

Oct. 28, 1941.

T. C. KORSMO

2,260,462

DIE FOR PRESSURE CASTING

Filed April 9, 1941

4 Sheets-Sheet 3

Fig. 3

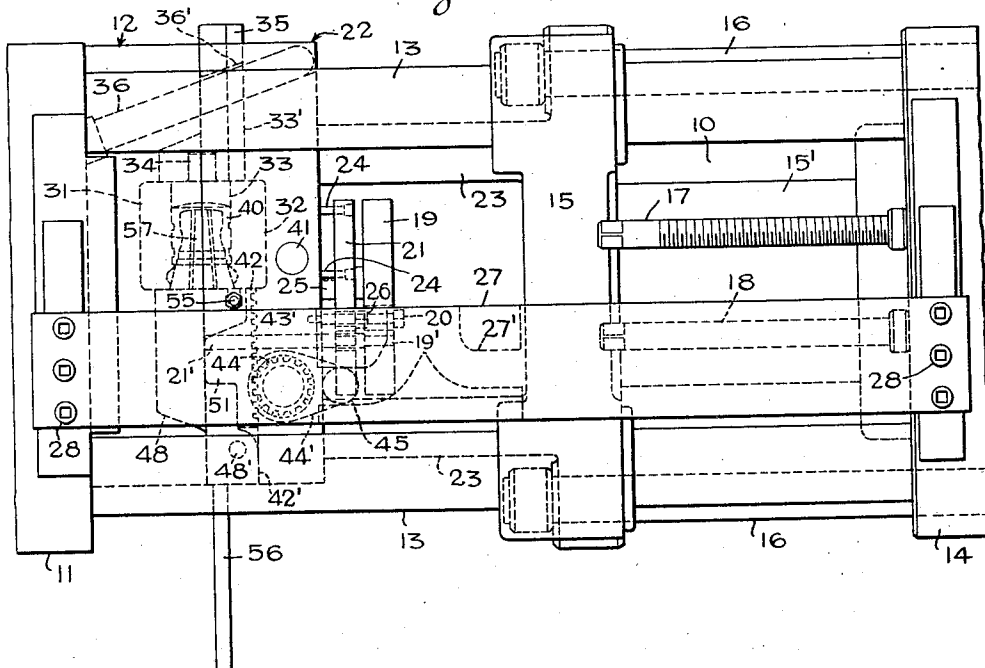
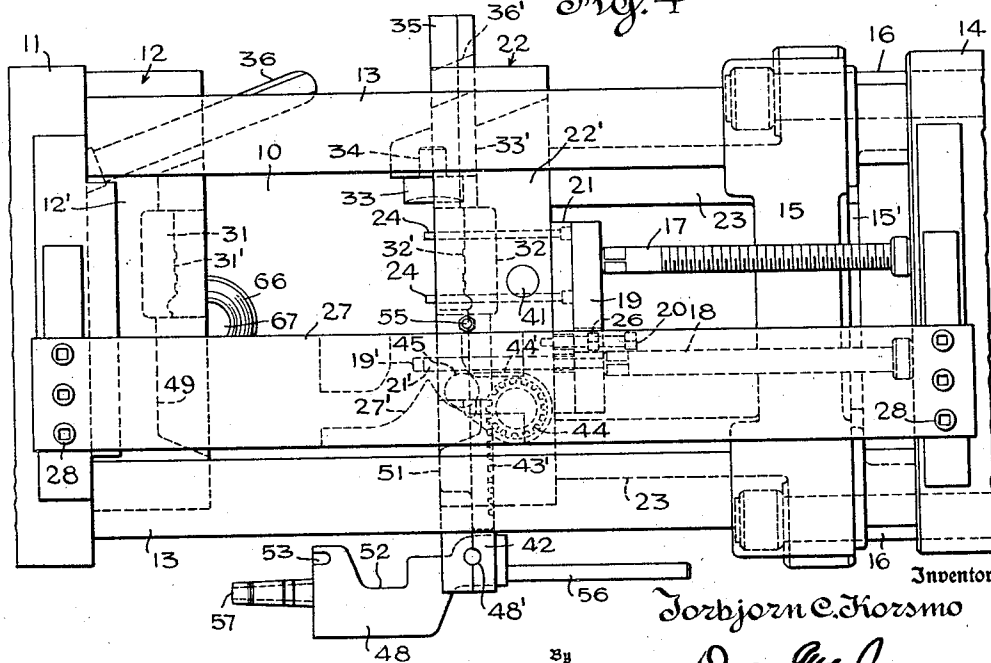


Fig. 4



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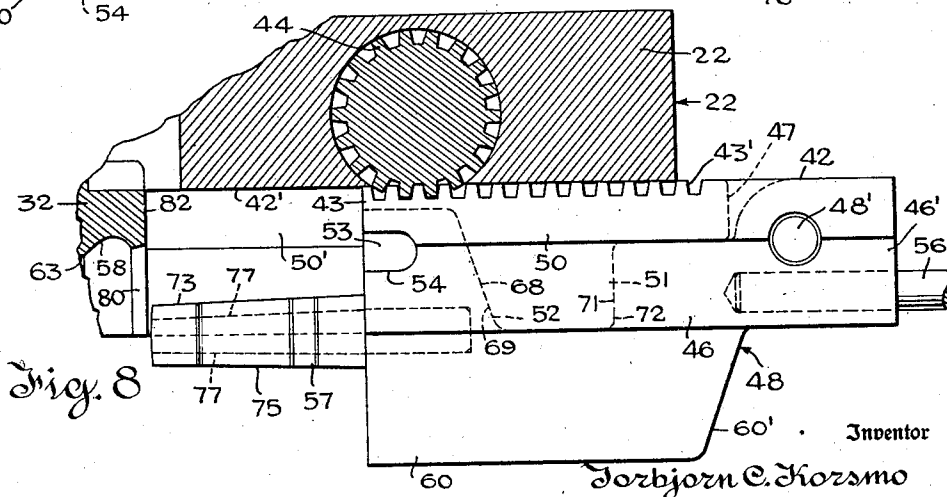
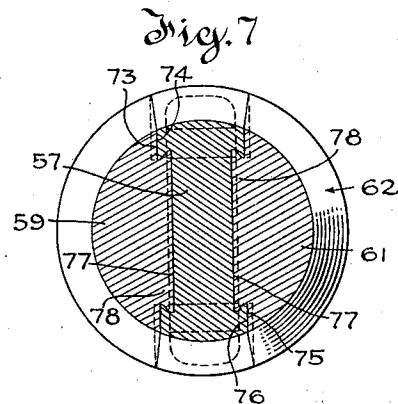
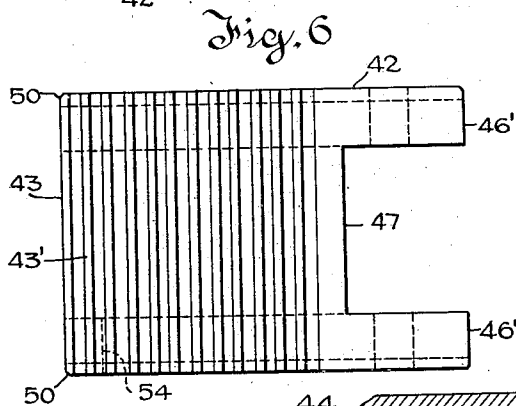
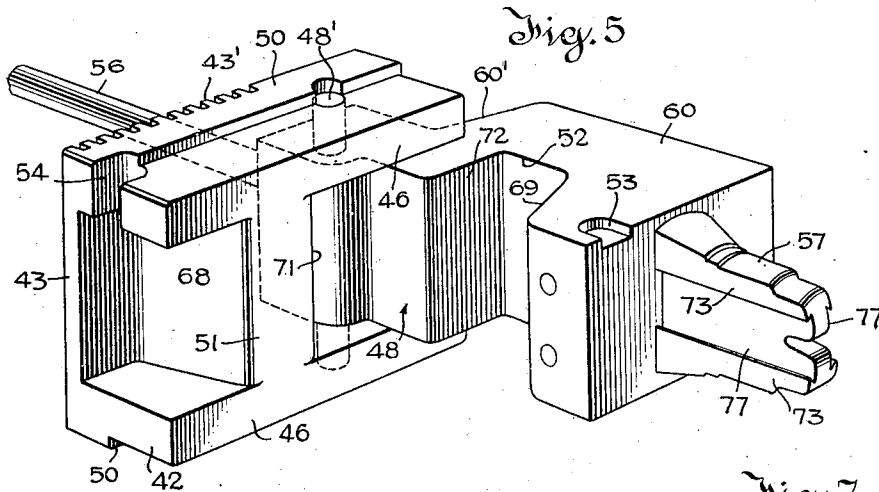
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DIE FOR PRESSURE CASTING

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18 Claims. (Cl. 22—151)

This invention relates to dies for die casting machines and particularly to the form and mounting therein of a contractible core and the mode of operating and manipulating such core during and after opening of the die and during closing of the die. The invention, though not necessarily limited thereto, was developed for, and has demonstrated particular utility in connection with, the casting of aluminum alloy pistons.

Simply for convenience the invention will be described as so embodied. The invention is especially applicable wherever the internal form of a cylindrical or cup-shaped casting requires the use of a contractible core, and is particularly useful when the length of the core is substantial, for example, nearly as long as the hollow casting.

To secure good grain, alloy pistons should be cast under heavy pressure. This requires accurate positive positioning of all die parts, particularly the main core. The invention ensures this by causing the separable main die halves or sections to accurately position and fix the components which form the contractible main core. The main core comprises a central axially-withdrawable section on which are formed converging guideways. Each of the converging guideways (of which there are two in the example illustrated) carries a complementary core section. Thus in the illustrated embodiment, two complementary sections with the central withdrawable section comprise the complete main core or main core assembly.

As the die initially opens, the main core assembly moves with the movable die half on which it is mounted, so that the casting is stripped from the fixed die half and from any core fixed thereto. During this phase a die component which defines the piston head is also retracted. In the next phase of opening movement the central section of the main core, which is supported by a slidable carriage on the movable die half, is completely withdrawn from the casting, thereby stripping the other sections of the main core from the casting because of the converging form of the core guideways, but leaving these core sections loose within the casting. In the final phase of opening movement any remaining small cores are withdrawn, after which the ejector mechanism ejects the casting and the contained core sections from the movable die half.

When the die is fully open the central section of the main core, which is permanently mounted for the purpose on a carrier pivotally supported by the movable die half, may be manually swung

outwardly away from the inner face of the movable die half and preferably entirely from between the die halves. After this the other parts of the main core are retrieved from the ejected casting and reapplied to the guideways on the central core section while the latter core section is removed from between the die halves and is thus in a position in which it is fully accessible to the operator to replace the retrieved core sections thereon without the die parts or machine parts interfering with this operation. The assembled main core is then manually swung back to position between the die halves, whereupon closure of the die will automatically return all die parts and cores to normal casting position.

A commercial embodiment of the invention, a die structure for casting trunk pistons for internal combustion engines, will now be described in detail with reference to the accompanying drawings, in which:

Fig. 1 is a face view (elevation) of the movable die half and all parts carried thereby, the parts being in the positions they assume when the die is closed. The molten metal supply well is shown in section.

Fig. 2 is a section of the die in closed position, the plane of section being indicated by the line 2—2 in Fig. 1.

Fig. 3 is a plan view of the die carrying parts of a die casting machine with the improved die mounted therein, the parts being shown in die-closed position. The position of the die cavity and of the cores is indicated in broken lines.

Fig. 4 is a similar view but illustrating the completely open position of the die, the central main core section being shown swung from between the die halves for reassembly of the other retrieved core parts therewith.

Fig. 5 is a perspective view of the main core carriage and the main core carrier which is hinged thereto. Only the central withdrawable section of the main core is shown. The parts are positioned as they are after the carrier is swung outward from between the die parts, as appears in Fig. 4.

Fig. 6 is an elevation showing the rack face of the core carriage and the lugs thereof between which the carrier is pivoted.

Fig. 7 is a transverse section of the main core assembly indicating the form of the guides which interconnect the three components of the core.

Fig. 8 is a view partly in plan and partly in section showing the core carriage fully retracted. In this position the central main core section has been completely withdrawn from the die

cavity and the cavity-forming inserts and hence from the casting and the loose main core sections therein, following which the latter were ejected, and the carrier may now be swung out to the position of Figs. 4 and 5. The carrier is, however, shown as it appears before being so swung out.

Fig. 9 is a vertical central section through the metal pressure chamber in the closed die and the registering metal well, the section being taken at right angles to Fig. 1.

Referring first to Figs. 3 and 4, bed portion 10 of the machine frame is provided with the rigid upright or hot plate 11. Hot plate 11 carries the fixed die half or die section, generally indicated at 12, and is connected by two guide rods 13 with the upright or head 14 which also is a fixed part of the frame. Guided for reciprocation on rods 13, to open and close the die, is a carriage 15 which is actuated by a hydraulic ram 16 carried by head 14. The ends of carriage 15 are connected by two tie rods 16 to the remote end of the ram (not shown). Threaded studs 17 and 18, carried by head 14, are adjustable stops which during opening of the die first arrest the movable core actuator plate 19 by direct engagement therewith and thus shortly thereafter cause engagement of the movable ejector plate 21 with plate 19 so as to arrest plate 21 also. Thus these two plates, which are slidably carried by the movable die half or section generally indicated at 22, are operated serially by stops 17, 18 as the movable die half moves in die-opening direction. As the opening movement is completed, movable die half 22 moves into contact with the arrested plates 19 and 21, as appears in Fig. 4.

Movable die half 22 is supported by two brackets 23 projecting to the left (Figs. 3 and 4) from the ends of carriage 15. Movable die half 22 slidably supports ejector plate 21 by means of the ejector pins 24 and the return pin 21' secured to the plate, and the core actuator plate 19 by means of the toothed core-actuating plunger 25 and the return pin 19' secured to plate 19 and extending through suitable openings in plate 21 (see Figs. 1 and 2). To effect the serial operation of plates 19 and 21 referred to above, these plates in normal die-closed position (Fig. 3) are spaced from each other and also from movable die half 22. Slidable return pins 21' and 19' for plates 21 and 19 extend through movable die half 22 to the parting line of the die when the die is closed (Figs. 2 and 3), are projected from the face of die half 22 when plates 21 and 19 are actuated near the end of the opening movement of the die (Fig. 4), and are returned by engagement fixed die half 12 to their original normal position and thereby restore plates 21 and 19 to their original positions of Fig. 3 when the die again closes. As shown in Fig. 2, headed studs 20 and 26, fixed on movable die half 22, have their shanks extending freely through suitable openings in plates 19 and 21, respectively, so that their heads accurately limit the return of these plates and connected parts to normal position. Opening 26' in plate 19 accommodates the head of stud 26 during relative movements of the plate and the stud.

A combination bar 27 extends between uprights 11 and 14 to which it is releasably connected by socket bolts 28. The combination bar is simply an interchangeable cam carrying member. It carries cams used to operate die components. In this case it carries a cam which actuates the main core.

The parts so far described are simply familiar components of known die casting machines, and no novelty is here claimed for any of them. Moreover, various known equivalents may be substituted so far as the present invention is concerned.

Refer now to Figs. 1 and 2.

The fixed die half or section 12 comprises a main body 12' and two fixed inserts, namely the fixed die half insert 31 which has a portion 31' forming half of the die cavity 40 (Fig. 2), and the insert 29 which forms half of the pressure chamber in which the casting material (molten metal in the particular case described) is subjected to pressure to force it into the die cavity. The movable die half or section 22, similarly to the fixed die half, comprises a main body 22' and two inserts, namely, the movable die half insert 32 which has a portion 32' forming the complementary half of die cavity 40, and the insert 30 which forms the complementary half of the pressure chamber.

Die half inserts 31, 32 are complementary, except that the portion of the closed die which forms the head of the piston casting comprises the axially retractable member 33 which is connected by neck 34 with the carrier 35. Carrier 35 is mounted in movable die half 22 for reciprocation in the direction of the piston axis. For this purpose carriage 35 is slidably arranged in an open-ended channel 33' in die member 22' with which it has slidable undercut tongue-and-groove connections at 35'. An angle pin 36 fixed in stationary die half 12 and extending obliquely through a slot 36' in carrier 35 serves to withdraw die member 33 as the die opens. This motion commences almost immediately after opening motion starts.

Fixed-die-half insert 31 carries a fixed core 37 which forms the wrist pin opening in the wrist pin boss on one side of the piston casting. Aligned with core 37 and axially movable in a suitable passage in die-half insert 32 in movable die half 22 is a companion core 38 for the opening in the wrist pin boss on the other side of the piston. Core 38 is connected to and actuated by toothed slide 39 guided in movable die half 22. A motion-transmitting pinion 41 journaled in die half 22 engages the teeth on plunger 25. Thus, near the end of the movement of die half 22 in an opening direction, arrest of plate 19 by stops 17 and 18 entails retraction of core 38. This follows retraction of member 33, and is subsequent to the contraction of the main core hereinafter described.

The main core carriage 42 is mounted for reciprocation on movable die half 22 to move in a path parallel with the axis of the piston. For this purpose core carriage 42 is slidably arranged in an open-ended channel 42' in movable die member 22' and has slidable undercut tongue-and-groove connections therewith formed by tongues or flanges 50 on carriage 42 and coacting undercut grooves 50' in die member 22'. Carriage 42 is channel or U-shaped in transverse section (see Fig. 5) and the outer face of its base 43 is toothed as indicated at 43'. These teeth mesh with elongated pinion 44 journaled in movable die part 22'. An arm 44' fast to pinion 44 carries a roller 45 confined in the Y-shaped cam slot 27' on the lower face of combination bar 27. The parts are so arranged that complete opening of the die will turn pinion 44 about 165°, thereby sliding core carriage 42 outward a distance such that the central main core section is moved completely from

between die half inserts 31 and 32 as indicated in Fig. 8.

Base 43 of core carriage 42, which latter has upper and lower side walls 46, is notched at 47 (Fig. 6) to provide perforated side wall extensions or lugs 48'. Between these lugs the outer end of the main core carrier 48 is located and secured by hinge pin 48', whereby carrier 48 is mounted for manual swinging movement on carriage 42. Normally carrier 48 is located in channel-shaped carriage 42 between walls 46 and against base 43 of the latter, with the inner ends of the carriage and the carrier flush with each other and abutting against side faces 81 and 82 of die inserts 31, 32 (as shown in Fig. 2) to aid in accurately and firmly locating the main core in die cavity 40. A recess 49 in fixed die half part 12 receives a projecting portion 60 of core carrier 48 and provides an inclined shoulder 49' engaging a similarly inclined shoulder 60' on carrier portion 60. This arrangement also aids in accurately and firmly locating the main core in the die as its is closed and the abutting shoulders relieve pin 48' of outward stress of carrier 48 thereon during the casting operation.

Core carriage 42 has a partition 51 which is normally located in a slot 52 in core carrier 48. Partition 51 and slot 52 provide one pair of abutting shoulders 68, 69 and a second pair of abutting shoulders 71, 72. The interengagement of shoulders 68 and 69 relieves pin 48' of stress as the die closes and carriage 42 moves the main core firmly into casting position in the die, and also aids in relieving pin 48' of stress during shooting of the casting. Engagement of shoulders 71 and 72 relieves pin 48' of stress when the die opens and carriage 42 moves outward to withdraw the central main core section. When the die is closed, vertically aligned notch 53 in core carrier 48 and notch 54 in core carriage 42 receive the lower end of the threaded core positioning and locking bolt or dowel pin 55 (Fig. 1) which is mounted in die member 22' and projects into channel 42' thereof. Thus, pin 55 normally locks core carrier 48 against swinging on pin 48' and the main core is rigidly held in place on movable die half 22, thereby assuring pulling of the casting from the fixed die half 12 and core 37 by the main core in the initial opening motion of the movable die half. When the die is wide open and hence outward sliding movement of carriage 42 and carrier 48 has freed their notches 53 and 54 from locking pin 55, main core carrier 48 may be swung out by the operator from between die halves 12 and 22 and into the position shown in Figs. 4 and 5 by means of handle 56.

Core carrier 48 permanently supports on its end the central section 57 of the main core. Core section 57 normally removably supports thereon the complementary sections 59 and 61 of the main core by means of slidable dove-tail guide connections between the core sections. The abutting plane faces 73 and 74 of sections 57 and 59, respectively, and the abutting plane faces 75 and 76 of sections 57 and 61, respectively, are arranged at a slight angle lengthwise of the core (Figs. 2 and 7) so that central core section 57 is tapered toward its outer end. Faces 73 and 75 of section 57 have dove-tail guide grooves 77, and face 74 of section 59 and face 76 of section 61 have dove-tail guides or tongues 78 which slidably interfit with grooves 77. The abutting surfaces of these tongues and grooves, including the undercut side walls of grooves 77 and the under-

cut edges of tongues 78, converge in conformity with the taper of middle section 57, so that when section 57 is withdrawn the parts 59 and 61 are drawn toward each other and thus stripped from the casting.

As is best shown in Figs. 1 and 2, adjacent carrier 48 and outside the die cavity proper, the base of the main core, made up of parts 57, 59 and 61, is tapered to form a right circular cone generally indicated at 62. Adjacent carrier 48 this cone is completely surrounded and closely embraced by the semi-circular tapered portions 79 and 80 of die half inserts 31 and 32. Thus, these complementary tapered portions form an annular tapered shoulder which engages tapered base 62 of the core to maintain removable core sections 59 and 61 in position with their inner ends in contact with carrier 48 and to accurately and firmly hold the three-section core assembly in place in the die cavity. As the die closes, side faces 81 and 82 of die inserts 31 and 32 act as stops to limit inward movement of carriage 42 and carrier 48. At the same time, tapered portion 80 of die insert 32 acts as a stop limiting the inward movement of core sections 57 and 59 by engaging their inclined base surfaces and thus accurately positioning these parts. Near the end of the inward movement of carriage 42 and carrier 48 notches 53 and 54 in these members engage dowel pin 55, thus further aiding in accurately locating the main core in the die and locking carrier 48 against swinging, as stated.

Die inserts 31 and 32 have an annular groove 58 and an annular rib 63 cooperating with tapered base 62 of the main core to form an annular gate or chamber 58' and an annular ingate 63' both of which surround base 62. Thus metal passing from gate 58' through ingate 63' is fed to die cavity 40 around a circle corresponding to what becomes the margin of the piston skirt. The sprue 64 connects gate 58' with open-bottom pressure chamber 65. When the die is closed, the pressure chamber registers with metal well 66 supported by machine bed 10 and containing a lowered forcing plunger 67 (Figs. 1 and 9), the illustrated machine being constructed according to Schultz Patent No. 2,103,438, issued December 28, 1937. A proper charge of metal having been placed in well 66 while the die is open and the die then closed, plunger 67 rises through well 66 and into pressure chamber 65 to transfer the metal from the well into the pressure chamber and then force it under high pressure into annular gate 58' and thence into die cavity 40 to form the piston casting.

Operation

The general operation of the device has been explained in connection with the description of the mechanism, but a recapitulation tracing the sequence of the various events will be helpful.

Assume that the die is closed as shown in Figs. 2, 3 and 9, and that the casting has been shot and plunger 67 returned to the position of Fig. 9. The opening motion of movable die section 22 is imparted to core carrier 48 and this motion also entails withdrawal of die member 33, which latter has some of the aspects of a core but is not strictly a core. The effect is to withdraw member 33 and to pull the casting out of the fixed die half 12 and off the fixed core 37. When the parts reach a position in which the casting in movable die half 22 is clear of core 37, cam 27' starts to rotate pinion 44 and move core carriage

42 outward. The effect of this is to withdraw main core part 57, thus contracting main core parts 59 and 61, which are thus stripped from the casting by core part 57 but left in loose condition therein for later removal by the operator. Pinion 44 rotates far enough to carry main core part 57 entirely from between die half inserts 31 and 32, so as not to interfere with subsequent ejection of the casting and the core parts 59 and 61 therefrom from movable die half 22. Core 38 is withdrawn next as the result of collision of plate 19 with stops 17 and 18. Finally, ejector pins 24 are actuated as the result of arrest of plate 21 by plate 19 so that the casting, with main core sections 59 and 61 still in it, drops from movable die half 22. The timing of the movements of the parts as just defined may be varied if found desirable, but withdrawal movement of main core part 57 should start before withdrawal of core 38 commences.

The machine now stops with the die in the full-open position of Fig. 4, whereupon carrier 48 with its permanent core part 57 is swung outward by the operator to the position shown in Fig. 4 by means of handle 56. Main core parts 59 and 61 are now recovered from the interior of the casting by the operator and slidably reassembled in their normal positions on central core part 57 as shown in Fig. 2. Since this reassembly takes place with core part 57 in the position of Fig. 4 where it is fully accessible to the operator obviously, this is an important aid in reassembling the core parts properly and with facility. Following this operation, the operator actuates handle 56 to swing carrier 48 with its reassembled main core back between die sections 12 and 22 and into the position of the parts shown in Fig. 8.

After another metal charge is placed in well 66, ram 15' is operated to close the die. Such closure automatically returns all die parts and cores to the normal casting position of Figs. 2 and 3 by the means already described, in readiness to shoot the next casting. During the closing movement of die half 22, reverse operation of pinion 44 by cam 27' slides carriage 42, carrier 48 and the assembled main core inwardly from the position of Fig. 8 and into normal casting position relatively to movable die half 22 (see Fig. 2) before the die completely closes, so as to prevent interference by fixed core 37 with the re-positioning of the main core. Member 33 is restored to casting position by pin 36. Near the end of the closing movement of die half 22, but subsequently to the re-positioning of the main core so as not to interfere therewith, return pin 19' engages fixed die half 12 and operates as explained to restore core 38 to casting position. Return pin 21' then operates similarly, as explained, to retract ejector pins 24.

It will be understood that the invention can be used with various die casting machines other than the particular one briefly described herein. It is also obvious that minor modifications in the arrangement of the main core can be made within the scope of the invention, and of course the form of this core and of the die halves is a function of the casting to be produced. The idea of feeding the die cavity from an annular gate surrounding the base of the main core, where the core is of sectional construction and is centered and confined by the die halves, is believed to be an important factor in the attainment of sound castings.

What is claimed is:

1. The combination in a multi-section sep-

arable casting die of a pair of die sections adapted for relative movement in a definite path to open and close the die, the opposed faces of said die sections having portions coacting to form a casting cavity when the die is closed; and a core assembly, comprising a permanent core member and at least one removable core member slidably mounted on said permanent member, carried by one of said die sections and located in casting position in the die cavity when the die is closed, the permanent core member being pivotally mounted on said die section and also mounted thereon for sliding movement, during opening of the die, sufficient at least to completely withdraw the permanent core member from a casting formed in the die and to separate the permanent core member from the removable core member which is retained in the casting, said permanent core member being swingable away from its supporting die section following said withdrawal to render it fully accessible to an operator for slidably mounting at least one removable core member thereon to form a core assembly, said assembly being swingable towards said die section while the die is open and then slidable thereon to position the assembly in the die cavity as the die is closed, the permanent core member being adapted for automatic actuation during opening and closing of the die to effect said sliding movements thereof.

2. The combination in a multi-section separable casting die as claimed in claim 1 wherein the permanent core member is pivotally mounted on a core carriage carried by the core supporting die section and having sliding interlocked connection therewith for sliding movement on said die section during opening and closing of the die to permit said sliding movements of the permanent core member.

3. The combination in a multi-section separable casting die as claimed in claim 1 wherein the permanent core member is rigidly supported on a core carrier which is pivotally mounted on a core carriage carried by the core supporting die section and having sliding interlocking connection therewith for sliding movement on said die section during opening and closing of the die to permit said sliding and swinging movements of the permanent core member.

4. The combination in a multi-section separable casting die as claimed in claim 1 wherein releasable locking means are provided to prevent said swinging movement of the permanent core member away from its supporting die section during the first part of the opening movement of the die, said withdrawing movement of the permanent core member serving automatically to release the locking means as opening movement of the die continues.

5. The combination in a multi-section separable casting die as claimed in claim 1 wherein releasable and restorable locking means are provided to prevent said swinging movement of the permanent core member away from its supporting die section during the first part of the opening movement of the die, said withdrawing movement of the permanent core member serving automatically to release the locking means as opening movement of the die continues, and said sliding movement to position the core assembly in the die cavity, as the die is closed, serving automatically to restore the locking means.

6. The combination in a multi-section separable casting die as claimed in claim 1 wherein means are provided for relieving stress on said

pivotal connection between the core assembly and its supporting die section by said core assembly during casting.

7. The combination in a multi-section separable casting die as claimed in claim 1 wherein the permanent core member is rigidly supported on a core carrier which is pivotally mounted on a core carriage carried by the core supporting die section and having sliding interlocked connection therewith for sliding movement on said die section during opening and closing of the die to permit said sliding and swinging movements of the permanent core member; and wherein releasable and restorable locking means are provided to prevent said swinging movement of the core carrier during the first part of the die opening movement and during the later part of the die closing movement, said retracting movement of the permanent core member serving to release the locking means and the return of the permanent core member into casting position in the die serving to restore the locking means.

8. The combination in a multi-section separable casting die as claimed in claim 1 wherein the permanent core member is rigidly supported on a core carrier which is pivotally mounted on a core carriage carried by the core supporting die section and having sliding interlocked connection therewith for sliding movement on said die section during opening and closing of the die to permit said sliding and swinging movements of the permanent core member; and wherein releasable and restorable locking means are provided to prevent said swinging movement of the core carrier during the first part of the die opening movement and during the later part of the die closing movement, said retracting movement of the permanent core member serving to release the locking means and the return of the permanent core member into casting position in the die serving to restore the locking means, said locking means comprising a separable pin-and-slot connection between the core carrier and the core carrying die section.

9. The combination in a multi-section separable casting die as claimed in claim 1 wherein the permanent core member is rigidly supported on a core carrier which is pivotally mounted on a core carriage carried by the core supporting die section and having sliding interlocked connection therewith for sliding movement on said die section during opening and closing of the die to permit said sliding and swinging movements of the permanent core member; and wherein guide means are provided on the core supporting die section for coaction with said core carrier to guide the core assembly and accurately position it in the die cavity during inward sliding movement of the core assembly, the core carrier and the core carriage as the die closes.

10. The combination in a multi-section separable casting die as claimed in claim 1 wherein means are provided for withdrawing the permanent core member as the die is opened, said means forming a slidable part of said core supporting die section on which the permanent core member is pivotally mounted; and wherein means are provided to relieve stress on said pivotal connection during said withdrawal movement of the permanent core member.

11. The combination in a multi-section separable casting die as claimed in claim 1 wherein the permanent core member is rigidly supported on a core carrier which is pivotally mounted on a core carriage carried by the core supporting die

section and having sliding interlocked connection therewith for sliding movement on said die section during opening and closing of the die to permit said sliding and swinging movements of the permanent core member; and wherein abutting surfaces are provided on the core carrier and the core carriage for relieving stress on said pivotal connection between the core carrier and the core carriage.

12. The combination in a multi-section separable casting die as claimed in claim 1 wherein the permanent core member is rigidly supported on a core carrier which is pivotally mounted on a core carriage carried by the core supporting die section and having sliding interlocked connection therewith for sliding movement on said die section during opening and closing of the die to permit said sliding and swinging movements of the permanent core member; and wherein said core carrier is formed with a recess and the core carriage has a lug adapted to be snugly located in said recess for relieving stress on said pivotal connection between the core carrier and the core carriage.

13. The combination in a multi-section separable casting die of a fixed die section; a die section adapted for movement towards and from the fixed die section to close and open the die, the opposed faces of said die sections having portions coacting to form a casting cavity when the die is closed; and a core assembly, comprising a permanent core member and at least a pair of opposed removable core members slidably mounted on said permanent member, carried by said movable die section and located in casting position in the die cavity when the die is closed, the permanent core member being pivotally mounted on the movable die section and also mounted thereon for sliding movement, during opening of the die, sufficient at least to withdraw the permanent core member completely from a casting formed in the die and completely from between said removable core members to separate the permanent core member from the removable core members which are retained in the casting, said permanent core member being manually swingable away from the movable die section following said withdrawal to render it fully accessible to an operator for slidably mounting at least a pair of removable core members thereon to form a core assembly, said assembly being manually swingable towards said movable die section while the die is open and slidable thereon to position the assembly in the die cavity as the die is closed, the permanent core member being adapted for automatic actuation during opening and closing of the die to effect said sliding movements thereof.

14. The combination as claimed in claim 13 wherein operating means are carried by the movable die section for imparting said sliding movements to the permanent core member during opening and closing movements of the die, said operating means being adapted for automatic actuation during said movements of the die by means on a casting machine in which the die may be mounted.

15. The combination as claimed in claim 13 wherein the permanent core member is arranged to swing in a substantially horizontal direction on its pivotal connection with the movable die section and is provided with a handle for effecting said swinging movements thereof.

16. The combination in a multi-section cast-

ing die of a fixed die section; a die section adapted for movement towards and from said fixed die section to close and open the die, the opposed faces of said die sections having portions cooperating to form a casting cavity when the die is closed; a core carriage reciprocally mounted on the inner face of the movable die section and having sliding interlocked connection therewith; a core carrier pivotally mounted on said core carriage; and a collapsible core assembly, comprising a middle core member permanently mounted on the core carrier and a pair of opposed removable core members slidably mounted on said permanent core member, located in casting position in the die cavity when the die is closed, the carriage together with the core carrier and the permanent core member being slidable as a unit on the fixed die half, during opening of the die, sufficient at least to withdraw the permanent core member completely from a casting formed in the die and completely from between said removable core members to separate the permanent core member from the removable core members which latter are retained in the casting, said core carrier and the permanent core member being manually swingable away from the movable die section following said withdrawal to render the permanent core member and its carrier fully accessible to an operator for slidably mounting a pair of removable core members on the permanent core member to form a core assembly, said assembly and the core carrier being manually swingable towards the movable die section while the die is open and then slidable as a unit with the core carriage on said die half to accurately and securely position the core assembly in the die cavity as the die is closed, the core carriage being adapted for automatic actuation during opening and closing of the die to effect said sliding movements thereof.

17. The combination in a multi-section separable casting die as claimed in claim 16 wherein rack-and-pinion means are provided on the movable die half for imparting said sliding movements to the core carriage, the core carrier and the permanent core member during opening and closing movements of the die, said operating means being adapted for automatic actuation during said movements of the die by means on a casting machine in which the die may be mounted; wherein a handle is provided for swinging

the core carrier which latter is arranged for swinging movement completely from between the open die sections; and the permanent core member and the removable core members are provided with slidable interlocking tongue-and-groove connections with each other and said connections converge towards the outer end of the permanent core member, so that withdrawal of the latter core member contracts the other core members to loosen them from the casting.

18. The combination in a multi-section separable casting die of a plurality of die sections adapted for relative movement to open and close the die, the opposed faces of said die sections having portions coacting to form a casting cavity, other portions coacting to form an annular groove and still other portions coacting to form an annular tapered shoulder, when the die is closed; and a core assembly having a tapered base portion and comprising a permanent central core member and a pair of opposed removable core members mounted on said permanent core member by means of slidable interlocking tongue-and-groove connections, said core assembly being slidably carried by one of said die sections for movement into casting position in the die cavity as the die is closed and in which position said core assembly cooperates with said cavity-forming portions of the die sections to provide an annular casting cavity space, said tapered base portion of the core assembly coacts with said annular groove to form an annular gate and an annular ingate connecting said gate and said annular casting cavity space, and said tapered base portion of the core assembly engages said annular tapered shoulder to accurately locate the assembly in the die cavity and prevent movement of the movable core members on the permanent core member, the permanent core member being slidable on its supporting die section, during opening of the die, sufficient at least to withdraw the permanent core member completely from a casting formed in the die and completely from between said removable core members to separate the permanent core member from the removable core members which are retained in the casting, said permanent core member being adapted for automatic actuation during opening and closing of the die to effect said sliding movements thereof.

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