Aug. 21, 1962 E. R. POWELL 3,049,768

APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 1

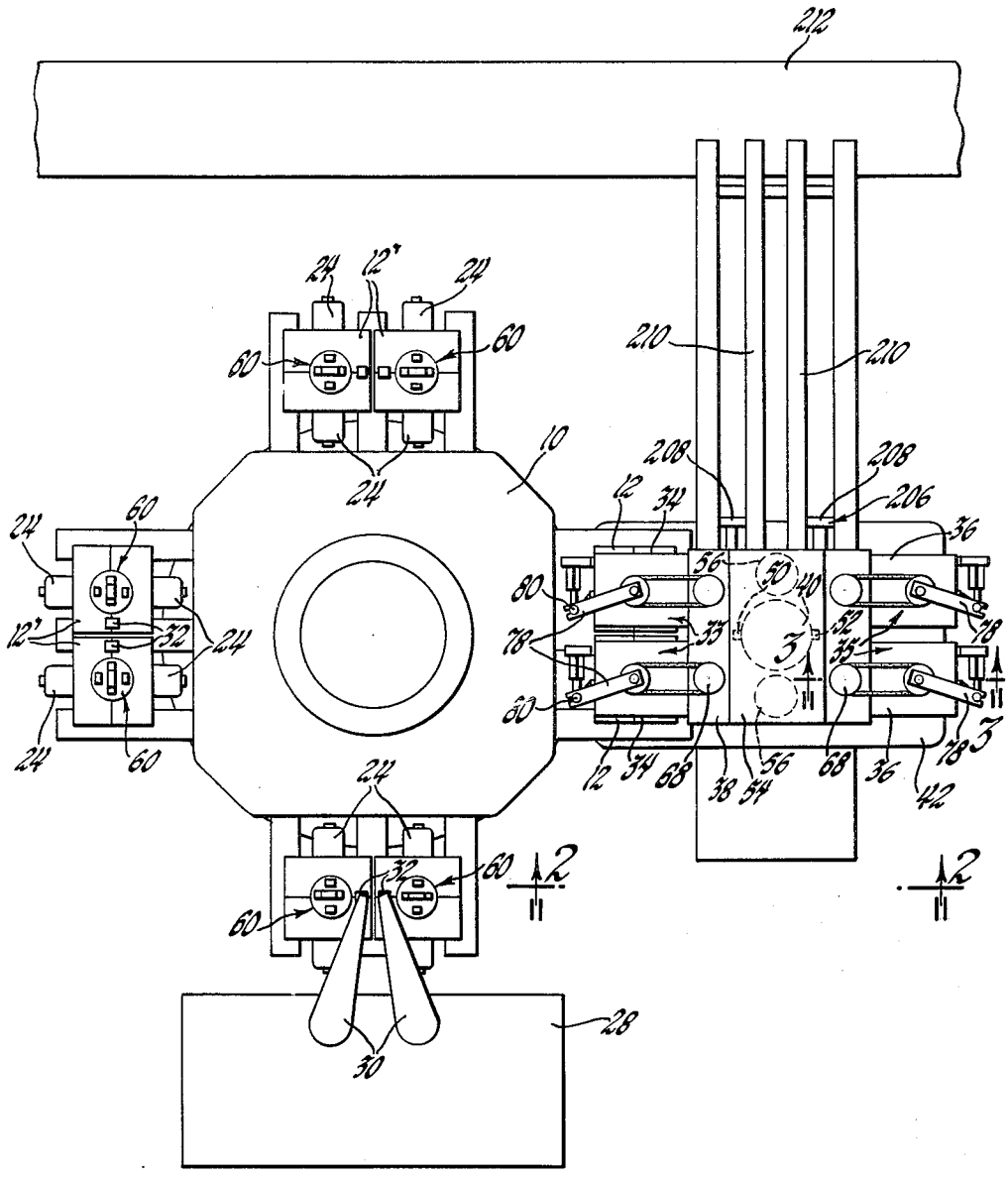


Fig. 1

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APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 2

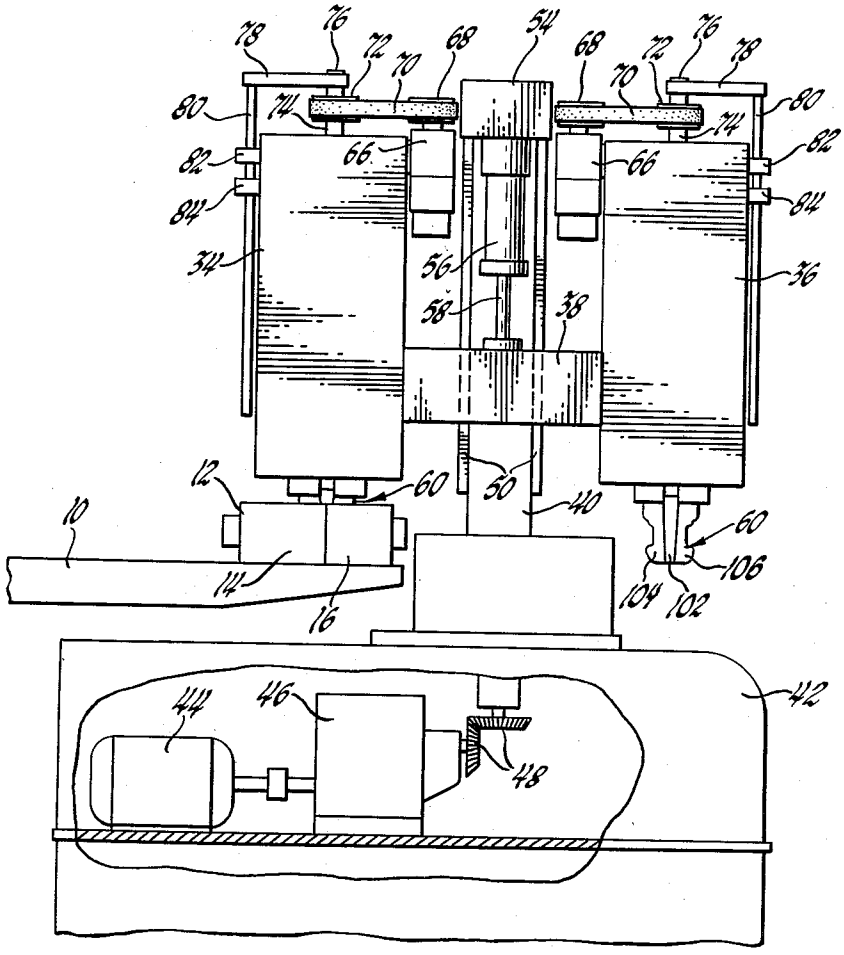


Fig. 2

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APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 3

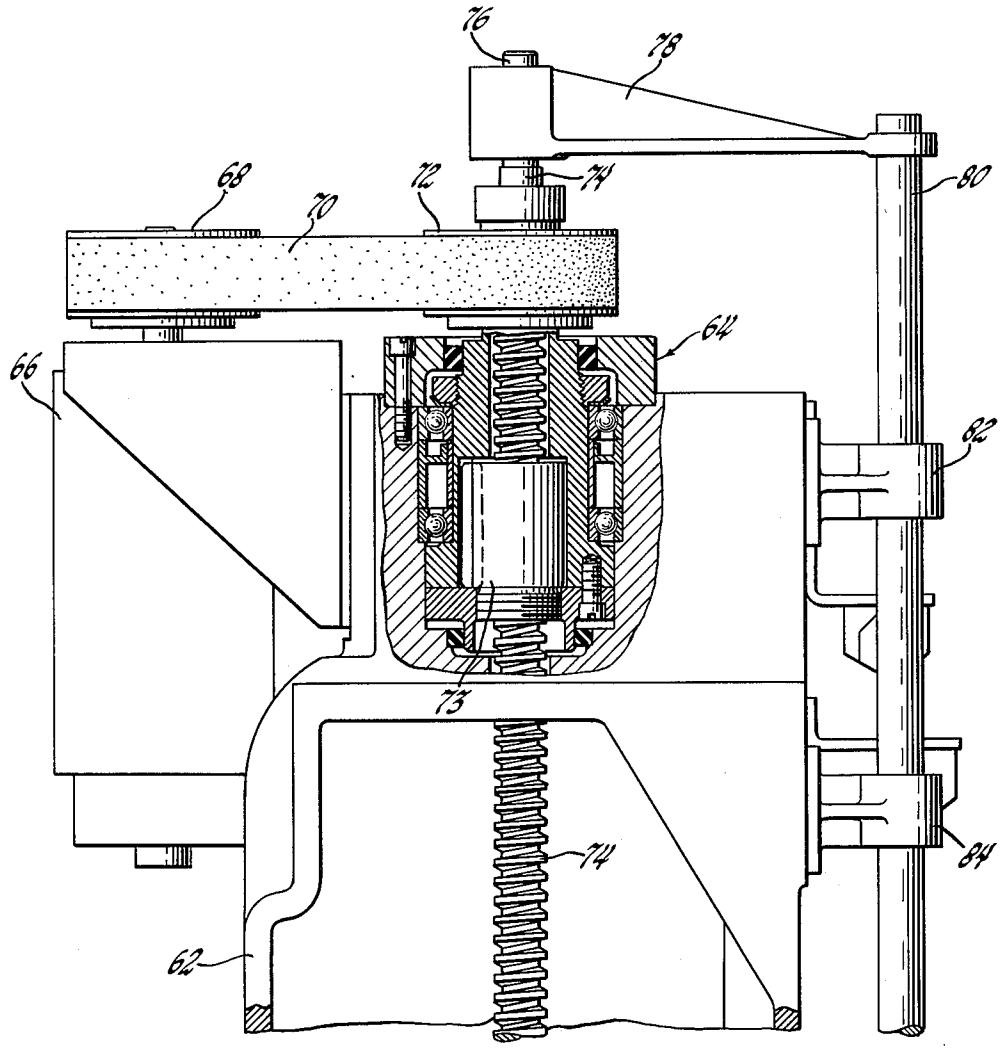


Fig. 3

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APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 4

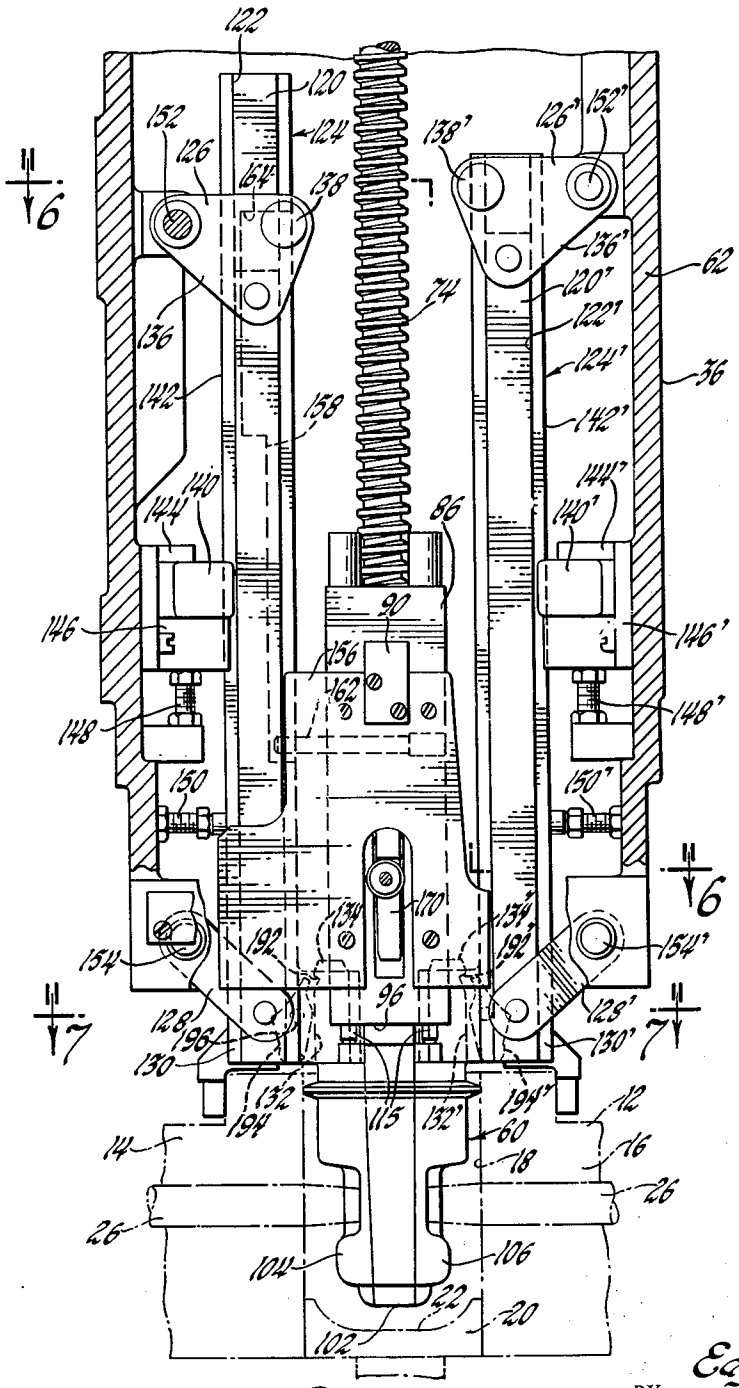


Fig. 3a

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Aug. 21, 1962 E. R. POWELL 3,049,768

APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 5

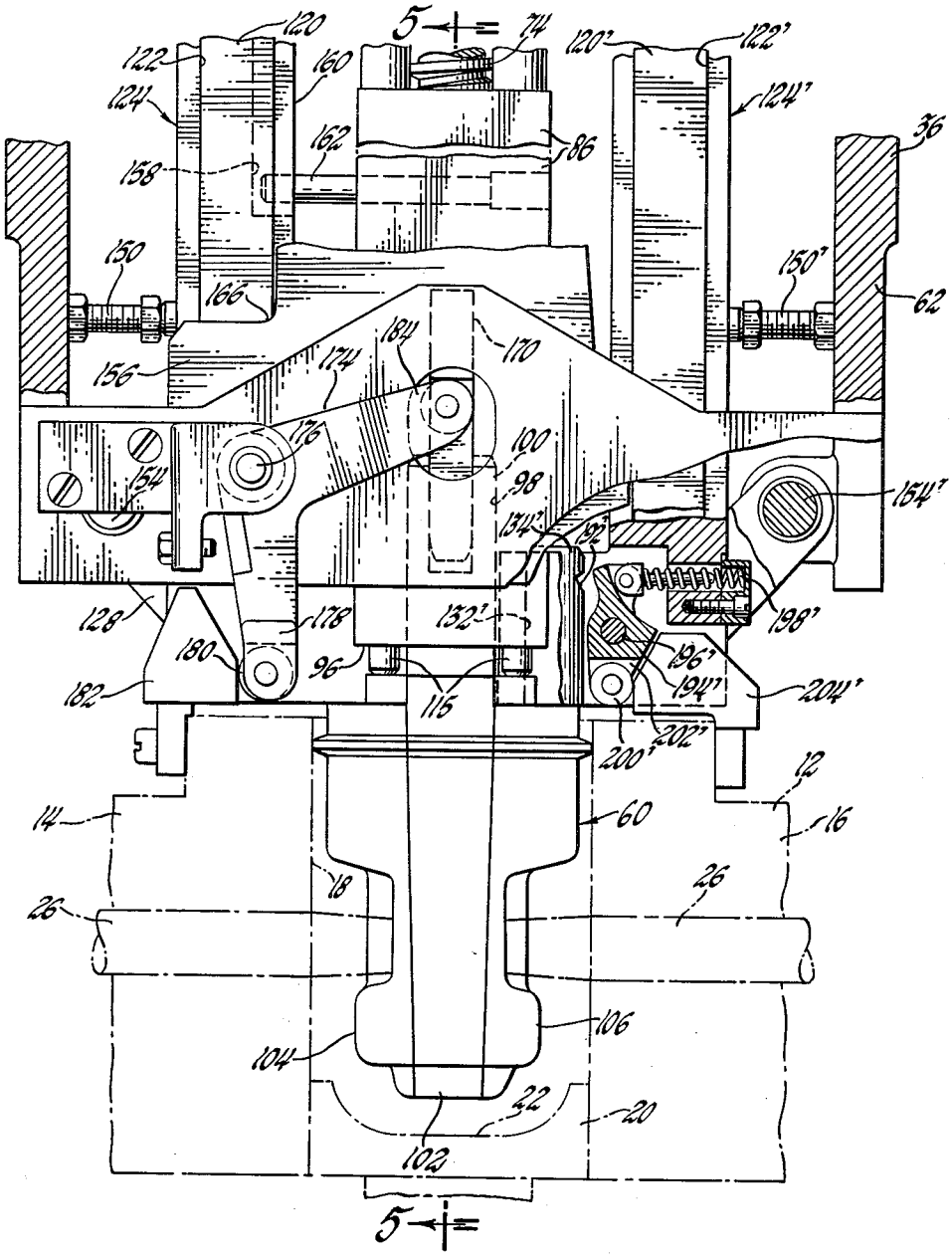


Fig. 4

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Aug. 21, 1962 E. R. POWELL 3,049,768

APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 6

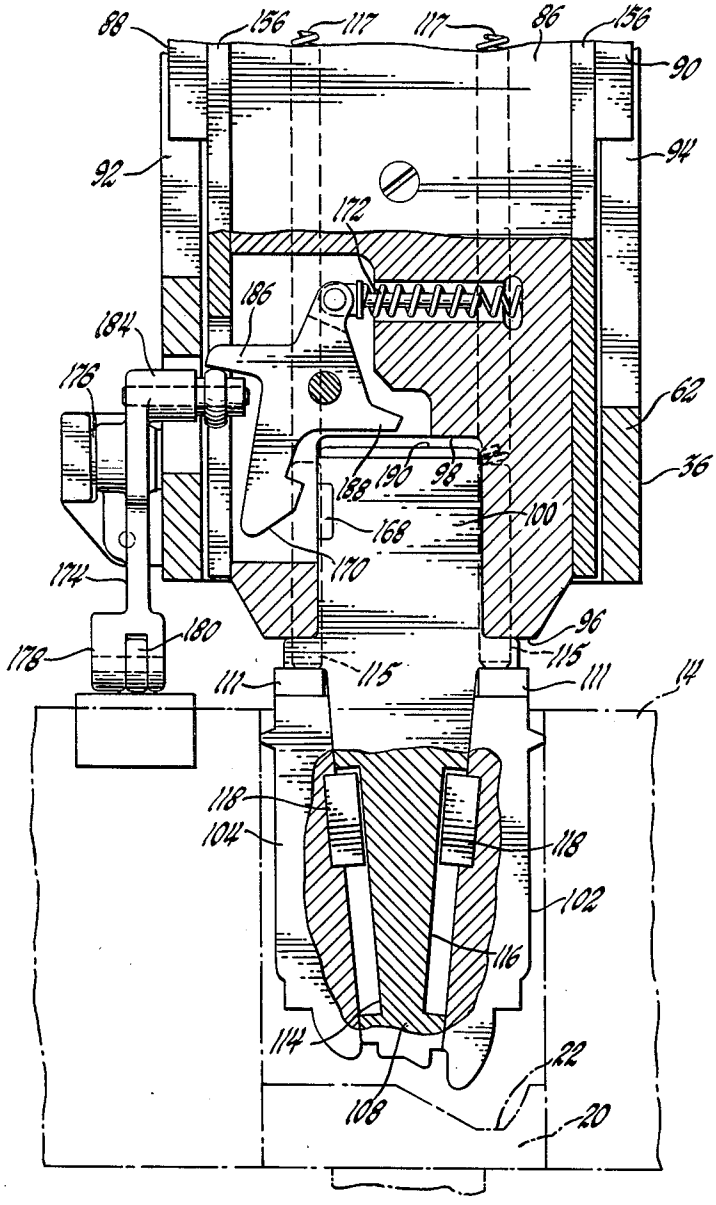


Fig. 5

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Aug. 21, 1962 E. R. POWELL 3,049,768

APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 7

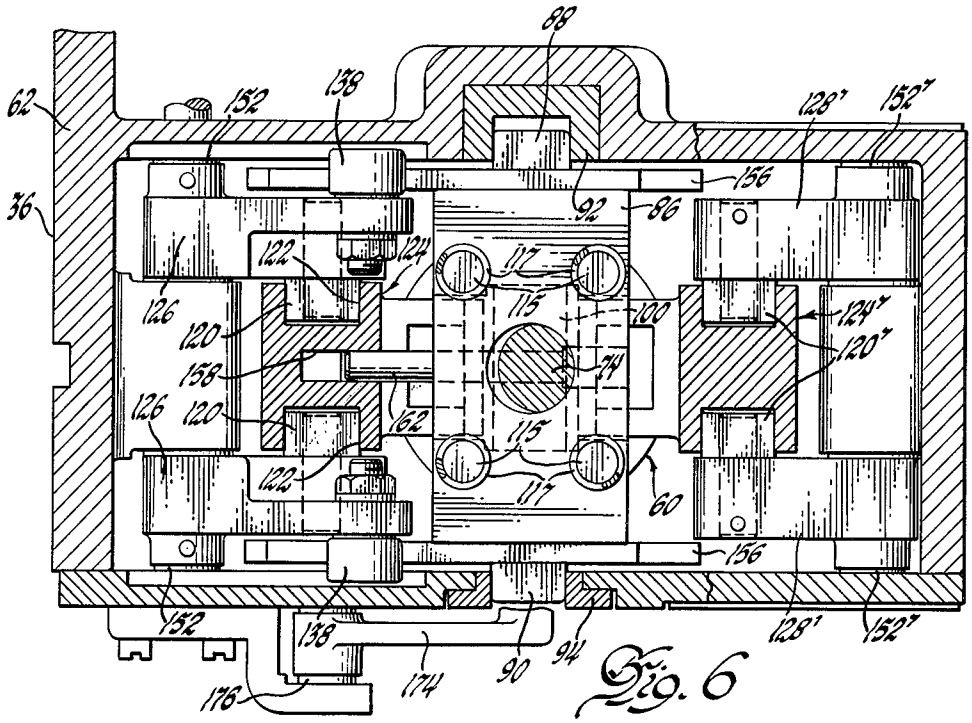


Fig. 6

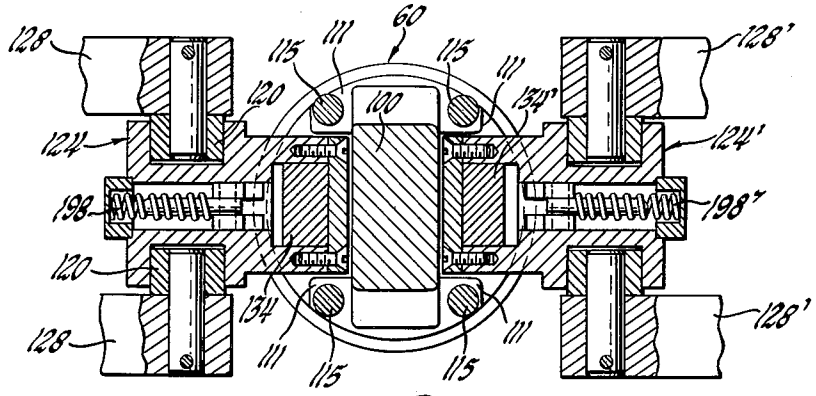


Fig. 7

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APPARATUS AND PROCESS FOR CASTING PISTONS

Filed April 30, 1959 8 Sheets-Sheet 8

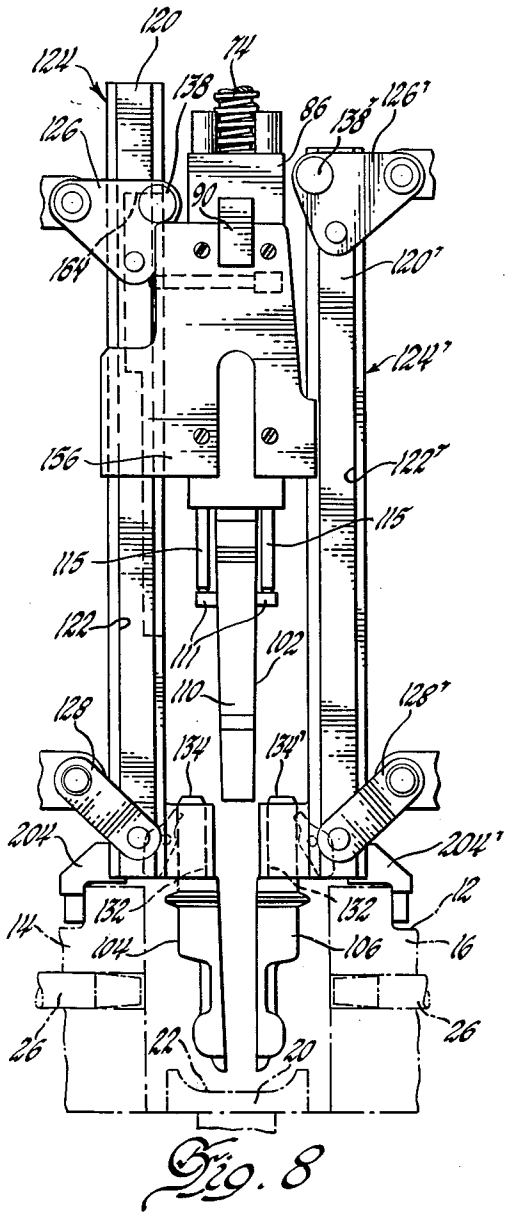


Fig. 8

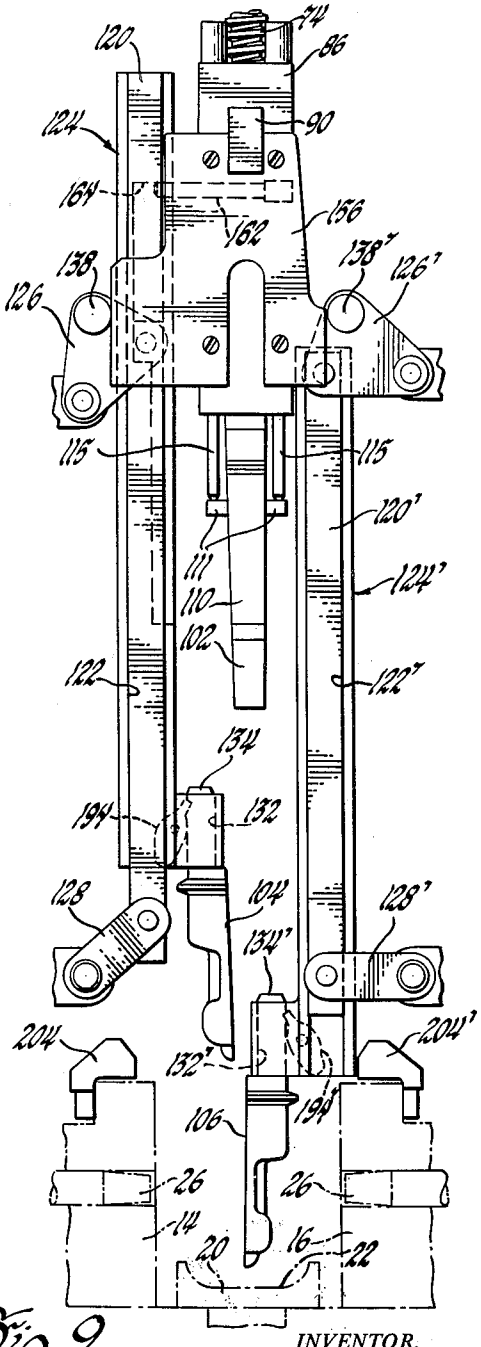


Fig. 9

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Patented Aug. 21, 1962

3,049,768
APPARATUS AND PROCESS FOR CASTING PISTONS

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Filed Apr. 30, 1959, Ser. No. 810,164
16 Claims. (Cl. 22—93)

This invention generally relates to an improvement in a process and apparatus for casting and more particularly the invention is directed to the molding of hollow articles, including cup-shaped castings, which require a complex internal core structure, such as is necessary in the casting of pistons for internal combustion engines.

The method and apparatus comprehended by the invention involves the use of permanent molding techniques rather than the well known green sand type of casting. By permanent molding I refer to the casting techniques using a single mold and core of metal or other non-frangible material to form an infinite number of reproductions.

The permanent molding of hollow or cup-shaped articles usually includes an internal core structure and cooperating mold members to define the external contour of the article which is to be cast. A piston for an internal combustion engine, for example, requires a highly complex core structure due to the presence of internal ribs, bosses and other irregular surface configurations. Moreover, the presence of reinforcing metal inserts causes additional complexity to the internal surface further complicating the core structure. Although the invention is particularly useful in producing pistons for internal combustion engines, the advantages provided by the invention can also be obtained in the manufacture of other types of castings.

In the casting of pistons for internal combustion engines using a permanent mold, the highly complex configuration of the core structure does not permit ready withdrawal of the core from the cast article. It is generally necessary that the core be a composite structure which can be disassembled or collapsed to facilitate removal from the interior of the cast article. A number of differing devices, or core pullers, have been employed to effect automatic disassembly and removal of the composite core from within the cast article. None of the devices heretofore employed had provision for ready detachment of the core from the core pulling apparatus.

The methods and apparatus which are presently employed in the manufacture of pistons for internal combustion engines generally involves casting the piston in a head up position. Although casting the piston in such a position may provide certain benefits, such as procedure inherently involves a number of disadvantages. Since the head portion of a piston is generally thicker than the remainder of the piston, this portion tends to cool more slowly. Thus risers must be used to feed molted metal to the head portion during its solidification. The risers, of course, should solidify after the head of the piston. Due to the close proximity of the risers to the head of the piston, the head cannot be cooled too rapidly. Moreover, a higher pouring temperature must be used to keep the risers molten for a satisfactory period of time.

It is extremely desirable, however, to solidify the molten metal as fast as possible to obtain a smaller grain size in the solidified metal. The smaller grain size is more receptive to subsequent aging by heat treatment. A tougher and harder piston can be obtained when the piston is cast in the head down position. This latter position permits extremely rapid cooling of the head portion to provide a denser casting.

In addition, lower pouring temperatures can be used,

decreasing cooling time and heating costs, and the danger of rejections due to excessive detrimental shrinkage is materially decreased. Thus, by casting a piston in the head down position the overall number of acceptable pistons produced can be materially increased at a lower average cost per piston.

Additionally, the casting of pistons in the head up position requires introducing the core structure from below the mold members. Such an arrangement does not readily permit the detachment of the core from the core supporting device and movement of the detached core with the mold. Thus, the conventional apparatus remains virtually inactive during the solidification of the molten metal. Moreover, in such a structure the mold and core frequently must be cooled between casting operations additionally causing delay.

It is a principal object of this invention to provide an improved method and apparatus for casting hollow articles at a higher production rate with a lower percentage of rejections due to shrinkage problems than heretofore possible. It is a further object of the invention to provide an apparatus having readily detachable cores facilitating the interchange of core members. A still further object is to provide a new means for assembling and disassembling a composite core. Another object of the invention is to provide an apparatus for casting internal combustion engine pistons in a head down position wherein the core defining the internal structure of the piston is automatically attached and detached from the core support device.

These and other objects of the invention are attained employing an apparatus which includes a core pulling device mounted on a vertically reciprocable indexing support and a separately indexing mold table. The composite core is detached from the core pulling device by closing action of mold members on the separately indexing mold table. Two pairs of composite core pulling devices are oppositely mounted on the support so that while one of the core pairs is in use the other pair is cooling. A plurality of mold pairs are carried by the indexing mold table. The composite cores are deposited in the molds and indexed around therewith on the table. The cores in the molds are subsequently retrieved as the mold table completes a full revolution and moves into vertical alignment beneath the core pulling devices.

The use of a plurality of pairs of molds on an indexing mold table and cores detachable from the core pulling apparatus eliminates inactivity during the solidification period inherent in conventional apparatus. The use of the additional pairs of cores on the indexing support for the core pulling device eliminates inactivity during cooling of the cores inherent in conventional apparatus. The casting of the piston in the head down position permits extremely rapid cooling and allows the metal to be poured into the mold at a lower temperature to aid in reducing the cooling periods between pourings, increasing the productivity of the machine. Moreover, the head down casting position reduces the danger of rejections due to detrimental shrinkage to further increase effective productivity of the machine.

Other objects, features and advantages obtained with the separately indexing mold table and core support devices will become more apparent from the following description of specific embodiments thereof and from the drawings, in which:

FIGURE 1 shows an elevational top view of an apparatus comprehended by the invention;

FIGURE 2 shows an elevational side view along the line 2—2 of FIGURE 1;

FIGURE 3 shows an enlarged view in partial elevation along the line 3—3 in FIGURE 1;

FIGURE 3*a* is a continuation of FIGURE 3 showing

an enlarged sectional view along the line 3—3 of FIGURE 1;

FIGURE 4 shows an enlarged fragmentary view in partial section of the apparatus shown in FIGURE 3*a*;

FIGURE 5 shows a sectional view along the line 5—5 of FIGURE 4;

FIGURE 6 shows a sectional view along the line 6—6 of FIGURE 3*a*;

FIGURE 7 shows a sectional view along the line 7—7 of FIGURE 3*a*; and

FIGS. 8 and 9 show a view of a parallel linkage and cam arrangement comprehended for the core pulling device in the subject invention.

Referring now to FIGURES 1 and 2, there is shown a mold table **10** having thereon a multiplicity of pairs of similar molds **12** which define cavities for casting pistons for an internal combustion engine. Each of the molds **12** (schematically shown in FIGURES 4, 8 and 9) includes two horizontally movable parts **14** and **16** which define the side walls **18** of the cavity and a fixed disk-like member **20** which forms the lower end wall **22** of the cavity. Adjacent each horizontally movable member is means **24** for reciprocating the member. Horizontal tapered shafts **26** in each movable member project into the mold cavity to form wrist pin openings in the cast piston. Should it be desirable to employ movable wrist pin cores, the same means **24** for moving the mold member can be adapted to also move the respect... wrist pin cores. The movable members can be actuated generally in any suitable manner, such as by means of an air cylinder, suitably connected air or electric motors, or the like.

Adjacent the mold table **10** is a reservoir **28** of molten metal. The reservoir has a pair of pouring spouts **30** thereon for simultaneously introducing molten metal into each sprue **32** of a pair of permanent molds **12**. The molten metal in the reservoir **28** can be of any suitable metal for permanent mold casting. A specific example of one such metal which can be used is the aluminum alloy F–132 having the following composition:

Copper	2.0%–4.0%.
Silicon	8.5%–10.5%.
Magnesium	0.5%–1.5%.
Nickel	0.5% maximum.
Iron	1.0% maximum.
Manganese	0.5% maximum.
Titanium	0.2% maximum.
Zinc	1.0% maximum.
Other elements, each	0.05% maximum.
Other elements, total	0.2% maximum.
Aluminum	Balance.

Also adjacent the mold table **10** is an assembly having two pairs **33** and **35** of core pulling or stacking devices **34** and **36** mounted on a vertically reciprocable indexing support **38**.

Two pairs of core pulling or stacking devices **36**, hereinafter referred to as core stackers, are oppositely mounted on a frame support **38**, which is in turn mounted on a vertical column **40**. The column is rotatably mounted on a base member **42**. A motor **44** within the base member, acting through a reducing device **46** and bevel gears **48**, provides means for rotating the column **40**. The frame support member **38** is vertically reciprocable on the column **40** but is not rotatably movable thereon. Axially extending keys **50** on the periphery of the column **40** engage corresponding grooves **52** in the frame support **38** to restrict rotation of the support member on the column **40**. Accordingly, rotation of the column by the motor **44** in the base member **42** simultaneously induces rotation of the frame support member **38** and attached core stackers **36**.

A transversely extending cross bar **54** is rigidly secured to the upper end of the column. Two air cylinders **56** depending from the column cross bar **54** have piston rods **58** secured to the frame support **38**. Actuation of the air cylinders **56** raises and lowers the frame support member **38** on the column **40**.

The molds **12** on the indexing mold table **10** are positioned so that rotation of the table on its vertical axis, indexing, can bring the molds **12** into corresponding vertical alignment with cores **60** carried by the core stackers **36**. By corresponding vertical alignment I mean that one of a pair is vertically aligned with one of another pair and the second of the former pair vertically aligned with the second of the latter pair. Analogously, the core stackers are positioned on the frame support **38** to permit corresponding vertical alignment of both pairs **33** and **35** of core stackers **36** with the molds **12** by rotation of the column **40**. The table is rotated by means (not shown) similar to that shown in FIGURE 2 for indexing the column **40**.

Referring now to FIGURES 3, 3*a*, 6 and 7, each of the core stackers **36** has a frame **62** which is suitably secured to the frame support member **38**, such as by bolts (not shown) or the like. With the understanding that all of the core stackers **36** are alike, I shall proceed with a detailed description of only one of them to avoid unnecessary duplication. The core stacker **36** has a ball nut assembly **64**, such as is well known in the art, mounted on the upper end of the frame **62**. A motor **66** is also mounted on the frame adjacent the ball nut assembly **64**. The motor **66** has a pulley wheel **68** thereon which, by means of a connecting belt **70**, rotates a second pulley wheel **72** which is attached to a rotatable ball nut **73** in the ball nut assembly **64**.

Extending upwardly through the ball nut **73** of the assembly **64**, is a vertical screw **74** for the ball nut **73**. The upper end **76** of this screw hereinafter called ball screw, has a bracket **78** laterally projecting therefrom above the ball nut assembly **64**. A rod **80** depends downwardly along the outside of the core stacker from the bracket **78** through guide members **82** and **84**.

The lower end of the ball screw has a cross head **86** thereon. Bosses **88** and **90** on opposite side surfaces of the cross head engage corresponding vertical guides **92** and **94** in the side walls of the core stacker frame **62**. The engaging bosses **88** and **90** restrict rotation of the cross head **86** and attached ball screw **74** when the ball nut **73** is rotated. Accordingly, rotation of the ball nut **73** raises the ball screw **74** and attached cross head **86** within the frame **62**. The bosses **88** and **90** are made of a suitable low-friction material, such as bronze, to insure smooth vertical movement within the steel guides **92** and **94**, respectively. The lower end **96** of the cross head **86** has a recess **98** therein for receiving a projection **100** extending upwardly from a center section **102** of a three-section composite permanent core **60**.

The composite core **60** generally contains three general sections, two side sections **104** and **106** and a wedge-shaped center section **102**. The center section **102**, shown schematically in FIGURE 5, is in turn transversely divided into a middle part **108** and two side parts or flip cores **110** and **112**. The side surfaces **114** and **116** of the middle part **108** adjacent the flip cores **110** and **112** are inclined outwardly toward the flip cores so that the middle part **108** acts as a wedge therebetween. The mating surfaces of the flip cores **110** and **112** are also inclined in complement to the middle part **108**. The flip cores are suitably attached to the middle part, such as by a sliding key arrangement **118** to permit the mating surfaces of the parts to slide along their length. Thus, movement of both flip cores **110** and **112** downwardly along the mating adjacent surfaces **114** and **116**, respectively, of the middle part **108** permits the flip cores to converge, collapsing the center core section **102**. Suitable stop means, of course, are provided to maintain the parts in assembly.

At the upper ends of each flip core are lateral extensions **111** which rest on the upper surfaces **113** of the

side core sections 104 and 106 when the various core parts are assembled. The flip cores are urged downwardly by pins 115 in the cross head 86 engaging with the upper surface of the lateral extensions. Each of the pins is respectively biased downwardly by means of a coil spring 117 in the cross head.

The ball screw is interjacent support members for each of two side core sections 104 and 106 which, together with the center core section 102, form the internal configuration of the piston to be cast. The construction of the supporting members for each of the side core sections is generally similar. However, the construction of the supporting members for the side core section 104 additionally includes provision to raise the attached side core section with respect to the other side core section 106. In view of the general similarity of construction, a description of the former will include a description of the latter. Accordingly, the detailed description of the former will serve as a specific description of both.

The support members for the side core 104 include a pair of sliding keys or slides 120 lying in vertical channels 122 on opposite sides of an H-shaped channel member 124. Each of the slides 120 is secured to the frame by pivotally mounted upper and lower parallel links 126 and 128. The lower end 130 of the channel member 124 has a recess 132 therein for receiving a projection 134 on the side section 104 of the composite core 60.

The upper parallel link 126 for each slide 120 is generally of a flat triangular configuration in which the lower side 136 of the triangle functions as the parallel link. A roller 138 is generally located on each triangle 126 near the vertex thereof opposite the lower side 136.

The channel member 124 has a laterally extending boss 140 on the surface 142 thereof adjacent the frame 62 for engagement with corresponding stop blocks 144 and 146 on the frame. The engagement of the boss 140 with the stop blocks locates the channel member 124 vertically for proper positioning of the various core sections when assembled. The upper stop block 144 is used to restrict upward movement of the support member during upward movement of the slide. The height of the stop blocks 144 and 146 on the frame 62 can be adjusted by means of the adjusting screw 148. The maximum downward movement of the slides 120 is determined by the limit of the channel member travel toward the frame 62. The adjusting screw 150 between the frame and the channel member forms a positive stop for lateral movement of the channel member and, accordingly, indirectly regulates the maximum downward movement of the slides 120. Thus, movement of the parallel links 126 and 128 on their respective frame pivots 152 and 154 laterally moves the channel member 124 and attached side core section 104 toward or away from the ball screw 74.

Cam members 156 are mounted on opposite sides of the cross head 86 for coaction with the rollers 138 on the upper links of the side section core support members. As shown more clearly in connection with FIGURES 8 and 9, the cam members 156 on the cross head 86 move upwardly a predetermined distance before they engage the rollers 138. The amount of predetermined upward movement is sufficient to completely remove the center core section 102 attached to the cross head from the mold cavity. Subsequent upward movement brings the cam 156 into engagement with the pair of rollers 138 on the upper links 126 of the side core support member 124. Further upward movement of the cam causes lateral inward movement of the support member 124. The supporting members for both of the side core sections 104 and 106 have members functioning as described above.

However, the supporting members for the side core section 104 also have a lost-motion connection with the cross head 86 to raise the side core section 104. After a predetermined upward movement of the cross head and the center core section has been removed from the mold cavity, the section 104 is raised in translation with the center core section 102. The channel member 124 has a longitudinal groove 158 in its surface 160 adjacent the ball screw 74. A pin 162 on the cross head 86 moves upwardly in the groove 158 when the cross head is raised. The groove 158 can be of a constant depth sufficient to permit maximum inward movement of the channel member 124. However, the lower part of the groove need only be shallow, whereas the upper portion relatively deeper to accommodate the inward movement of the channel member 124 when the pin 162 on the cross head 86 raises to that area.

The pin 162 moves freely in the groove 158 until it reaches the wall 164 on the upper end of the groove. While the pin is moving upwardly in the groove, the cam 156 engages the rollers 138 shifting the channel member 124 inwardly wherein the boss 140 clears the upper stop block 144. Further upward movement of the ball screw 74 causes engagement of the pin 162 with the groove end wall whereupon the side core section support 124, now free of the upper block 144, moves vertically in translation with the ball screw 74. Simultaneously further coaction of the roller 138 with the cam member 156 at 166 causes lateral movement of the side core section support 124 outwardly away from the ball screw.

The cam 156 is constructed so as to sequentially coact with the side core support members 124 and 124'. The initial cam engagement moves the side core section 104 laterally toward the ball screw 74 into the space vacated by the center section 102 of the core. Subsequent upward movement of the ball screw 74 lifts the side core section 104 from the mold 12. After the side core section 104 is lifted free of the mold 12, additional cam action causes the side core section 104 to move outwardly away from the ball screw. The ball screw continues to raise after the first side core is removed causing the remaining side core section 106 to move laterally into the center core section position. The cross head cam 156 engages with the rollers 138' on the upper links 126' and rotates the upper and lower parallel links 126' and 128' respectively about their frame pivot 152' and 154' moving the support 124' for the side core section 106 inwardly.

Referring now to FIGURES 4 and 5, the center section 102 of the composite core has a projection 100 thereon extending upwardly into a corresponding recess 98 in the lower surface 96 of the cross head 86. A notch 168 is provided in the side of this projection for engagement with a latch member 170 in the cross head 86. The latch 170 is biased by a spring 172 to provide automatic locking of the central core section 102 to the cross head 86 when the projection 100 is fully inserted in the recess 98. Automatic unlocking of the assembly is provided by means of an angle member 174 pivotally mounted at 176 to the frame 62 on the core stacker. The lower end 178 of the angle member 174 has a roller 180 thereon for engagement with a cam 182 on one of the mold members 14. The opposite end 184 of the angle member 174 is adapted to engage a tang 186 on the latch member 170. The latch member also has an extension 188 thereon which abuts the upper end 190 of the center core section 102. Positive locking of the assembly is insured by action of the upper end 190 of the projection 100 on the extension 188 as well as by the spring 172 in the cross head 86.

Lateral movement of the mold members 14 and 16 shown in FIGURE 4 causes the mold cam 182 to engage the roller 180 rotating the angle member 174 on the frame pivot 176 and unlocking the latch. Each of the side core sections 104 and 106 also is secured to the core stacker by means of a quick-disconnect latch arrangement. The latch arrangement for each of the side core sections being the same, the following description will serve to illustrate both.

The side core section 106 has an upwardly extending projection 134' thereon which is fitted into a corresponding recess 132' in the lower end 130' of the side core section support 124'. A notch 192 is provided in the

projection 134 for engagement with a pawl 194 which is pivotally mounted at 196 on the side core section support 124. The pawl 194 is biased into engagement with the notch 192 by a spring 198. A roller 200 is provided on the lower end 202 of the pawl 194 for contact with a cam 204 on the mold member 16. Lateral inward movement of the mold members 14 and 16, shown in FIGURE 4, causes the cam member 204 to contact the roller 200 and unlock the pawl 194 from the notch 192. Since the closing action of the mold members releases the composite core 60 from the core stacker 36, the stacker can be raised and indexed, leaving the composite core in the mold 12.

Removal of the center core section 102 is accomplished by opening the mold 12 and locking the center section 102 to the cross head 86. Commencing movement of the cross head 86 only raises the middle part 108 of the center core section. The spring biased pins 115 urge the flip cores 110 and 112 in a downward direction so that initially only the middle part raises while the flip cores, urged by the flip core pins, move laterally inwardly sliding down the middle part. Thus, in the initial upward movement of the middle part 108 the flip cores 110 and 112 simultaneously laterally converge on one another to free the composite center core section 102 of any lateral inward extension of the piston. The removal of the remainder of the composite core 60 is effected by completing withdrawal of the three-part composite center core section 102 and laterally moving the side core section 104 into the space vacated by the center core section. The laterally moved side core section 104 is raised free of the mold cavity and subsequently the other side core section 106 is laterally moved to the center core section position in the cavity.

To cast a pair of pistons in accordance with my invention a pair of core stackers 36 are vertically aligned over a corresponding pair of molds 12 on the mold table 10. The core stackers lower the cores 60 into the mold area and the mold members 14 and 16 close to define a cavity for casting a piston. The closing action of the mold members releases the composite cores from the respective core stackers and the core stackers are raised leaving an assembled composite core disposed in each mold cavity.

The mold table 10 commences a single revolution by indexing 90 degrees to position the core-containing molds 12 at the pouring station or reservoir 28 where molten metal is introduced into the mold cavities. It is often preferred to preheat the mold cavity and cores to a temperature of approximately 400° F. to 450° F. to inhibit premature solidification of the metal in the mold during pouring. The hereinbefore described alloy when used in making pistons generally should be at a temperature between approximately 1250° F. and 1320° F. while excellent results have been obtained using a pouring temperature of 1280° F.

After the molten metal is introduced into the molds, the mold table completes the revolution back to the core stackers 36 during the solidification period. The completion of one full revolution of the table 10 brings the molds 12 back into vertical alignment beneath the core stackers. While the molten metal is solidifying, it is often desirable to retract the cores 26 which form the wrist pin openings of the piston. This can generally be accomplished during the solidification period as the mold table 10 is rotating the molds into position beneath the core stackers.

The speed at which the mold table rotates is preferably regulated so that the revolution is completed at precisely the time for withdrawing the composite cores. The overall period of time between the commencement of the pouring and the time at which the mold is opened will vary according to the structure of the piston which is cast, the alloy which is used, rate of cooling, etc. However, I have found that an overall duration of approximately 30 seconds can be used in some instances where the pouring time involves approximately 7 seconds to 10 seconds and the dwell time or subsequent solidification period is approximately 20 seconds. The core stackers then descend into engagement with the cores and the molds open, locking the composite cores to their respective stackers. In some instances, however, it may be desirable to leave the wrist pin cores in place until the mold is opened and withdraw the central and one side section from the composite core prior to opening the mold. The specific sequence of core withdrawal and mold openings can be varied without deviating from the spirit of the invention provided that at least one side section of the core is left within the mold cavity for withdrawal of the cast piston.

The cross head 86 of each core stacker then commences to raise, collapsing the cores as the stacker itself raises. The cast piston clings to the cores so that during the elevation the cast pistons are lifted free of the mold members 14 and 16. The stackers are then indexed 90 degrees clockwise and lowered to a piston collection station 206. During this action the composite core 60 is being collapsed and withdrawn from the cast piston but the lateral movement of the secondly moved side core section 106, to which the piston clings, is not made. The descent of the stackers after indexing 90 degrees positions each of the pistons beside an abutment 208. The lateral movement of the side core section 106 is then made wherein the piston strikes the abutment 208 and falls free of the side core section 106. The piston drops into a collection channel 210 and is shuttled to a conveyor 212 which carries the piston to other areas for further processing.

The core stacker then raises and indexes another 90 degrees clockwise bringing the second pair of core stackers 36' into vertical alignment above the molds 12 from which the pistons have just been withdrawn. These latter core stackers 36' then descend, lowering their composite cores 60' into the respective mold areas and the mold members 14 and 16 are closed to define the mold cavity. The closing action of the mold members unlocks the latter pair of cores 60' from the stackers 36', permitting the stackers to be raised leaving the cores within the mold cavities. With the core stackers in elevated position, the mold table 10 is rotated 90 degrees to position the mold pair at the pouring station or reservoir 28 to cast another pair of pistons.

Since the solidification period is sufficient in duration to permit a plurality of cores to be positioned in the molds and pistons to be cast, additional pairs of molds 12' are provided on the mold table. Accordingly, when a pair of cores 60 are deposited in a mold pair 12 and indexed to the pouring station 28, another pair of molds 12' are brought into vertical alignment beneath the core stackers. Thus, as shown in FIGURE 1, if three additional pairs of molds 12' are appropriately placed on the table, the production rate of the machine is increased threefold.

Should additional mold cooling be desirable, provision can be made in connection with the mold table to continuously supply a liquid coolant to the molds. Similarly, it may be preferred to provide a continuously circulated liquid coolant in the composite cores. Although my invention includes the use of a period for cooling the duplicate pair of cores between uses, in some instances it may be desirable to continue cooling the composite cores after depositing the cores within the mold. In such instance the mold table can be provided with a source of liquid coolant which can be readily attached to the cores. Thus, the cores will be continuously cooled as the core containing molds rotate on the table during the solidification period.

With the use of a duplicate pair of cores and core stackers, while one pair of cores is in use the other pair of cores is cooling. It is sometimes preferred to make a piston having a ferrous reinforcing ring insert which

projects inwardly from the inner periphery of the piston. While the composite core is cooling it can be reassembled within such a ring so that the assembled cores can then carry the reinforcing ring into the mold cavity.

Moreover, it may be desirable to additionally employ a reinforcing metal insert in the cast piston in the area where a piston ring groove is to be subsequently machined. Additional devices can be mounted on the core stacker support to place such a ring into the mold areas when the core stackers are indexed to deposit the cast pistons into the collection channel.

It is generally preferred to provide a silica or aluminum oxide ceramic coating on the mold cavity defining surfaces and the composite core. Mixtures such as china clay, French chalk or whiting mixed with small amounts of sodium silicate as a binder can be used. The coating mixture is sprayed onto a hot mold to a thickness of approximate 0.003 inch to 0.005 inch. Occasionally certain areas of the cavity walls may require somewhat heavier coatings to insulate the molten metal in that area so as to keep it in a molten stage somewhat longer. Analogously, heavier coatings on riser portions of the cavity are generally desirable so that the riser metal will feed properly. Coatings in the riser area of approximately 0.030 inch can be used. During operation of the casting apparatus, a mold release agent is preferably periodically applied to the mold cavity and composite core. One mold release which can be used is a mixture of one part colloidal graphite and 10 parts water, by volume.

Of course, it is understood that the method of removing the cast piston from the composite core and transferral of the piston to a moving conveyor might be accomplished in a number of ways. Although I have described my invention in its preferred form, it is not intended that it be so limited except as defined in the appended claims.

It is also understood that the operation of my invention can be suitably accomplished manually, semi-automatically or fully automatically as is desired. For example, by attaching appropriate devices, such as to the vertical rod 80 depending from the horizontal bracket attached to the upper end of the ball screw, the sequence of core collapse can be automatically regulated. Suitably placed limit switches, check valves or the like coacting with valves associated with the mold table can be used to automatically regulate the sequence of operation to completely eliminate manual regulation of the apparatus.

What is claimed is:

1. In a casting apparatus employing a permanent composite core, a core pulling device which includes a frame, a slide movably mounted on said frame by pivotally mounted parallel links, a core section support member relatively movable on said slide, said core section support member having a lower end to which a first section of a composite core is suitably secured, a movable support means for a second section of said composite core adjacent said support member, a second section of said composite core suitably attached to said support means, means for vertically moving said support means, and a cam member associated with said support means for coaction with said parallel links to laterally move said first core section toward said support means after a predetermined vertical movement of said support means.

2. In a casting apparatus employing a permanent composite core, a core pulling device which includes a frame, a slide movably mounted on said frame by pivotally mounted parallel links, a core section support member relatively movable on said slide, said core section support member having a lower end to which a first section of a composite core is suitably secured, a movable support means for a second section of said composite core adjacent said support member, a second section of said composite core suitably attached to said support means, means for vertically moving said support means, a cam member associated with said support means for coaction with said slide and parallel links to laterally move said first core section toward said support, and lost motion means coacting with said supports for moving said core section support on said slide in translation with said support means after a predetermined vertical movement of said support means.

3. In a casting apparatus employing a permanent composite core having three general sections, a core pulling device which includes a frame, a first slide movably attached to said frame in a first parallel linkage having pivotally mounted parallel links, a second slide movably attached to said frame opposite said first slide in a second parallel linkage having pivotally mounted parallel links, a first core section support member relatively movable on said first slide, a second core section support member relatively movable on said second slide, interjacent said supports a movable support means for a third section of said composite core, means for moving said support means parallel to said slides, a cam member associated with said support means for sequential coaction with said first and second parallel linkages, respectively, and lost motion means coacting with said first support for moving said first support on said slide in translation with said support means after a predetermined movement of said support means.

4. In a casting apparatus employing a permanent composite core, a core pulling device which includes a frame, a first slide movably attached to said frame in a parallel linkage having pivotally mounted parallel links, a first core section support member relatively movable on said slide, a first section of a composite core suitably secured to said core section support member, a second slide movably attached to said frame opposite said first slide in a parallel linkage having pivotally mounted parallel links, a second core section support member relatively movable on said second slide, a second section of said composite core suitably secured to said second support member, a movable support means for a third section of said composite core interjacent said parallel linkages, means for moving said support means parallel to said slides, a third section of a composite core suitably attached to said support means, and cam means coacting sequentially with said parallel linkages for sequentially moving said first and second core sections laterally toward one another after a predetermined movement of said support means.

5. In a casting apparatus employing a permanent composite core, a core pulling device which includes a frame, a first slide movably attached to said frame in a parallel linkage having pivotally mounted parallel links, a first core section support member relatively movable on said slide, said core section support member having a lower end which is adapted to receive a projection of a first section of a composite core, a latch associated with said end and locking said projection to said support member, a second slide movably attached to said frame opposite said first slide in a parallel linkage having pivotally mounted parallel links, a second core section support member relatively movable on said second slide, said second support member having a lower end which is adapted to receive a projection of a second section of said composite core, a latch associated with the latter end for locking the latter projection to said second support member, movable support means for a third section of said composite core interjacent said parallel linkages, means for moving said support means vertically between said slides, lost motion cam means sequentially coacting with said parallel linkages to successively move said first and second support members successively laterally toward said support means and lost motion means coacting with said first support member for moving said first support vertically on its slide in translation with said support means after a predetermined vertical movement of said support means.

6. An apparatus for casting comprising a mold support, a mold on said support having movable members co-

operating to define a cavity for casting a piston, means for moving said members, a core pulling device movably mounted on a support adjacent said mold support, said device having a frame, a slide movably attached to said frame in a parallel linkage having pivotally mounted parallel links, a core section support member relatively movable on said slide, a section of a composite core suitably secured to said core section support member, a latch associated with said support member to lock said core section to the support member, cam means coacting with said parallel linkage for moving said support member laterally after a predetermined upward movement of said cam, means for moving said cam parallel to said slide, and means for indexing and vertically reciprocating said core pulling device, said device being so located as to be indexable into vertical alignment with said mold for positioning said core within said cavity.

7. An apparatus for casting comprising a mold support, a pair of molds on said support, each of said molds having movable members cooperating to define a mold cavity, means for moving said mold members, a plurality of pairs of core pulling devices movably mounted on a support adjacent said mold support, each of said devices including a frame, a first slide movably attached to said frame in a first parallel linkage having pivotally mounted parallel links, a second slide movably attached to said frame opposite said first slide in a second parallel linkage having pivotally mounted parallel links, a first core section support member relatively movable on said first slide, a second core section support member relatively movable on said second slide, interjacent said supports a movable support means for a third section of said composite core, means for moving said support means parallel to said slides, a cam member associated with said support means for sequential coaction with said first and second parallel linkages, respectively, and lost motion means coacting with said first support for moving said first support on said slide in translation with said support means after a predetermined movement of said support means, a composite core suitably attached to each of said core pulling devices, said pairs of devices so located as to be indexable into corresponding vertical alignment with said mold pair for positioning a core within each cavity of said mold pair.

8. An apparatus for casting comprising a rotatably mounted mold support, means for rotating said mold support, a plurality of molds on said support, said molds having movable members which assemble to define a mold cavity, means for moving said mold members, a core pulling device movably mounted on a support adjacent said mold support, said device having a frame, a slide movably mounted on said frame by pivotally mounted parallel links, a core section support member relatively movable on said slide, said core section support member having a lower end adapted to receive a projection of a section of a composite core, a latch on said end of said support member coacting with said projection for locking said core section to said support member, a movable support means for a second section of a composite core adjacent said support member, means for moving said support means parallel to said slide, a cam member associated with said support means for coaction with said parallel links to laterally move said first core section toward said support means after a predetermined vertical movement of said support means, means for indexing and reciprocating said device, said molds and said device being so located as to be indexable into vertical alignment for successively positioning a core within the cavity of each of said molds, and means coacting with each assembled mold for detaching a core from a core pulling device positioning the core within the assembled mold.

9. An apparatus for casting comprising a rotatably mounted mold support, means for rotating said mold support, a plurality of molds on said support, said molds having movable members which assemble to define a cavity for casting a piston, means for moving said members, a plurality of core pulling devices movably mounted on a support adjacent said mold support, means for indexing and vertically reciprocating said devices, each of said devices including a frame, a slide movably attached to said frame in a parallel linkage having pivotally mounted parallel links, a core section support member relatively movable on said slide, said core section support member having a lower end adapted to receive a projection of a section of a composite core, a latch on said end of said support member coacting with said projection for locking said core section to said support member, a composite core suitably attached to each of said core pulling devices, said molds and said devices being located so as to be indexable into vertical alignment for successively positioning a core within the cavity of each of said molds, and cam means associated with said molds for actuating said latch to detach a core from a core pulling device positioning the core within the assembled mold.

10. An apparatus for casting comprising a rotatably mounted mold support, means for rotating said mold support, a plurality of molds on said support, said molds having movable members cooperating to define a cavity for casting a piston, means for moving said members, a core pulling device movably mounted on a support adjacent said mold support, said device including a frame, a first slide movably attached to said frame in a first parallel linkage having pivotally mounted parallel links, a second slide movably attached to said frame opposite said first slide in a second parallel linkage having pivotally mounted parallel links, a first core section support member relatively movable on said first slide, a second core section support member relatively movable on said second slide, interjacent said supports a movable support means for a third section of said composite core, means for moving said support means parallel to said slides, a cam member associated with said support means for sequential coaction with said first and second parallel linkages, respectively, lost motion means coacting with said first support for moving said first support on said slide in translation with said support means after a predetermined movement of said support means, means for indexing and vertically reciprocating said device, a composite core suitably attached to each of said core pulling devices, said molds and said device being located so as to be indexable into vertical alignment for successively positioning a core within the cavity of each of said molds, and means coacting with each assembled mold for detaching a core from a core pulling device positioning the core within the assembled mold.

11. An apparatus for casting comprising a rotatably mounted mold support, means for rotating said mold support, a plurality of molds on said support, said molds having movable members which assemble to define a cavity, means for moving said members, a core pulling device movably mounted on a support adjacent said mold support, said device including a frame, a first slide movably attached to said frame in a parallel linkage having pivotally mounted parallel links, a first core section support member relatively movable on said slide, said core section support member having a lower end which is adapted to receive a projection of a first section of a composite core, a latch associated with said end and locking said projection to said support member, a second slide movably attached to said frame opposite said first slide in a parallel linkage having pivotally mounted parallel links, a second core section support member relatively movable on said second slide, said second support member having a lower end which is adapted to receive a projection of a second section of said composite core, a latch associated with the latter end for locking the latter projection to said second support member, movable support means for a third section of said composite core interjacent said parallel linkages, means for moving said support means vertically between said slides, lost motion

cam means sequentially coacting with said parallel linkages to successively move said first and second support members successively laterally toward said support means, lost motion means coacting with said first support member for moving said first support vertically on its slide in translation with said support means after a predetermined vertical movement of said support means, means for indexing and vertically reciprocating said device, said molds and said device being located so as to be indexable into vertical alignment for successively positioning a core within the cavity of each of said molds, and cam means associated with said molds for actuating said latch to detach a core from a core pulling device positioning the core within the assembled mold.

12. The method of making a hollow casting which comprises the steps of placing an assembled composite core within a casting cavity of a composite permanent mold, introducing molten metal into said cavity, disassembling said mold after solidification of said molten metal in the form of a hollow casting, removing said casting from the area of said mold members while simultaneously partially collapsing said core, and transferring said casting to a collection station where collapse of said core is completed to cause movement which disengages the casting from the collapsed core.

13. The method of making a hollow casting which comprises the steps of placing an assembled composite core within a casting cavity of a composite permanent mold, moving said mold and core to a pouring station, introducing molten metal into said cavity, moving said mold so as to vertically align said mold with a core pulling device, after a suitable duration attaching a core pulling device to said composite core, disassembling said mold, removing a cast article from said mold while simultaneously partially collapsing said core, transferring said partially collapsed core with said article clinging to at least one uncollapsed section thereof to a collection station, and completing core collapse at said collection station in such a manner as to strip the adhering article from the core.

14. The method of casting a piston for an internal combustion engine which comprises the steps of preheating a composite permanent mold having a plurality of movable members which assemble to form a casting cavity, placing an assembled preheated composite core within said cavity, moving said mold and core on an indexing support to a pouring station, introducing molten metal into said cavity, indexing said mold support during solidification of said molten metal in the form of a piston so as to vertically align said mold with a core pulling device, after a suitable duration attaching said core pulling device to said composite core, disassembling said mold, removing the piston from said mold members while simultaneously collapsing said core, and transferring said piston while clinging to at least one section of said composite core to a collection station where said core is completely collapsed causing the piston to strike an abutment and be stripped from said core.

15. In a piston making machine employing a permanent composite core for defining the interior surface of a piston, a core pulling device which includes a frame, a slide movably mounted on said frame by pivotally mounted parallel links, a core section support member relatively movable on said slide, said core section support member having a lower end to which a first section of a composite core is suitably secured, a movable support means for a second section of said composite core adjacent said support member, a second section of said composite core suitably attached to said support means, means for vertically moving said support means, and a cam member associated with said support means for coaction with said parallel links to laterally move said first core section toward said support means after a predetermined vertical movement of said support means.

16. An apparatus for casting comprising a rotatably mounted mold support, means for rotating said mold support, a mold on said support, said mold having movable members which assemble to define a mold cavity, a source of molten casting metal adjacent said mold support, a device for collapsing and withdrawing a composite core from said mold cavity, said device movably mounted on a support adjacent said mold support, means for vertically reciprocating said device, a composite core suitably attached to said device, said mold being located on said mold support so that rotation of said mold support successively moves said mold into corresponding vertical alignment with said device for positioning a core within the cavity of the mold, quick disconnect means for detaching a core from the device actuated by the mold, and means for stripping cast articles from said core by the final collapsing movement of said core.

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