 10 p.s.i. or so as limited primarily by the strength of the mold assembly.

If it is not desirable or necessary to admit gas to the molds, the gas supply and regulating system of FIG. 9 from the reservoir **82** to the rotatable joints **91** on each spindle tube **92** may simply be omitted or disconnected from the spindle tubes. Thus, the several mold cavities are still vented to the atmosphere at the center of the turret so that moisture from the cooling chamber **28** will never be drawn into the mold cavities during the cooling operation.

After the molds are loaded and closed at the loading station, the motors **24** and **25** on the associated spindle **22** are energized to rotate the mold assemblies **75** about two axes. Rotation about one such axis is caused by the motor **24** which drives the inner shaft **41** about its axis. Such rotation of the shaft **41** drives the bevel gears **48** and **68**, and, therefore, the shaft **64** about its axis. Rotation of the shaft **64** about its axis causes the mold assembly **75** to be rotated about the axis of the shaft **64** in the direction of the arrow **110** (FIG. 9).

As the mold assembly **75** is rotated about the axis of the shaft **64** in the direction of the arrow **110** by the motor **24**, the motor **25** rotates the outer sleeve **40** about its axis. Rotation of the sleeve **40** about its axis causes the shaft **64** to be rotated about the axis of the sleeve **40**. The mold assembly **75** is thereby also rotated about the axis of the sleeve **40** in the direction of the arrow **111** (FIG. 9).

The relative speeds of the motors **24** and **25** may be independently varied to suit a particular molding operation. These relative speeds are preselected and are primarily dependent upon the shape of the article to be molded. This mold rotation, like the flow of inert gas (when used), is started and stopped automatically by suitable cam and switch controls (not shown) actuated by indexing of the table **21**. Such rotation is continued during all of the treating operations performed on the molds and during the indexing operations between treating stations so that once the motors **24** and **25** are energized they are not deenergized until the mold assembly **75** returns to the mold unloading station.

The loaded and rotating mold assemblies **75** are in dexed to the oven **26** (FIGS. 1, 2, 12, and 13) by driving the table **21** in a clockwise direction. The drive means for the table **21** comprises a drive motor **112** (FIGS. 2 and 7) which is mounted on a pedestal base **113**. A pinion gear **114** on a power input shaft **115** of the drive motor **112** drives a ring gear **116** in a clockwise direction with respect to the base **113**. The inner surface of the ring gear **116** comrpises a bearing race which cooperates with ball bearings **117** and a stationary bearing race **118** which is fixed to the pedestal base **113**. The table **21** is connected to the ring gear **117** by bolts **119** so that the table is driven in a clockwise direction by the ring gear **116**. The motor **112** is started and stopped according to any preselected time cycle of operation by any conventional timer control (not shown).

Upon rotation of the table **21**, the mold assemblies **75** on the outer end of a spindle **22** enter the oven **26**. To permit such entry into the oven **26**, a door **120** is raised by a suitable door opening mechanism (not shown). The inner face or wall of the oven **26** is provided with a horizontal slot **121** to provide clearance for the spindle **22**, the slot **121** preferably being largely closed by a depending curtain **122** that is simply deflected upwardly by the spindle as shown in FIG. 3. When the mold carrying spindle **22** positions the mold assembly **75** within the oven **26**, the motor **112** is stopped by a suitable control means (not shown) for a predetermined heating period.

The oven **26** provides a heating chamber **124** which is defined by a top wall **125**, an inner sidewall **126**, a heat directing baffle assembly **127**, a damper **128**, the entrance door **120**, and an exit door **123**. The oven **26** further includes a fuel delivery chamber **129** which is defined by the baffle assembly **127**, the damper **128**, the top wall **125**, sidewalls **130**, and a rear wall **131**. A burner nozzle **132** extends through the top wall **125** into the fuel delivery chamber **129** and may be a natural gas burner which heats air in the chamber **129**. The heated air is delivered by a centrifugal fan or blower **133** into the baffle assembly **127** which forms a distribution chamber **134**. The baffle assembly **127** has a multiplicity of outlet openings **135** which are preferably adjustable in size and are distributed over a vertical wall portion **136**, an oblique wall section **137**, and a horizontal wall portion **138** of the assembly **127**, so that heated air will be distributed around the rotating molds within the heating chamber **124** for uniformly heating the molds and the plastic material contained therein. As indicated by arrows in FIG. 2, the heated air is directed so as to flow over all surfaces of the rotating molds by the distribution of the baffle openings, including the opposed surfaces of the two mold assemblies which are swept by the hot air directed axially toward the mold supporting end of the spindle **22** between the mold assemblies. The damper **128** controls the total volume of air which is admitted to the delivery chamber **129**, and its distribution can be regulated by adjusting the sizes of the baffle openings.

The wall **131** of the delivery chamber **129** is provided with an electrically controlled and powered, quick opening, "panic" door **139**, which may be quickly opened as a safety precaution if a mold carrying spindle **22** cannot be indexed from the heating chamber **124** at the proper time. By opening the "panic" door **139** and turning off the fuel nozzle **132**, cool air will be drawn through the opening provided by the door **139** and directed around the rotating molds within the chamber **124**. At the same time that the "panic" door **139** is opened by an appropriately located "panic" control button (not shown) the main oven doors **120** and **123** are also opened. This may be effected automatically by any suitable interlock system (not shown) for opening the main oven doors in response to operator actuation of the "panic" button, as well as by indexing of the table **21**. Thus, whenever indexing of the table **21** is delayed by mold unloading or loading problems, for example, the machine operator, by actuating the "panic" button, may rapidly cool the oven **26** and thereby avoid charring the resin in the molds within the oven and the mold cleaning problems that would result.

When the predetermined treating time in the oven **26** has elapsed, the motor **112** is again energized to open the oven exit door **123** and index the rotating molds from the oven **26** to the oven **27** (FIG. 1) or to the cooling chamber **28** (FIGS. 12 and 13) if the process does not require a second heating operation. The oven **27** may be joined to the oven **26** by an enclosure **140** to minimize the loss of heat and chilling of the molds during their transfer from the first oven to the second oven. The oven **27** in FIG. 1 and the ovens **26** of FIGS. 12 and 13 may be identical with the oven **26** of FIG. 1 and, therefore, will not be shown or described in detail.

The doors **120** and **123** for the oven or ovens are necessarily simultaneously actuated if the machine employs as many spindles as processing stations (FIGS. 1, 12, 13), and this is most suitably done in response to indexing of the table **121** by the controls mentioned above. Otherwise a separate control for each door is required.

A temperature differential may be maintained between the ovens **26** and **27**, by appropriate setting of conventional, separate, burner and damper controls (not shown) for the two ovens, as process requirements may dictate. Commonly, a higher temperature will be maintained in the first oven **26**, well above the temperatures reached by the molds and their contents during the dwell of the molds in that oven. In that case, the temperature in the second oven may be held at a level to maintain or only slightly raise the temperatures of the molds and their contents above the temperatures created in the first oven. On the other hand, when the resin being molded is of a thermosetting type, for example, a first stage reaction temperature may be developed in the first oven maintained at one oven temperature, and a second stage reaction temperature may be developed in the second oven maintained at a second, higher, oven temperature. Various other heating cycle requirements are satisfied more readily and with better control by employing the dual oven arrangement of FIG. 1 than would be possible with a single, elongated oven chamber enclosing a plurality of heating stations.

After completion of the heating operation in the second oven **27** (FIG. 1), or after completion of a single-stage heating operation in a single oven **26** (FIGS. 12 and 13), the spindle **22** and its mold assemblies **75** are indexed to the cooling chamber **28** in all forms of the machine. The cooling chamber **28** (FIGS. 1 and 2) is defined by a top wall **150**, an outer sidewall **151**, and an inner sidewall **152**. The inner sidewall **152** is provided with a horizontal opening **153** (FIG. 2) to permit the spindle **22** to move the mold assembly **75** into position within the cooling chamber. The entrance and exit (radial) sides of the cooling chamber may be open to permit the entrance and exit of the mold assembly **75** or may be provided with automatically controlled doors to prevent outward splashing of a cooling liquid or an objectionable flow of cooling steam into a room in which the machine is located.

Within the cooling chamber, the mold assemblies may be first cooled with wet steam at about 5 to 50 pounds p.s.i. gauge and at a temperature of about 225° F. or somewhat higher, depending upon the solidification temperature of the particular resin if the resin is thermoplastic. To this end, there is provided a plurality of steam nozzles **154** which are directed toward the rotating mold assembly **75**. A fan **155** is provided to effect rapid air circulation over all surfaces of each mold **76**, either as a separate cooling step before cooling with steam or water, or as a means for accelerating drying of the molds after a water cooling step. The steam temperature is selected to provide rapid cooling to a point only slightly below the solidification temperature of a thermoplastic resin (generally around 300° F.) or to a comparable temperature if a thermosetting resin is being molded. After the mold temperature has been initially lowered by a steam spray cooling water is sprayed through the same nozzles **154**, or through separate nozzles if desired, to further cool the mold assembly to a temperature which will permit handling at the mold unloading and loading station.

After the mold assemblies have been cooled in the cooling chamber **28**, the table **21** is again indexed to move the cooled molds to the next station for unloading and, optionally, also for reloading. To facilitate unloading of the molds, it is desirable to stop the spindle rotation by the time the molds arrive at the unloading station and to do this so that the molds have the desired orientation for convenient unloading and reloading. To this end, a magnetically permeable (iron) disc-shaped vane **160** (FIGS. 7 and 7A) is concentrically mounted on the outer sleeve **40** of each spindle **22** for turning within a slot **161** of a vane switch **162** mounted on the outer end of the spindle housing **42**. The vane **160** is notched at **163** to provide an interruption of a magnetic flux path across the switch slot **161** through the vane **160** when the molds are in their desired loading and unloading orientation. In addition, for each spindle, two additional cams (not shown), like the cam **123**, and another step switch (not

shown), like the switch **122**, are respectively mounted on the table **21** and pedestal **113** at suitable locations for coaction to close and open the power circuits for the drive motors **24** and **25** associated with that spindle. This step switch and the vane switch **160** are connected in parallel in the motor power circuits so that both must open to stop the motors. Thus, after the step switch in the motor power circuits has been opened, the switch **162** is also opened the next time the notch **163** in the disc **160** arrives in the position shown in FIG. 7A so as to deenergize the drive motors for that spindle and stop the spindle rotation with the desired orientation of the molds. By using motors **24** and **25** having conventional dynamic breaking that stopping is substantially instantaneous.

As will be appreciated from the foregoing, this invention provides effective apparatus for carrying out a number of advantageous process steps which result in more efficient production of improved molded articles. One of these process steps in the feeding of inert gas to the molds, as described above, to minimize oxidation and degradation of the resin and to reduce shrinkage and permanent distortion of the molded articles by supporting them internally during cooling.

Another of these process steps is the above-described two stage heating of the molds and their contained resin, one stage at one of the process stations and the second stage at the succeeding process station. Since each dwell of the rotating table is necessarily of the same duration in a multiple spindle machine of the character shown in FIG. 1, such two stage heating at two stations makes more efficient cycling of the machine possible since most molding operations require a longer heating time than cooling time. The output of a machine having a given number of spindles may be increased as much as 100% by such use of two ovens and two heating stations, while providing greater processing flexibility as pointed out above.

Still another of these process steps is the two-stage cooling of the mold and molded article therein, first with a relatively high temperature fluid, such as wet steam, to quickly and uniformly lower the temperature of the molded article only slightly below the temperature at which a thermoplastic resin is completely solidified, and then with a liquid coolant, such as water, to complete the cooling operation. Despite the relatively high temperature of the wet steam, the water droplets therein flash into vapor when they contact the hotter molds, thus rapidly extracting heat while obtaining the greater surface scrubbing action of the steam spray and more rapid and complete envelopment of the molds by the cooling fluid. The result is rapid cooling at a more uniform rate over the entire surface of each mold and less product distortion from differential cooling. Though such two-stage cooling is relatively rapid, it is not quite as rapid as when the molds are initially contacted with a water spray and, therefore, reduces the cooling shock while the product is undergoing solidification.

Shock during the initial cooling may be still further reduced merely by delaying the steam cooling step and running the fan **155** (FIG. 2) to effect initial cooling in a current or room temperature air, then stopping the fan during the successive steam and water cooling steps, and finally restarting the fan to accelerate drying of the wet molds before they are indexed to the next station for unloading and reloading. As previously mentioned, any number and sequence of the air, steam, and water cooling steps described herein may be used to adapt the cooling operation to the particular job. Also, of course, other cooling media may be substituted for steam or for water.

What is claimed is:

1. Apparatus for rotationally casting plastic articles comprising at least one mold carrying spindle assembly, indexing means for moving said spindle assembly along a path from a mold loading station to at least one heating station and then to at least one cooling station and for stopping said spindle for a predetermined period at each station, said indexing means having a table on which said spindle assembly is mounted, fastening means fixing said spindle assembly to said table, said fastening means being releasable to permit removal of said spindle assembly from said table as a unit, said spindle assembly comprising (a) a hollow outer sleeve mounted for axial rotation in bearing means and being substantially entirely supported by said bearing means, said bearing means being removably mounted on said table, (b) a shaft mounted for coaxial rotation within said outer sleeve, (c) a mold support extending transversely from one end of said spindle assembly, (d) driving connections between (1) said sleeve and said shaft and (2) said mold support for rotating said mold support about angularly related axes upon rotation of the sleeve and shaft about their common axes, and (e) separate drive means for independently rotating said sleeve and shaft.

2. Apparatus for rotationally casting plastic articles as set forth in claim **1** wherein said mold support is supported by said outer sleeve.

3. Apparatus for rotationally casting plastic articles as set forth in claim **1**, wherein said spindle assembly includes passage means from the interior of each mold in said mold assembly to a vent spaced outside of said cooling station when the mold assembly is at said cooling station.

4. Apparatus for rotationally casting plastic articles as set forth in claim **3**, wherein said spindle assembly is provided with means for delivering gas to the interior of each mold in said mold assembly through said passage.

5. Apparatus for rotationally casting plastic articles as set forth in claim **4**, wherein said passage means is provided with valve means which is responsive to movement of a spindle assembly from said mold loading station to a heating station for admitting said gas through said passage means when said movement obtains.

6. Apparatus for rotationally casting plastic articles according to claim **1**, wherein said heating station comprises an oven, said oven being located in the path of said spindle assembly so that said mold assembly is surrounded by said oven when the spindle assembly is stopped at the heating station, said oven having first and second door means which are respectively opened to permit the mold assembly to enter the oven and to leave the oven, means defining a heating chamber and a fuel delivery chamber in said oven, said heating chamber and said fuel delivery chamber being separated by a baffle assembly having a multiplicity of outlet openings which direct heat from the fuel delivery chamber in two directions toward said mold assembly and about a substantial portion of the envelope traced by the mold assembly as it is rotated.

7. Apparatus for rotationally casting plastic articles according to claim **6**, wherein said heating chamber is provided with door means which is openable to the atmosphere to draw cool air into the oven if a mold carrying spindle cannot be indexed from the oven.

8. Apparatus for rotationally casting plastic articles according to claim **6**, wherein said mold support comprises at least two mold groups, each of said groups being mounted on a mold group carrying arm which extends radially from said shaft, and wherein said two directions are (1) axial with respect to said shaft and (2) transverse with respect to said shaft.

9. Apparatus for rotationally casting plastic articles as set forth in claim **1**, wherein said cooling station comprises a cooling chamber having means to deliver cooling steam to the mold assembly to rapidly cool the mold assembly and to deliver water to the mold assembly to further cool said assembly.

10. Apparatus for rotationally casting plastic articles comprising at least one mold carrying spindle assembly, indexing means for moving said spindle assembly along a path from a mold loading station to a heating station and then to a cooling station and for stopping said spindle

assembly for a predetermined period at each station, said indexing means having a table on which said spindle assembly is removably mounted as a unit, said spindle assembly comprising a hollow outer sleeve rotatably mounted in and extending through a mounting box having bearing means therein rotatably mounting said sleeve, said sleeve being substantially entirely supported by said bearing means, said mounting box being mounted on said table, fastening means fixing said box to said table, said fastening means being releasable to permit removal of said box and, therefore, said spindle assembly from said table as a unit, a shaft mounted for coaxial rotation within said sleeve, a mold support extending transversely from one end of said arm, gear means between said shaft and said mold support to rotate said mold support about a first axis normal to the axis of said shaft and the axis of said sleeve, linkage means between said sleeve and said mold asembly to support and rotate said mold support about a second axis angularly related to said first axis, housing means enclosing said gear means, and separate drive means for independently rotating said sleeve and shaft.

11. Apparatus for rotationally casting plastic articles according to claim **10**, wherein said spindle assembly includes passage means from the interior of each mold in said mold support to a vent spaced outside of said cooling station when the mold support is at said cooling station.

12. Apparatus for rotationally casting plastic articles according to claim **11**, wherein said passageway extends axially through said shaft and is provided with means for delivering gas to the interior of each mold in said mold support through said passage.

13. In apparatus for rotationally casting plastic articles comprising at least one mold carrying spindle assembly mounted on an indexing means which moves said spindle assembly along a path from a mold loading station to a heating station and then to a cooling station and which stops said spindle assembly for a predetermined period at each station, the improvement wherein said heating station comprises an oven having a fuel delivery chamber, a heating chamber, and a distribution chamber separating said fuel delivery chamber and said heating chamber, means to deliver heated fuel to said fuel delivery chamber, blower means to force heated atmosphere from said fuel delivery chamber to said distribution chamber, said distribution chamber extending vertically between said fuel delivery chamber and said heating chamber and then horizontally along the bottom of said heating chamber and having outlet openings along its vertical and horizontal extent for directing heated atmosphere in two directions toward the center of said heating chamber and around substantial portions of molds positioned in said heating chamber.

14. In apparatus for rotationally casting plastic articles comprising at least one mold carrying spindle assembly, indexing means for moving said spindle assembly along a path from a mold loading station to a heating station and then to a cooling station and for stopping said spindle assembly for a predetermined period at each station, the improvement wherein said cooling station comprise a cooling chamber having inwardly directed steam nozzles therein for delivering wet cooling steam to mold positioned within said cooling chamber and for delivering water to said molds after delivery of said wet steam.

15. In apparatus for rotationally casting plastic articles comprising a mold carrying spindle assembly for mounting a mold or group of molds at one end of the spindle assembly and for rotating the mold or molds about two angularly related axes, said spindle assembly comprising an outer sleeve, an inner shaft rotatably mounted within said sleeve and drive means for rotating the shaft and sleeve about their axes, the improvement which comprises a housing fixed to the end of said sleeve, a mold carrying shaft extending transversely with respect to the axis of said sleeve, through said housing, and rotatably mounted for axial rotation by bearing means in said housing, gear means between said inner shaft and said mold carrying shaft and completely enclosed within said housing for rotating said mold carrying shaft about its axis upon rotation of said inner shaft.

16. Apparatus for rotationally casting plastic articles comprising at least one mold carrying spindle assembly, indexing means for moving said spindle assembly along a path from a mold loading station to at least one heating station and then to at least one cooling station and for stopping said spindle for a predetermined period at each station, said indexing means having a table on which said spindle assembly is removably mounted as a unit, said spindle assembly comprising (a) a hollow outer sleeve mounted for axial rotation in bearing means and being substantially entirely supported by said bearing means, said bearing means being mounted on said table, fastening means fixing said bearing means to said table, said fastening means being releasable to permit removal of said bearing means and, therefore, said spindle assembly from said table as a unit, (b) a shaft mounted for coaxial rotation within said outer sleeve, (c) a mold support extending transversely from one end of said spindle assembly, (d) driving connections between (1) said sleeve and said shaft and (2) said mold support for rotating said mold support about angularly related axes upon rotation of the sleeve and shaft about their common axes, and (e) separate drive means for independently rotating said sleeve and shaft, means for arresting the rotation of said mold support at a mold unloading station so that molds carried by said mold suport are arrested at a predetermined orientation for unloading and reloading.

17. Apparatus for rotationally casting plastic articles as set forth in claim **16**, wherein said mold arresting means comprises a disc-shaped vane concentrically mounted on said hollow outer sleeve, means defining an opening through said vane, switch means responsive to the position of said opening when said mold is in said predetermined orientation to permit said separate drive means to be de-energized, and means to de-energize said separate drive means only when said orientation obtains and said switch means is operated.

18. Apparatus for rotationally casting plastic articles as set forth in claim **1**, wherein said separate drive means includes independent drive means for rotating said mold support about each of said angularly related axes.

19. Apparatus for rotationally casting plastic articles comprising at least one mold carrying spindle assembly, indexing means for moving said spindle assembly along a path from a mold loading station to at least one cooling station and for stopping said spindle for a predetermined peirod of time at each station, said indexing means having a table on which said spindle assembly is removably mounted as a unit, said spindle assembly comprising (a) a hollow outer sleeve mounted for axial rotation in bearing means and being substantially entirely supported by said bearing means, said bearing means being removably mounted on said table, (b) a shaft mounted for coaxial rotation within said outer sleeve, (c) a mold support extending transversely from one end of said spindle assembly, (d) driving connections between (1) said sleeve and said shaft and (2) said mold support for rotating said mold support about angularly related axes upon rotation of the sleeve and shaft about their common axes, and (e) separate drive means for independently rotating said sleeve and shaft, means for arresting the rotation of said mold support at a mold unloading station so that molds carried by said mold support are arrested at a predetermined orientation for unloading and reloading, said mold arresting means comprising a disc-shaped vein concentrically mounted on said hollow outer sleeve, means defining an opening to said vein, switch means responsive to the position of said opening when said mold is in said predetermined orientation to permit said separate drive means to be de-energized, and means to de-energize said separate

drive means only when said orientation obtains and said switch means is operated.

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