Nov. 11, 1930. J. H. WILLIAMS 1,781,143

METHOD OF MAKING CASTINGS

Filed March 7, 1927 3 Sheets-Sheet 1

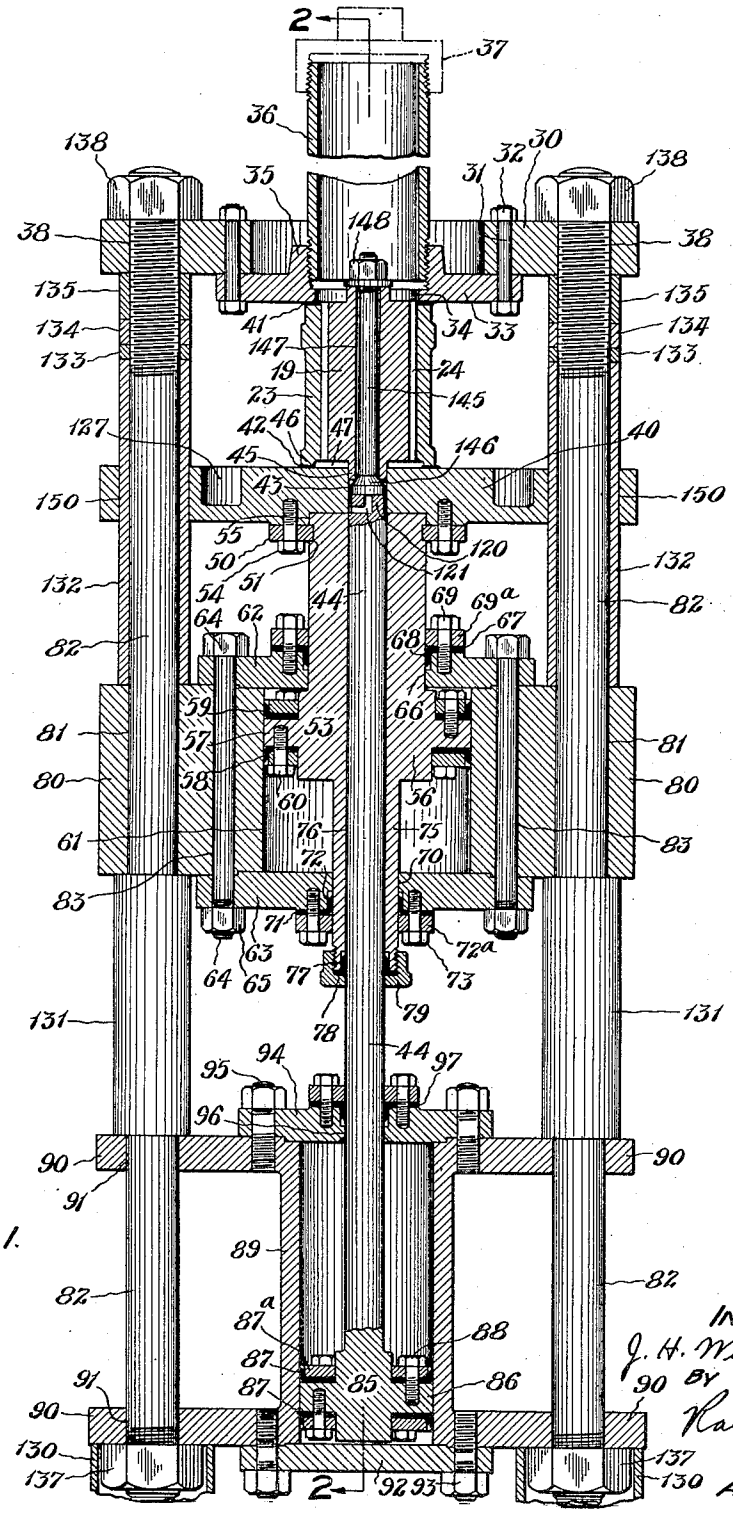


FIG. 1.

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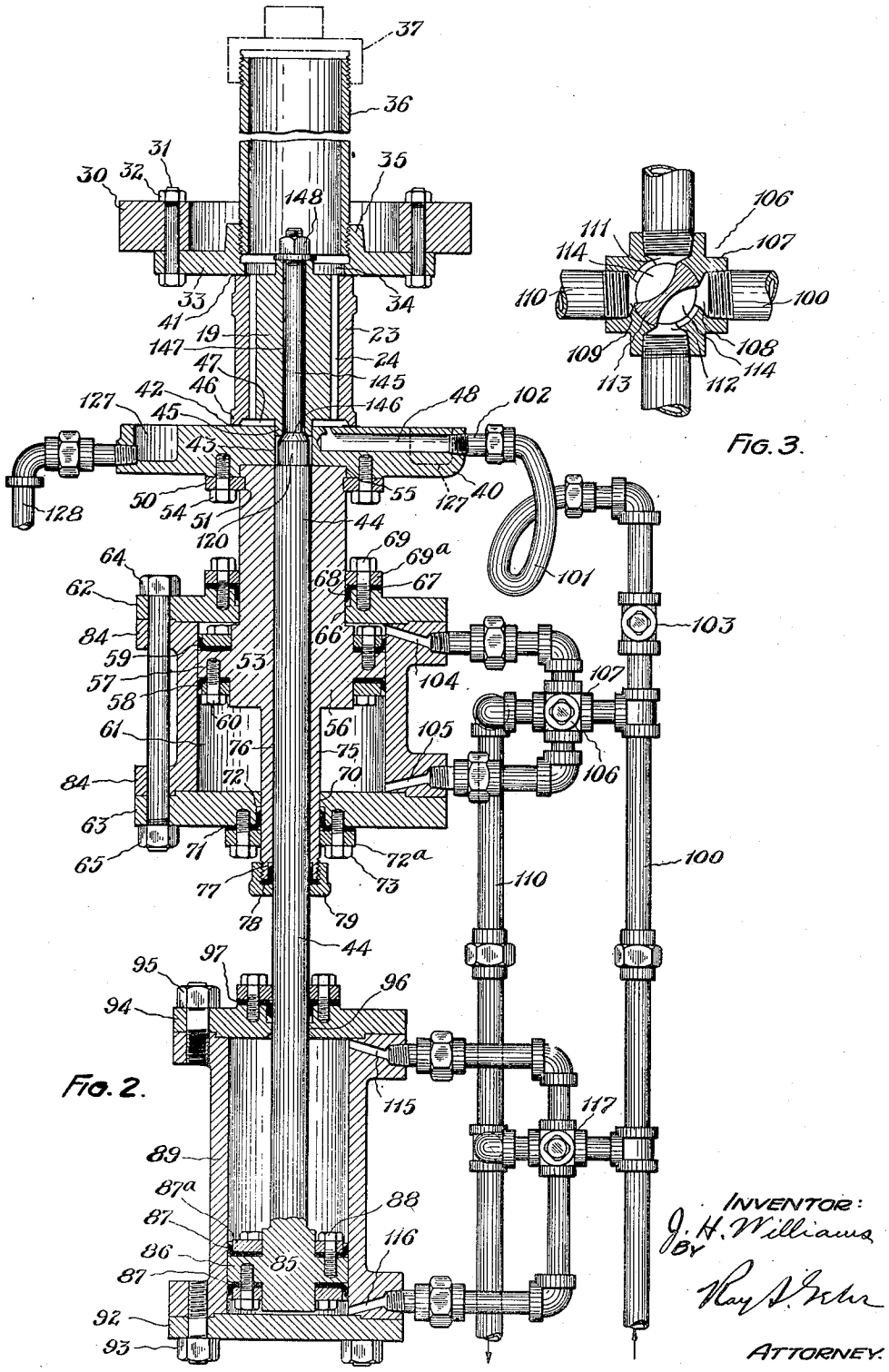


FIG. 2.

FIG. 3.

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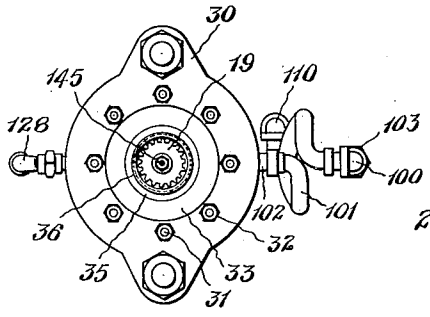


FIG. 5.

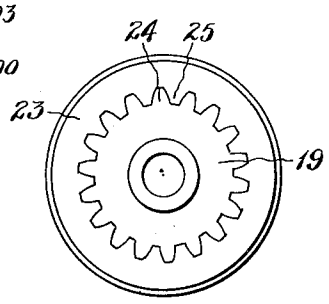


FIG. 7.

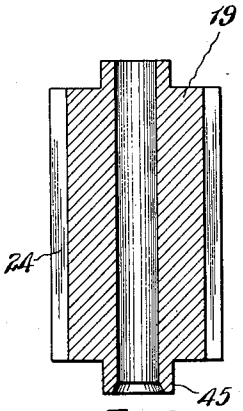


FIG. 8.

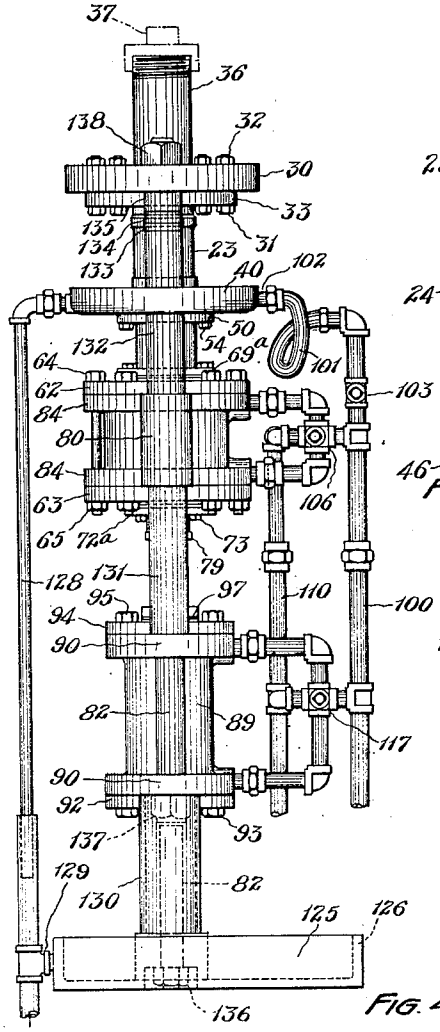


FIG. 4.

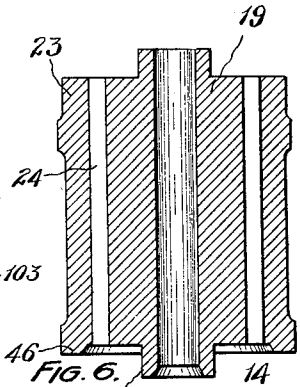


FIG. 6.

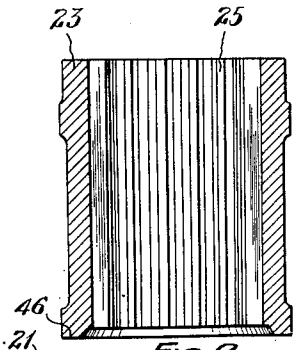


FIG. 9.

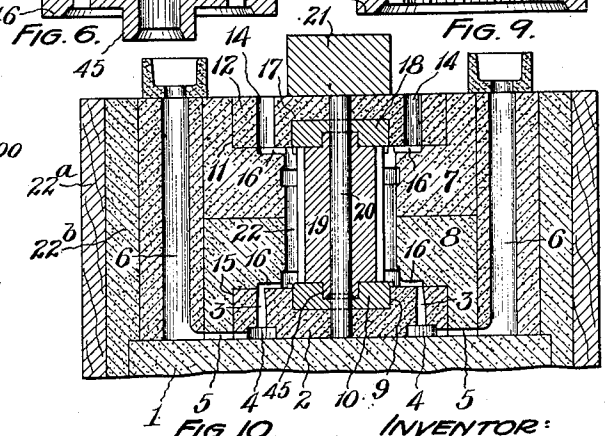


FIG. 10.

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UNITED STATES PATENT OFFICE

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METHOD OF MAKING CASTINGS

Application filed March 7, 1927. Serial No. 173,224.

The invention relates to the production of castings having either tubular or reentrant cross sections so that the casting when formed in the mold either wholly or partially embraces a part of the mold structure. Notable examples of such castings are internal gears and also laps of a certain type which resemble internal gears in form and which are adapted for use in the truing of external gears by the method devised by A. W. Copland and M. I. Mathewson and set forth in their U. S. Letters Patent No. 1,683,867. Such internal gears and laps are, of course, instances of castings of tubular cross section.

One of the principal objects of the invention is the provision of an improved method by the use of which castings of the character referred to can be produced with a high degree of accuracy.

Another object of the invention is the provision of an improved method by the use of which accurately formed castings of the character last referred to can be produced with the metal of their inner surfaces highly chilled and having the fine-grain structure characteristic of such chilled metal.

A further object of the invention, ancillary to those above noted, is the provision of an improved method for removing solid metal cores or mold sections from tubular or reentrant section castings of the character referred to.

The improved method consists essentially in pouring the casting in contact with an accurately formed and smoothly finished metal core or other mold section having a form complimentary to that of the embracing surfaces of the casting to be produced; separating the casting and the core or mold section referred to from the remainder of the mold; subjecting the joint between the casting and core or mold section to liquid pressure until the liquid enters between and lubricates the abutting surfaces of the casting and core or other mold section; and then forcing the core or other mold section out of the embracing walls of the casting.

As above stated, laps of the character referred to constitute a notable example of castings to which the invention is applicable, such laps being in the general nature of axially elongated internal gears, and for purposes of explanation and illustration the method and preferred apparatus for carrying it out will be described in detail as applied to laps of this character, reference being had to the accompanying drawings showing the preferred apparatus.

In the drawings:

Fig. 1 is a vertical section through the upper part of the apparatus for removing the core from the casting.

Fig. 2 is a vertical section on the line 2—2, Fig. 1.

Fig. 3 is an enlarged vertical section through a four-way valve forming part of the apparatus.

Fig. 4 is a side elevation on a smaller scale of the entire apparatus.

Fig. 5 is a plan view of the apparatus shown in Fig. 4.

Fig. 6 is an enlarged vertical section of the lap casting and the core as they come from the mold.

Fig. 7 is a plan view of the parts illustrated in Fig. 6.

Figs. 8 and 9 show the core and lap, respectively, after they have been separated.

Fig. 10 is a vertical section on a reduced scale of the entire mold used in casting the laps.

Reference will first be made to Fig. 10 which shows the main parts of a mold designed for the casting of the laps. The lap is to be formed with internal teeth complementary to those of the spur gears to be lapped thereby and consequently the metal core of the mold must be formed with external teeth similar to those of such gears. In Fig. 10 the reference character 1 indicates the base portion of a mold which is formed of dry sand. Resting thereon in a central position is a spindle gate core 2 also of dry sand with sixteen spindles 3 formed thereon and equally spaced around the core 2. In this core 2 at the base of the spindles 3 is an annular space 4, which serves to transfer molten metal from the feeder passage 5 and pouring gates 6 to the spindles 3 from there into the casting cavity 22 of the mold.

The main body portion of the mold is divided on a horizontal plane into an upper section 7 and a lower section 8, both formed of dry sand. The lower body portion 8 has a recess 15 into which the core 2 is fitted. The spindle core 2 has a recess 9 in its upper face in which is inserted an iron chill 10.

Complementary to core 2 and resting in a recess 11 in the upper body portion 7 of the mold is another dry sand core 12, which has formed therein four openings 14 equally spaced around the core 12. In the upper and lower sides of the body portions 7 and 8 respectively, are recesses 16 which allow communication between the spindles 3 and the cavity of the mold, and also between said cavity and the riser openings 14. The core 12 has a recess 17 for the reception of a second iron chill 18.

In the center of the mold and resting on lower chill 10 is a steel core 19. Extending through this core 19, and also lower core 2, chills 10 and 18, and upper core 12 is a central bore which is adapted to receive the central rod 20. Resting on the top of the core 12 and rod 20 is a weight 21. Surrounding the mold is a flask 22^a. A space 22^b is provided between the walls of the mold and flask for the reception of green sand.

The mold is assembled and operated as follows: The base slab 1 is placed on a bottom of green sand, which is leveled off for the reception of the base. Core 2 is fitted into the recess 15 of lower body portion 8 and is placed on base 1. Iron chill 10 is then placed in recess 9. Steel core 19 is then placed in position, and upper body portion 7 is then placed on lower body portion 8. Core 12 is then placed in recess 11 of mold section 7. If the steel core 19 does not match the mold in length, upper body portion 7 is rubbed on lower portion 8 until they do match. In practice portions 7 and 8 are purposely made longer than is required so as to insure a proper fit. The mold is then taken apart and the feeder passages 5 are cut. The mold is then reassembled leaving out core 19, core 12 and chills 10 and 18, and pouring gates 6 are then pasted thereon so that they will register with the feeder passages. The entire mold is then covered with paper. The flask 22^a is placed around the mold and space 22^b is packed with green sand until it is level with the top of the mold. The steel core 19 is then preferably coated, while at a temperature of about 100° F., with a solution of bone black in water. The chill 10, the steel core 19, chill 18, core 12, rod 20 and weight 21 are all placed in position. Molten metal is then poured into gates 6 until it appears in risers 14. The casting is allowed to cool until it is thoroughly congealed and then the mold is broken away and the steel core 19 with the casting is removed and set upon its end to cool.

With the above described mold and procedure the casting produced, particularly the metal at the inner surfaces of the lap, is strongly chilled and is correspondingly hard and dense. However, by a modified method it is possible to produce soft iron laps or other castings. In this latter case the chills 10 and 18 are omitted and the metal core 19 is preliminarily heated in a suitable manner to control its chilling effect while, at the same time, the advantages of accurate form of the core are retained.

Whether the casting produced as above described be chilled or soft, as it cools it contracts and more or less strongly grips the core 19 with the result that the removal of such a solid core from the casting without damaging the core or casting has heretofore been a practically insurmountable obstacle. But by my improved method and apparatus I am enabled to accomplish such removal.

The means for separating the lap from the steel core 19 is shown in Figs. 1 to 9, inclusive.

The steel core 19 with a cast iron lap 23, as it comes from the mold is shown in Figs. 6 and 7. The registering teeth of the core and lap are indicated at 24 and 25, respectively. Figs. 8 and 9 show the core and lap after they have been separated by the method and apparatus hereinafter described.

Referring to Figs. 1, 2 and 4 in detail: The apparatus has an upper rigid clamping ring 30. Clamped to this ring by means of bolts 31 and nuts 32 is an adapter plate 33. Different size adapters can be used for different size laps. An opening 34 is provided centrally of the adapter so that the core 19 may be ejected from the lap 23. A boss 35 projects upwardly from the adapter plate and is arranged around the periphery of the opening 34. This boss is provided with screw threads for the reception of a casing 36. A cover 37 is attached to the casing by means of screw threads or the like. Two openings 38 are provided in the ring 30 for the reception of tie rods 82 for a purpose to be hereinafter described.

Arranged below and spaced from the clamping ring 30 and adapter 33, is a movable clamping plate 40. In the operation of the device the lap 23 is rigidly held between these clamping elements 33 and 40. Packing rings 41 and 42 are provided at the upper and lower ends of the lap 23 so as to prevent oil from escaping. A central bore 43 is provided in the plate 40 for the reception of a ram rod 44. It will be noted that on core 19 and lap 23 respectively, extensions 45 and 46 have been provided. Extension 45 extends into the upper part of bore 43 and extension 46 rests on the clamping plate 40. This arrangement of the two extensions just described with relation to the plate 40 provides an annular space 47 between the plate 40 and the core and lap, for a purpose to be hereinafter described. The plate 40 is provided with a passageway

48 (Fig. 2) which leads to the annular space 47 for the passage of liquid under pressure.

A piston 53 is rigidly attached to this movable clamping plate 40 by means of a split ring 50 fitting into a groove 51 in the piston. This ring is secured to the plate 40 by means of screws 54. This piston is fitted into a recess 55 in the clamping plate 40.

The piston has an integral head 56 disposed in the cylinder 61. This head has an annular flange 57, to which the packing rings 58 and 59 are secured by means of bolts 60, thereby forming a liquid tight fit in the cylinder 61.

The cylinder 61 is closed at both ends by means of plates 62 and 63 secured to the cylinder by means of tie bolts 64 and nuts 65. These bolts extend through the body of the cylinder and secure the plates to the ends thereof. The plate 62 has an opening 66 in its center for the purpose of receiving the upper end of the piston 53. A liquid tight fit is provided between the piston 53 and plate 62 by a packing means 67 which is secured in the recess 68 of the plate by means of screws 69, acting on a clamping ring 69[a].

An extension 75 is integral with the piston head 56, and reciprocates in an opening 70 in the lower cylinder plate 63, and thereby forms a guiding means for the piston. Suitable packing rings 71 are fitted in a recess 72 in the plate 63 and are held in place by means of a clamping plate 72[a] and screws 73.

A bore 76 extends centrally of piston 53 and piston extension 75 for the reception of the ram rod 44. The lower end of extension 75 has a recess 77 cut therein. This recess together with packing 78 and cover 79 form a stuffing box for the ram rod 44.

It will be noted from an examination of Fig. 1 that the cylinder 61 has two solid integral extensions 80 arranged opposite each other and these extensions have openings 81 for the reception of tie rods 82, and also openings 83 for the reception of bolts 64. The remaining tie bolts 64 engage the cylinder through integral flanges 84, seen in Fig. 2.

The lower end of ram rod 44 terminates in a piston 85. This piston has an integral flange 86 to which packing rings 87 are secured by means of plate 87[a] and screws 88. Enclosing the piston is a cylinder 89 having integral extensions 90 in which the openings 91 are provided for the reception of the tie rods 82.

The lower end of the cylinder 89 is closed by means of the plate 92 and stud bolts 93. The upper end is closed by means of a plate 94 and stud bolts 95. The plate 94 has a central opening 96 for the passage of the ram rod 44. A suitable packing means 97 is provided in the opening 96 for the ram rod, so as to form a fluid tight connection.

The reference character 100 denotes a pipe line (see Fig. 2) which is connected at its lower end to a suitable oil pump or accumulator (not shown) for delivering oil under pressure to the apparatus. Connected to the upper end of this pipe line is a flexible conduit 101, which in turn is connected at its other end to a suitable connection 102 on the movable plate 40. This connection 102 is threaded into the outer end of passage 48 in the clamping plate. This conduit 101 is made flexible so that the plate 40 will be free to move. A valve 103 of ordinary construction controls the flow of oil to the movable clamping plate.

The clamping cylinder 61 has oil ports 104 and 105 arranged at its upper and lower ends respectively, so as to allow oil under pressure to enter the said cylinder on either side of piston head 56 to control the movement of the same. Oil also exhausts through these ports 104 and 105. When one of the ports is acting as a means for introducing oil under pressure the opposite port is acting as an exhaust. This movement is controlled by means of the four-way control valve 106, which is shown in detail in Fig. 3. The valve casing 107 of this valve 106 has four openings equally spaced around the same. The openings 108 is connected to the pressure line 100, and opening 109 is connected to the exhaust line 110 which leads to a suitable oil supply reservoir (not shown). Openings 111 and 112 have connections which lead to the oil ports 104 and 105, respectively, of the cylinder 61. The central valve member 113 is adapted to rotate in the casing 107, and has two ports 114 cut in the body thereof at opposite sides so as to establish connections between the cylinder and the two lines, that is the supply line 100 and the exhaust line 110. These connections are effected in the following manner: When one end of the cylinder 61 is in communication with the supply line by means of one of the valve ports 114, the other end of the cylinder will be in communication with the exhaust line 110, through the other valve port 114.

Cylinder 89 has ports 115 and 116 at opposite ends thereof. These ports are connected to supply line 100 and exhaust 110 by means of a second fourway valve 117. This four-way valve 117 is identical, in construction and operation, with valve 106 described above. The movement of piston 85 is controlled by the operation of the valve 117 in the same manner that piston head 56 is controlled by valve 106.

The upper end of ram rod 44, see Fig. 1, has a reduced extension 120 which projects into bore 43 of clamping plate 40. In this extension 120 is a right-angle passageway 121, which acts as a means for equalizing the oil presssure in a manner to be hereinafter described.

Referring particularly to Fig. 4, it will be seen that the apparatus is mounted on a

base 125 which has a flange 126 provided around its outer edge so as to catch any oil which may leak out of the connections.

In the movable clamping plate 40 an annular trough 127 is provided to catch the oil which may escape when the lap 23 and core 19 are removed. Trough 127 is connected with a return oil pipe 128 which leads to the supply reservoir. Base 125 is connected by means of conduit 129 to this return pipe 128. (See Fig. 4.) This base 125 is adapted to be mounted on some suitable support (not shown) such as a floor of the building, or the like.

As can be seen from an examination of Fig. 4, tie rods 82 project upwardly from the base 125 on opposite sides thereof. The rigid parts of the apparatus are connected together by means of these tie rods 82. It will be noted that the tie rod 82 has an enlarged section 131, the purpose of which is to keep the cylinders 61 and 89 spaced apart. Sleeves 130, 132, 133, 134 and 135 surround the rods 82 and also serve to keep the several parts of the apparatus separated as can be seen from an examination of Figs. 1 and 4. Nuts 136, 137 and 138 are attached to the tie rods so as to draw the several parts together on their spacing sleeves, thereby rigidly securing the several parts to each other. The movable clamping plate 40 has openings 150 through which the tie rods 82 and spacing sleeves 132 extend. This is for the purpose of guiding the movement of the plate 40.

It will be seen from an examination of Figs. 1 and 2 that the steel core 19 has a bolt 145 with a beveled head 146 secured in its central opening 147 by means of a nut 148. The bolt 145 is placed in the opening so as not to allow any oil to pass into casing 36 during one step in my process.

It will be noted that between the cylinder 61 and the ring 30 I have shown the several spacing sleeves 133, 134 and 135 of different lengths. These sleeves are adapted to be removed or added at the will of the operator so as to adapt the machine to different length laps 23.

In carrying out my improved method, the operation of the apparatus is as follows: When the cast iron lap 23 and the embraced mold section (in this case the core 19) have cooled sufficiently after having been removed from the mold, the lap is machined or otherwise prepared for use. Then the bolt 145 is secured in the aperture 147 of the steel core 19 by means of the nut 148, and the steel core with the lap thereon is placed in position with the lap 19 registering with the opening 34 in the adapter plate 33. The packing rings 41 and 42 having been placed in position, oil under pressure is admitted through four-way valve 106 to the port 105 of the cylinder 61 thereby moving the piston 53 upwardly. This piston 53 carries the lower clamping plate 40 with it. This plate 40 engages the projection 46 on the lap 23 and thereby firmly clamps the lap between it and the adapter plate 33. The projection 45 on the core 19 extends into the bore 43 of the plate 40. Cap 37 having been removed from the casing 36, valve 103 is opened thereby allowing oil under pressure to enter the annular space 47 formed at the lower end of the lap and core, through the opening 48 in the plate 40. This oil under pressure is forced between the abutting surfaces of teeth 24 and 25. This latter action lubricates and separates these surfaces and the pressure of the oil on the lower end of the core 19 forces the latter from the lap 23 and into the casing 36.

The above described operation is in most cases sufficient to extract the core from chilled iron laps. Should this operation fail to do the work, valve 117 is turned in such a manner as to allow oil under pressure to enter through port 116 to the cylinder 89. This operation will cause the piston 85 carrying the ram rod 44 to move upward. The continuation of this upward movement of the ram rod 44 causes it to strike the head 146 of the bolt 145 arranged in the central opening in the core and thereby mechanically eject the core from the lap.

However, should this latter operation fail, the core and lap are then taken from between the two clamping plates, the bolt 145 is removed therefrom and the core and lap are then placed between the two clamping plates as before and the cap 37 is placed in position on casing 36. It will be noted that the upper end of ram rod 44 and also the projection 45 on the lower end of the steel core fit loosely in the bore 43 of the movable clamping plate. It will also be noted that a right-angle passageway 121 is located in the upper end of the ram rod 44. Pressure is again admitted through valve 103 to the annulus 47. Oil under pressure will then find its way into the upper casing 36 due to the loose fitting of the projection 45 with the bore 43, the passageway 121 and the central opening 147 in the core. It will be seen that oil under pressure is then being forced along the gear teeth 24 and 25 from both ends and this is continued until the oil has fully penetrated between and lubricated the abutting surfaces of the lap and core, and by expanding the lap or outer part, relieved the shrinkage pressure on the core, either in part or entirely, thereby causing separation of adjoining surfaces or relief of bearing between them. While the lap or outer part is thus under pressure valve 117 is opened to allow oil under pressure to pass through opening 116, raise piston 85, and ram 44, and thereby forcibly eject core 19 into casing 36. The pressure is cut off by proper manipulation of valves 117 and 103, the cap

37 is removed and the core is then lifted out of the casing.

When the abutting surfaces of the lap and core are lubricated in the manner described, the core can be forced from the lap without undue pressure and consequently without injury to the said surfaces. The result is that by my improved method of casting it is possible to produce a casting of annular or tubular cross section having its inner surfaces formed with a relatively high degree of accuracy. Also as pointed out, the casting can be made either chilled or soft.

I have referred to the casting 23 as a cast iron lap and to the part 19 as a steel core, but it will be understood that this is for illustrative purposes only and that the casting may be either in the form of a lap, an internal gear or any other casting of tubular or annular shape or having reentrant walls, which it is desired to form with accurate surfaces or which it is desired to form of chilled metal. Furthermore, it is obvious that the casting may be made of metals other than iron.

While I have described the preferred procedure for the carrying out of my invention it will be understood that there can be wide variation therefrom without departing from the invention as defined in the appended claims.

What I claim is:

1. The method of forming annular or reentrant section castings which comprises pouring molten metal around a metal mold section; removing the casting and mold section from the remainder of the mold; subjecting the joint between the casting and mold section to the pressure of liquid outside the joint until the liquid enters between and lubricates the abutting surfaces of the casting and mold section; and forcing the mold section out of the embracing walls of the casting.

2. In the method of forming annular or reentrant section castings, the steps which comprise: pouring molten metal around a metal mold section; removing the casting and mold section from the remainder of the mold; subjecting the joint between the casting and mold section to the pressure of liquid outside the joint until the liquid enters between and lubricates the abutting surfaces of the casting and mold section and separates them.

3. In a method of forming annular or reentrant section castings, the steps which comprise: pouring molten metal around a metal mold section; removing the casting and mold section from the remainder of the mold; subjecting the joint between the casting and mold section to the pressure of liquid outside the joint until the liquid enters between and lubricates the abutting surfaces of the casting and mold section, thereby separating them; and then forcing the mold section out of the embracing walls of the casting.

4. In a method of forming annular or reentrant section castings, the steps which comprise pouring molten metal around a metal mold section; removing the casting and mold section from the remainder of the mold; subjecting the joint between the casting and mold section to liquid under pressure outside the joint at each end thereof until the liquid enters between and lubricates the abutting surfaces of the casting and mold section and separates them.

5. In a method of forming annular or reentrant section castings the steps which comprise pouring molten metal around a metal mold section; removing the casting and mold section from the remainder of the mold; subjecting the joint between the casting and mold section to liquid under pressure outside the joint at each end thereof until the liquid enters between and lubricates the abutting surfaces of the casting and mold section and separates them; and then forcing the mold section from the embracing walls of the casting.

In testimony whereof I affix my signature.

JAMES H. WILLIAMS.