March 31, 1942. LE ROY LAYTON 2,278,325

PROCESS FOR FINISHING FORGINGS

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Fig. 1.

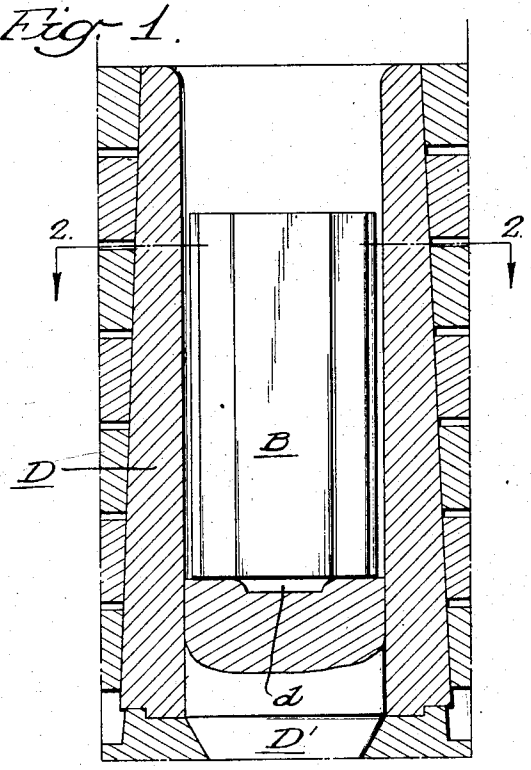


Fig. 3.

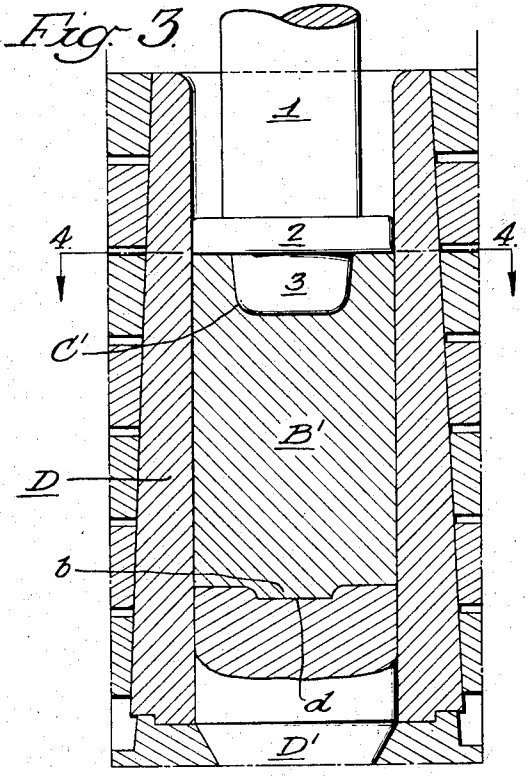


Fig. 5.

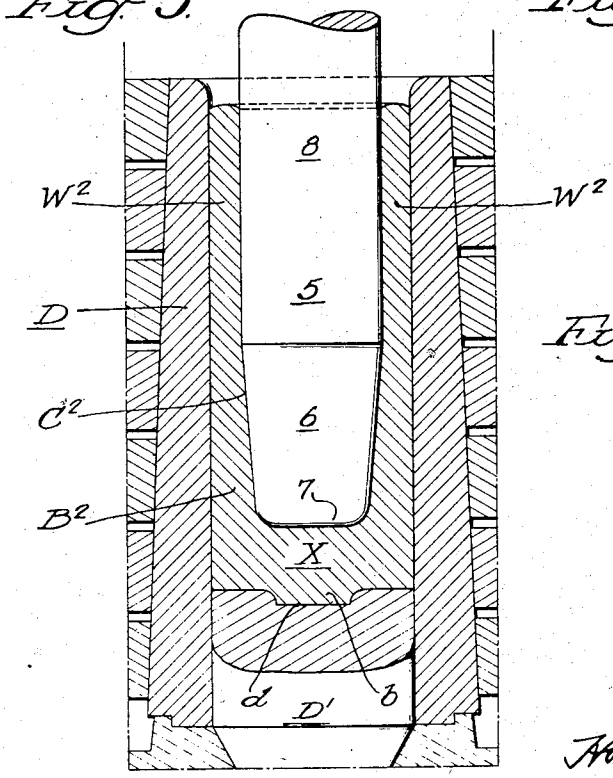


Fig. 2.

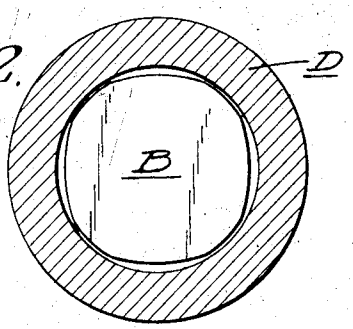
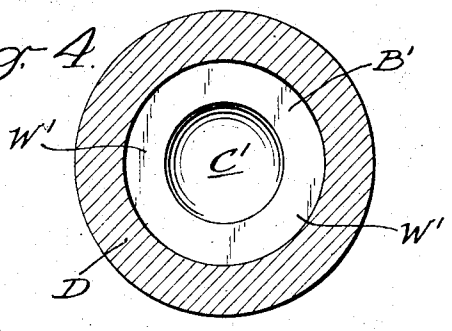


Fig. 4.

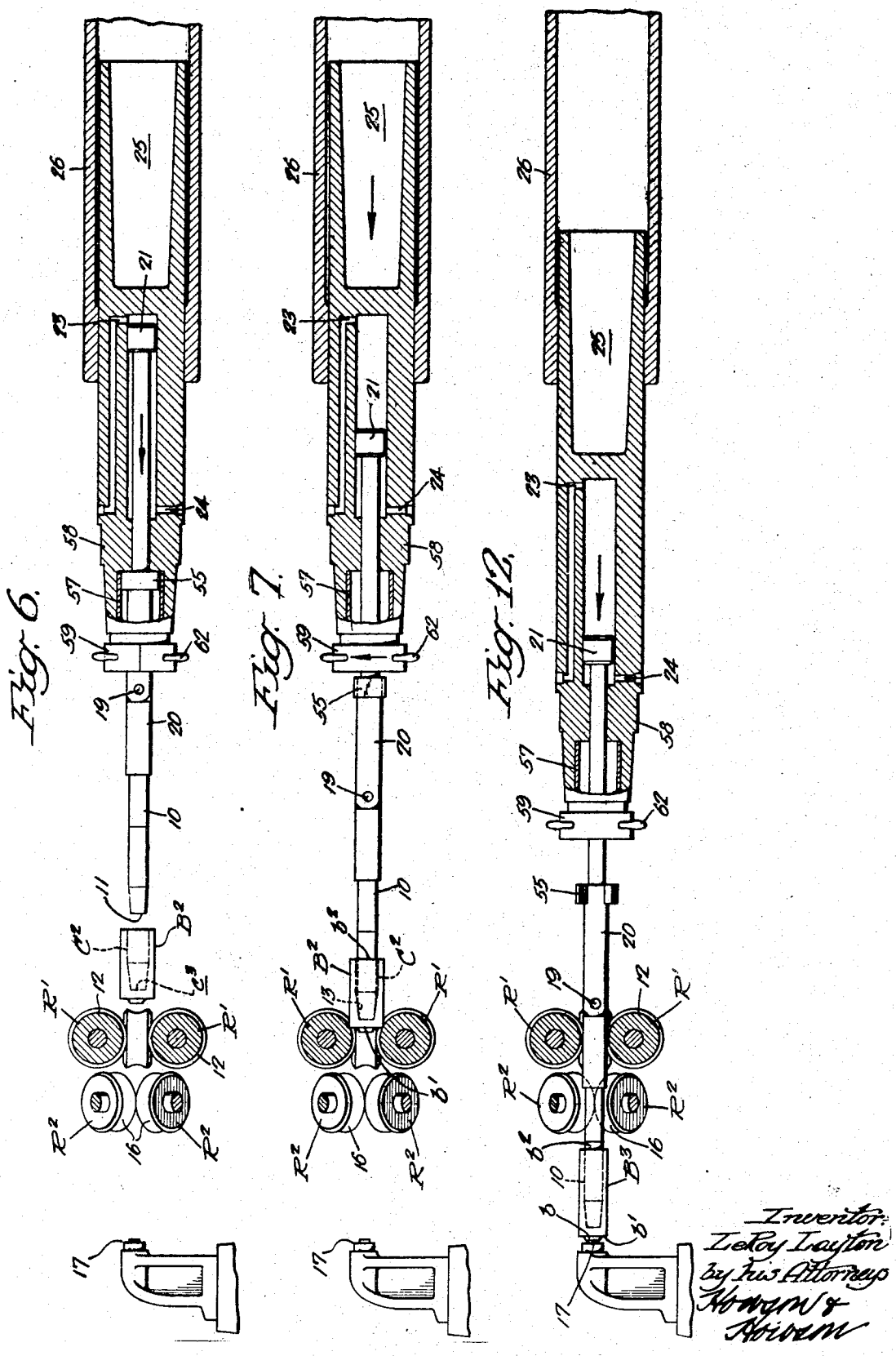


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Fig. 8.

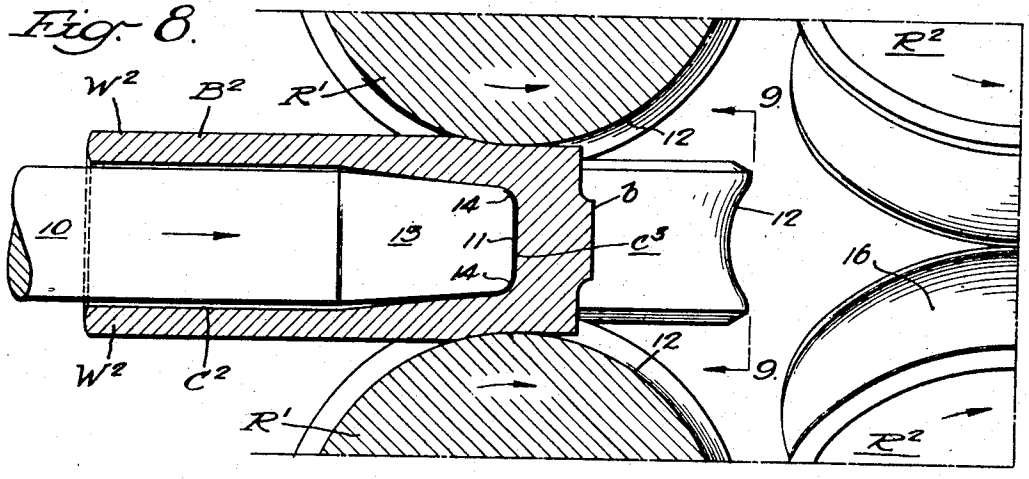


Fig. 9.

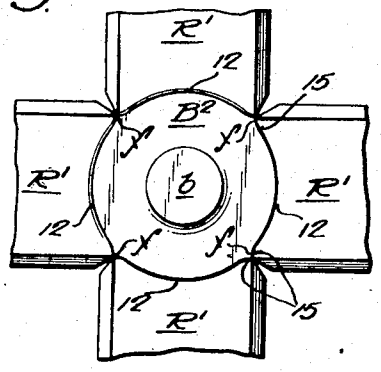


Fig. 11.

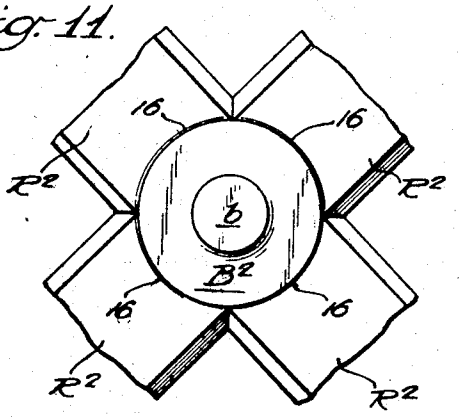


Fig. 10.

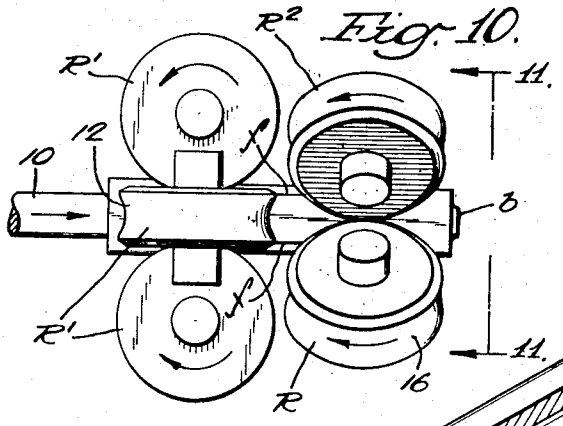
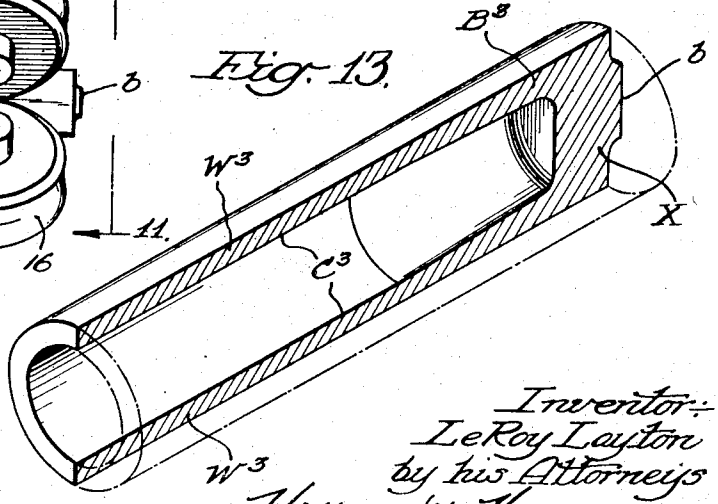


Fig. 13.



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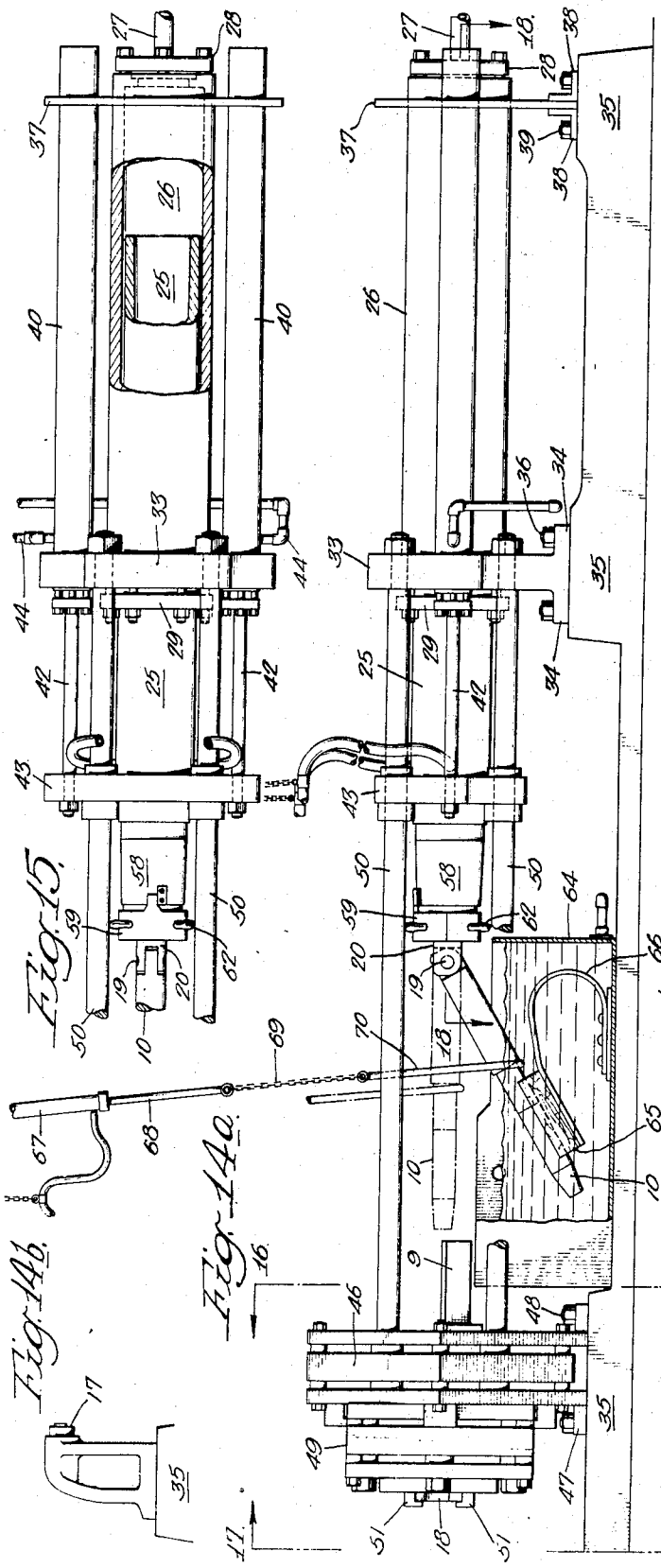


Fig. 15.

Fig. 14a.

Fig. 14.

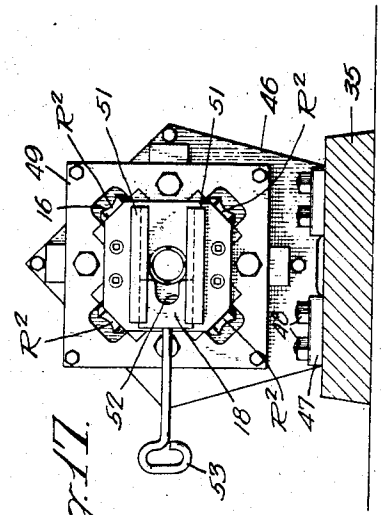


Fig. 17.

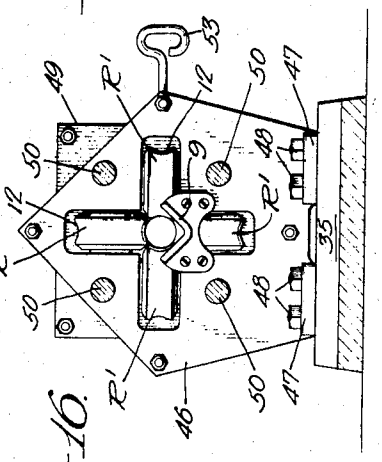


Fig. 16.

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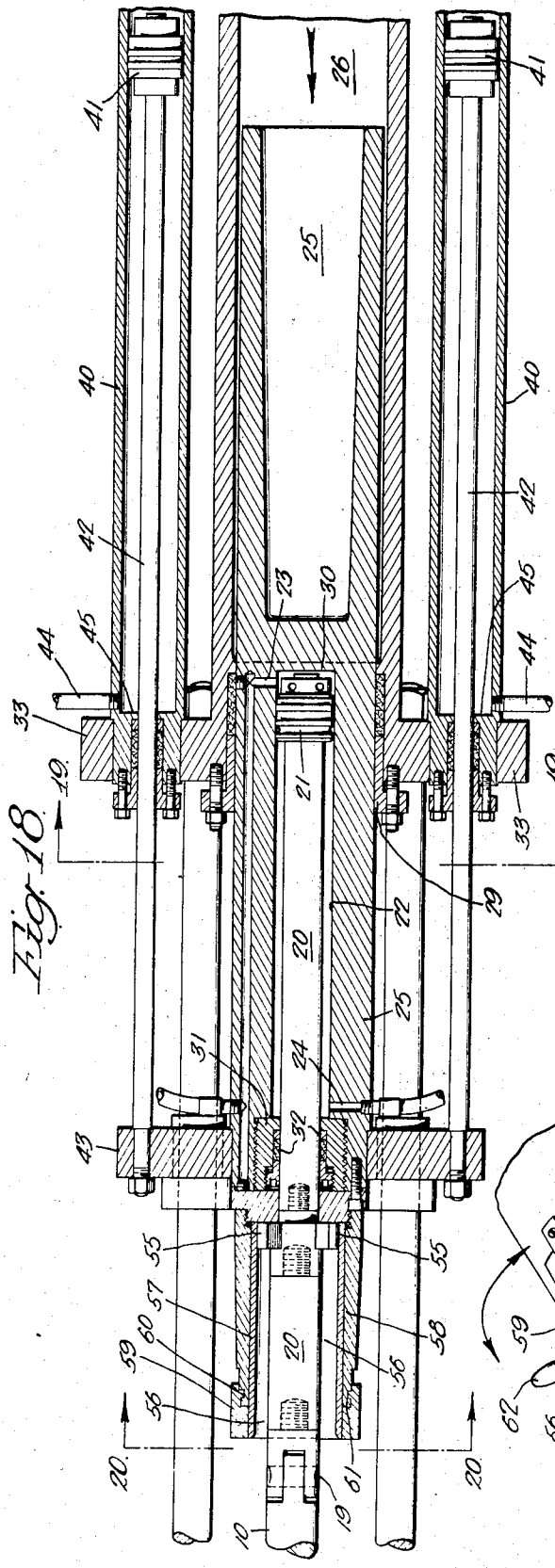


Fig. 18.

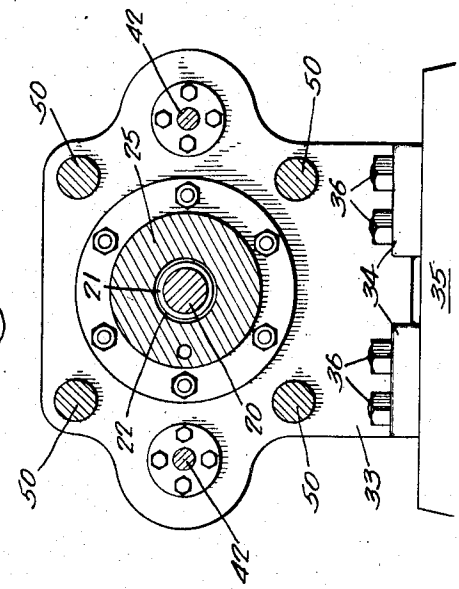


Fig. 19.

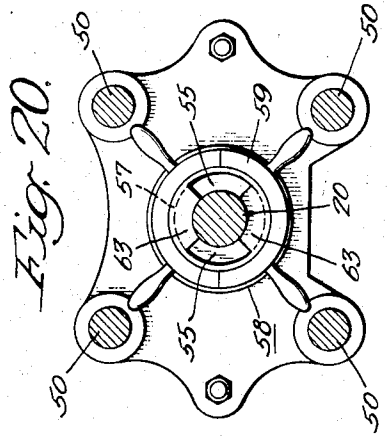


Fig. 20.

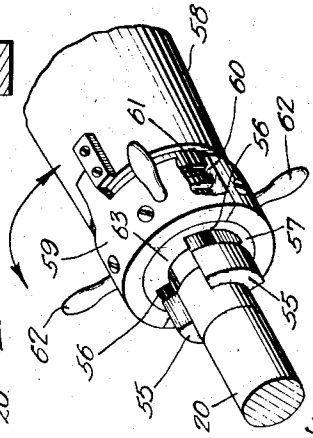


Fig. 21.

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Patented Mar. 31, 1942 2,278,325

UNITED STATES PATENT OFFICE

2,278,325

PROCESS FOR FINISHING FORGINGS

Le Roy Layton, Lansdowne, Pa., assignor to Lansdowne Steel & Iron Company, Morton, Pa., a corporation of Pennsylvania

Application October 12, 1938, Serial No. 234,713

2 Claims. (Cl. 29—1.21)

This invention relates to the manufacture of hollow forgings in general and more especially to those employed as the main body portions of armament projectiles, which require accuracy in the forgings as to balance and uniformity about the longitudinal axes thereof.

Prior to the present invention it has been customary to machine-finish, i. e. bore and/or ream, the interior surface of the cavity of each shell-case forging made by the punch or piercing tool, in addition to turning the exterior surface of the forging, in order to produce a concentrically balanced shell with truly circular, concentric inner and outer surfaces and a wall of uniform thickness therebetween. Ordnance requirements in these respects have been so stringent that it has heretofore been considered practically impossible to produce a satisfactory shell casing without machining the interior surface of the forging.

The present invention contemplates a method and apparatus for producing hollow forgings acceptable for use in the manufacture of shell casings and which as such will not require machine-finishing of the interior surfaces of the punch cavities.

The process and apparatus forming the subject matter of the present invention will be fully disclosed hereinafter, reference being had to the accompanying drawings, of which:

Fig. 1 is a vertical sectional elevation of a primary forging die with a heated billet therein;

Fig. 2 is a sectional plan view taken on the line 2—2, Fig. 1;

Fig. 3 is a view similar to Fig. 1, with the billet consolidated in the lower part of the die under a consolidating and initial piercing tool;

Fig. 4 is a sectional plan view taken on the line 4—4, Fig. 3;

Fig. 5 is a view similar to Figs. 1 and 3 with the metal displaced upwardly in the die around a secondary piercing tool;

Fig. 6 is a diagrammatic longitudinal sectional elevation of the finishing machine, with the partially completed forging about to be entered by the finishing tool;

Fig. 7 is a view similar to Fig. 6 showing the finishing tool pressing the partially completed forging into the bite of a set of primary reducing rolls;

Fig. 8 is an enlarged sectional view showing the partially completed forging being contracted cross-sectionally by the primary reducing rolls;

Fig. 9 is a transverse elevation viewing the primary rolls and reduced forging from the plane indicated by the line 9—9, Fig. 8;

Fig. 10 is a side elevation showing the partially completed forging being reduced, elongated and finished by the primary and a secondary set of rolls;

Fig. 11 is a transverse vertical elevation showing the secondary or finishing rolls gripping the forging, as viewed from the plane indicated by the line 11—11, Fig. 10;

Fig. 12 is a view similar to Figs. 6 and 7, showing the completed forging after passing through the primary and secondary rolls and making contact with a marking die;

Fig. 13 is a sectional perspective view of a finished forging;

Figs. 14*a* and 14*b* constitute a side elevation, partly in section, of that portion of the apparatus shown in Figs. 6, 7 and 12;

Fig. 15 is a plan view, partly in section, of a portion of the apparatus shown in Fig. 14;

Fig. 16 is a transverse sectional elevation taken on the line 16—16, Fig. 14*a*;

Fig. 17 is a transverse sectional elevation taken on the line 17—17, Fig. 14*a*;

Fig. 18 is a sectional plan view taken on the line 18—18, Fig. 14*a*;

Fig. 19 is a transverse sectional elevation taken on the line 19—19, Fig. 18;

Fig. 20 is a transverse sectional elevation taken on the line 20—20, Fig. 18; and

Fig. 21 is a perspective view of a detail of the invention.

It will be understood that the forgings manufactured in accordance with the principles of the present invention may be produced from round billets of substantially the same diameter as the opening in the die in which the preliminary steps of the process of the present invention are carried out; or the billets may be square or of other cross-sectional shape, with the transverse diagonal or other greatest cross-sectional measurement substantially equal to the diameter of the open mouth of the die; or the billets may be of the type disclosed in my two prior United States Patents No. 2,057,580 and No. 2,059,124, dated October 13, 1936, and October 27, 1936, respectively, wherein the corners of a square billet having normal diagonal measurements greater than the mouth opening of the die are reduced diagonally and the sides of the billet intermediate the corners bulged, by which the billet receives a peculiar, substantially circular cross sectional shape having its greatest measurement slightly less than the diameter of the mouth opening of the die, as shown in Figs. 1 and 2 of the present drawings.

In Fig. 1 of the present drawings a primary die D is shown as having received a heated billet B of the above noted peculiarly circular or other suitable shape. In the present instance the bottom of the die D, which may be fixed or movable, preferably the latter, is provided with a circular depression *d*.

In Fig. 3, a "dumping" or consolidating tool 1, having a collar 2 which more or less snugly fits the circular or other shaped bore of the die D and which, beneath the collar 2, is provided with a tapered, circular, or other shaped initial piercing lug or boss 3, has been lowered into the die D and pressed against the hot metal of the billet B under hydraulic or other power, sufficient to compress the billet B between the bottom of the die cavity and the underside of the collar 2. Under and by such compression the still-hot metal of the billet B is upset or caused to flow and become consolidated in the die D, around the boss 3, in the depression *d*, and into full contact with the side walls of the die D, as shown in Figs. 3 and 4.

The billet B is thus transformed into an initial forging blank B1, with a nose pad *b* formed on one end by the depression *d* in the bottom of the die D, a centralized initial piercing cavity C1 formed in the opposite end by the boss 3 of the tool 1, and with initial side walls W1, W1, of predetermined length and thickness formed around the centralized cavity C1.

The tool 1 after effecting the above noted consolidation of the hot metal in the lower part of the die D is withdrawn and a secondary piercing tool or punch 5 is lowered into the die D under hydraulic or other suitable power.

The secondary piercing tool 5 is of a substantially cylindrical form, in the present instance, although it may conform to any cross sectional shape that it may be desired to have in the cavity formed thereby in the forging.

The lower portion 6 of the secondary piercing tool 5 is tapered in accordance with the taper of the initial piercing boss 3 on the tool 1. The extreme end 7 of the tool 5 is of substantially the same size and shape as the initial piercing element 3 and consequently corresponds in shape and size to the initial cavity C1 formed in the initial blank B1 by the element 3.

The end 7 of the piercing tool 5 first makes snug contact with substantially the entire surface of the cavity C1 in the initial blank B1 and is then forced by hydraulic or other suitable power down deeper into the hot metal of the initial forging blank B1, causing the heated metal to flow upwardly in the die D around the tapered end 6 of the tool 5, then up around the body portion 8 of said tool, at all times making and maintaining complete contact with both the exterior surface of the tool 5 and the interior surface of the die D; whereby the walls W1, W1 of the blank B1 shown in Fig. 4 are thinned and elongated, as shown at W2, W2 in Fig. 5, with said walls extending upwardly from the closed bottom X of the partially completed shell casing; and whereby the cavity C1 of the blank B1 is elongated to the extent shown at C2 in Fig. 5, with the diameter of the cavity C2 substantially corresponding to the outside diameter of the piercing tool 5.

The operations or steps above disclosed complete what will be hereinafter termed a primary forging. These steps, insofar as described, are substantially the same as disclosed in my two previously noted patents.

The present invention is directed to steps employed in addition to those disclosed above and by which the interior of the forging is finished accurately without machining.

The preliminary steps disclosed above, and by which the primary forging B2 is produced, are all carried on in a single heat. The steps by which the primary forging B2 is finished are likewise carried on in the same heat with the preliminary steps, whereby reheating and, consequently, formation of excessive scale on the interior wall of the forging are eliminated.

The secondary piercing tool 5 is then removed from the hot metal in the die D and the primary forging B2 is kicked out of or otherwise removed from the die D, as by raising the movable bottom D1 of the die. The still-hot primary forging B2, after its removal from the die D, is placed in a horizontally disposed trough 9 (see Figs. 14*a* and 16), which supports said primary forging with its longitudinal axis coaxially aligned with the longitudinal axis of a finishing tool 10. As shown in Figs. 6, 7 and 8 the diameter of the finishing tool 10 is less than the diameter of the piercing C2 as made in the primary forging B2 by the second piercing tool 5.

With the primary forging B2 and the finishing tool 10 in the relative positions shown in Fig. 6, said finishing tool is advanced axially into the cavity C2 of said primary forging freely and substantially without contacting the side walls of the cavity until the blunt end 11 of said tool makes contact with the flat bottom end *c*3 of the cavity C2. Continued axial movement of the tool 10 advances the primary forging B2 into the bite of a series of rolls R1.

Each of the rolls R1 is provided with a concave face 12 and said concave faces are arranged about a common axis coinciding with the axis of the tool 10 and the primary forging B2 and collectively form a substantially complete circle through which the primary forging is passed by further axial movement of the finishing tool 10.

It will be noted upon reference to Fig. 7 that the outside diameter of the finishing tool 10 is less than the inside diameter of the cavity or bore C2 of the forging B2; and that the angle of taper of the end 13 of the tool 10 is less than the angle of taper of the inner end of the cavity C2 of the forging B2. Consequently, as the tool 10 moves from the position shown in Fig. 6 to the position shown in Fig. 7 it makes no contact whatsoever with the side walls of the cavity C2. The only contact made between the tool and the forging until such time as said forging passes into the bite of the rolls R1 is that made between the flat blunt end 11 and rounded corners 14 of the tool 10 and the flat end *c*3 and correspondingly rounded corners of the cavity C2 in the forging.

Preferably, the diameter of the flat surface C3 and that of the blunt end 11 are substantially the same, whereby a snug fit between the two is accomplished, and consequent centering of the tool 10 with respect to the cavity C2 in the forging is effected. Continued movement of the tool 10 forces the forging B2 into the bite of the rolls R1, as shown in Figs. 8 and 9.

The circle or throat described by the combined concave faces 12 of the rolls R1, R1 is less in diameter than the outside diameter of the forging B2 and as the forging is passed through the throat formed by said rolls it is reduced in diameter or contracted cross-sectionally, causing a corresponding reduction in the diameter of the

cavity C2 and effecting contact between the outer surface of the tool 10 and the inner wall of the cavity C2 at the same time. As the passage of the forging through the rolls R1 by the tool 10 continues, reduction in diameter of the forging B2 progressively contracts the forging cross-sectionally and produces a further elongation of the walls W2 of said forging, along the length of the tool 10.

The side edges of the concave faces 12 of the rolls R1 are outwardly filleted, as indicated at 15 in Fig. 9, whereby, as the forging B2 passes through said rolls, longitudinal fins *f* are formed along the forging B2 and act to relieve the extremely high pressure produced by the reduction in the diameter of the forging as the same passes through the rolls R1.

From the rolls R1 the forging passes into the bite of a second series of rolls R2, as shown in Figs. 6, 7, 8, 10 and 11. The faces of the rolls R2 are concave, as illustrated at 16 in Fig. 11, and together with the edges of the concave faces in laterally abutting relation to each other forming a complete circle or throat of progressively smaller diameter than the throat formed by the rolls R1, R1.

As shown in Figs. 6 to 12 inclusive, the rolls R2 are of the same number as the rolls R1 and are set at right angles with respect to the rolls R1, whereby the fins *f* produced by the rolls R1 are engaged by the centers of the concave surfaces 16 of the rolls R2.

The throat described by the collective concave surfaces 16 of the rolls R2 as noted above is slightly less in diameter than the throat described by the concave surfaces 12 of the rolls R1, whereby, as the tool 10 continues to move axially, the primary forging B2 is advanced through the rolls R1 into the bite of the rolls R2 and through said rolls, which progressively reduces the outside diameter of the forging B2 with a relatively large reduction made by the rolls R1 and a relatively slight further reduction made by the rolls R2. The rolls R2 also, due to the position of the fins *f* with respect to the concave faces 16 of the rolls R2, eliminate said fins and produce a substantially complete plain cylindrical surface on the outside of the forging B2.

Reduction in the outside diameter of the forging molds said forging around the finishing tool 10, whereby the diameter of the cavity C2 is reduced to that of the outside diameter of the finishing tool 10 and a finished surface C3 is formed in the finished forging B3 shown in Fig. 13, the walls W3 of said finished forging being elongated as a result of reduction in diameter of the primary forging B2 about the finishing tool 10.

As the finished forging B3 passes out of the bite of the rolls R2, continued axial movement of the tool 10 causes the flat face of the pad *b* on the closed end X of the forging B3 to be brought into contact with a marking die 17, and, as illustrated in Fig. 12, the marking die 17 is arranged to apply any desired identification to the end of the completed forging.

Heretofore the finishing of the inside wall of the cavity of the shell casing and other hollow forgings by the piercing tool has been considered to be impossible, because of marring or other changing of the surface of the piercing tool as a result of successive piercing operations by said tool in each of which the piercing tool has remained in contact with the hot metal of the forging throughout the entire piercing and elongation of each forging, which resulted in overheating.

In the present instance, finishing of the interior surface of the forging cavities is made possible by employing the initial and/or secondary piercing tools, as above described, to produce the primary cavity C2 in the primary forging B2 by utilizing a finishing tool to complete the forging operations by making the finishing tool of a diameter less than that of the primary piercing tool and the primary cavity and contracting the primary forging cross-sectionally around the finishing tool, and by reducing the time of contact of the finishing tool with the hot metal of the forging, whereby the finishing tool does not absorb as great an amount of heat from the forging as the piercing tool heretofore, making the finishing tool less susceptible to marring.

As a further means of keeping the finishing tool from being marred or damaged, the tool is kept as cool as possible by being periodically submerged in water or other cooling liquid after each primary forging has been completed.

Furthermore, a variable stroke is provided for the finishing tool to cut down the time of its contact with the hot metal and whereby said tool is moved rapidly from the position shown in Fig. 6 to the position shown in Fig. 7, then slower as said tool advances the forging through the reducing rolls R1 and R2, then rapidly from the rolls R2 until the forging makes contact with the marking die 17, and then rapidly in a reverse direction from the position shown in Fig. 12 to that shown in Fig. 6 at the beginning of which the finished forging B3 is stripped from the end of the finishing tool 10 by a stripper 18 (see Figs. 14*a* and 17) all as will be more fully described hereinafter.

As shown in Figs. 6, 7, 12, 14*a*, 15 and 18 the finishing tool 10 is pivotally connected at 19 to one end of a piston rod or ram rod 20. The rod 20 is provided with a piston 21 at its opposite end which is slidably mounted in a cylinder 22. Ports 23 and 24, disposed at opposite ends respectively of the cylinder 22, admit and exhaust operating fluid to and from the interior of the cylinder 22, at opposite sides respectively of the piston 21.

The cylinder or piston bore 22 in which the piston 21 operates is formed in one end of a hydraulic ram 25. The ram 25 is mounted for axial movement in a ram cylinder 26. Operating fluid for moving the ram 25 relative to the cylinder 26 in the direction causing the finishing tool 10 to pass the primary forging B2 through the reducing rolls R1, R2, is admitted from a suitable source, such as a hydraulic accumulator, through a pipe 27 tapped into a cylinder head 28 which closes the one end of a ram cylinder 26. Escape of the operating fluid from the opposite end of the cylinder 26 around the ram 25 is prevented by a suitable packing gland 29.

In a like manner one end 30 of the piston bore 22 formed in the ram 25 is closed, as shown in Fig. 18, by the metal of the ram, thus preventing escape of operating fluid therefrom. The opposite end of the piston bore 22 is closed by a threaded plug 31 in which is mounted a suitable packing gland 32 which prevents escape of operating fluid from said end of said bore around the piston or ram rod 20.

The ram cylinder 26 is provided with a flange 33 which acts as a supporting frame for the one end of the cylinder. The flange 33 is provided

with feet 34 which rest on a solid foundation 35 and which are secured thereto by bolts 36. The opposite end of the cylinder 26 is supported by a frame 37 which rests on the foundation 35 and is provided with feet 38 which are secured to said foundation by bolts 39.

Supported by the frame members 33 and 37 at each of the opposite sides of the ram cylinder 26 is a ram returning cylinder 40. In each of the cylinders 40 is a piston 41 which is connected by a piston rod 42 to a flange 43 formed on or secured to the outer end of the ram 25. Pipes 44, 44 adjacent the frame 33 communicate with the interiors of the cylinders 40 between the fixed heads 45 thereof and the pistons 41. Motive fluid admitted through the pipes 44, 44 acting against the pistons 41 and through the rods 42, 42 returns the ram 25 to its initial position after the completion of each finished forging B3.

The reducing rolls R1 are rotatably mounted in a frame 46 which is provided with feet 47 secured to the foundation 35 by bolts 48. The rolls R2 are rotatably mounted in a framework 49 which is secured to or forms a part of framework 46 in which the rolls R1 are rotatably mounted. The roll supporting frames 46—49 are tied to the framework 33 which supports the ram cylinder 26 by means of tie rods 50, 50, said tie rods passing through the flange 43 on the ram 25 and functioning as a guide-way for the ram when the ram is projected from the cylinder 26.

The trough 9 which supports the primary forging B2 prior to its being engaged by the finishing tool 10 is secured to the roll frame 46, as shown in Figs. 14a and 16.

The stripper 18 by which the finished forgings B3 are removed from the finishing tool 10 is slidably mounted in guide-ways 51, 51 carried by the roll frame 49. The stripper 18 is provided with a slot 52 of a width slightly greater than the diameter of the tool 10 and less than the outside diameter of the finished forging B3. After the finished forging is moved to the position shown in Fig. 12 the stripper 18 is moved by an operating handle 53 from the position shown in Fig. 17 to a position wherein the slot 52 of the stripper fits around the tool 10 behind the finished forging B3 and whereby, as the tool 10 is retracted by reverse movement of the piston 21, the end of the finished forging B3 in which the finished cavity C3 is formed engages the stripper 18 which removes the said forging from the tool 10.

The piston or ram rod 20 is provided with a pair of segmental lugs 55, 55 which normally are slidably mounted in a correspondingly shaped pair of grooves 56, 56. The grooves 56 are formed in a sleeve 57 which is rotatably mounted in an extension 58 of and on the forward end of the ram 25. Secured to the sleeve 57 is a split collar 59 which is provided with an annular rib 60. The annular rib 60 is mounted in a correspondingly shaped groove 61 formed in the ram extension 58. The collar 59 is provided with suitable handles 62, 62 by which the collar 59 and consequently the sleeve 57 may be rotated to bring the solid portions 63 of the sleeve 57, which lie between the grooves 56, 56 of said sleeve, behind the segmental lugs 55, 55 on the ram rod 20 when such lugs are in the position shown in Fig. 21.

After each forging operation the finishing tool 10 as it passes beyond the rear end of the trough 9 swings about its pivot 19 dropping the penetrating end of said tool into a cooling liquid of any desired kind contained within a reservoir 64, as shown in Fig. 14a. The end of the tool 10 is prevented from striking the bottom of the container 64 by the underside of the tool 10 coming into contact with a block of wood 65 or other suitable material resiliently supported in any suitable manner as by a spring 66 shown in Fig. 14a.

The finishing tool 10 is raised from its inactive full line position shown in Fig. 14a to its operating position shown in broken lines in said figure by an air hoist or similar mechanism comprising a cylinder 67, a rod 68, chains 69 and yoke or loop 70 through which the tool 10 loosely extends.

When the primary forging B2 is placed in the receiving trough 9 the converging sides of said trough center said forging with respect to the axis of the ram rod 20 and the coinciding axis of the opening formed by and between the concave faces of the rolls R1, R1, and R2, R2. The tool 10 is then raised from its full line to its broken line position, as shown in Fig. 14a, which brings the axis of said tool into alignment with the axis of the primary forging B2. Fluid pressure admitted to the cylinder 22 through the port 23 quickly advances the ram rod 20 and tool 10 and causes the tool to move from the position shown in Fig. 6 into the cavity C2 of the forging B2, until the end 11 of said tool engages the base c3 of the cavity C2 and advances said forging along said trough into the bite of the rolls R1, in the position shown in Fig. 7.

In order to effect rapid movement of the tool into the cavity of the forging and the forging into contact with the rolls R1 it is preferable that air under pressure be used as the motivating fluid in the cylinder bore 22.

When the forward end of the forging B2 engages the rolls R1 the lugs 55 on the ram rod 20 have moved from the position shown in Fig. 18 to the position shown in Fig. 21 with respect to said ram. The collar 58 is then rotated to bring the solid abutments 63 into line with and behind the lugs 55. Motivating fluid, preferably water under high pressure from a hydraulic accumulator is then admitted to the rear end of the ram cylinder 26 through the pipe 27.

The slower moving hydraulic pressure then advances the ram 25 until the abutments 63 engage the lugs 55 on the ram rod 20. The ram rod 20 and the finishing tool 10 connected thereto are then locked to and move with the ram 25 as an integral part thereof and pass the forging B2 through the primary reducing rolls R1 and the secondary rolls R2.

As soon as the rear end b2 of the forging B2 passes the axis of the secondary rolls R2 the air pressure built up in the cylinder 22 between the piston 21 and the solid end 30 of said cylinder bore projects the ram rod 20 and finishing tool 10 rapidly, causing the flat face of the pad b on the forward end b1 of the finished forging B3 to strike the marking die 17 with an impact sufficient to impress the markings on the die 17 in the end of the forging B3.

The stripper 18 is then moved in behind the finished forging, as previously described, whereupon air under pressure is admitted to the port 24 at that end of the cylinder bore 22 between the piston 21 and the closure plug 31, while the port 23 is opened to exhaust, the collar 59 having previously been turned to realign the grooves 56

with the lugs 55 on the ram rod 20. The application of the air pressure to the cylinder 22 through the port 24 rapidly moves the ram rod 20 in a reverse direction, the first result of which is that the rear end b2 of the forging B2 strikes the stripper 18 and strips the forging B3 from the finishing tool 10 as the ram rod and finishing tool continue to move rearwardly, the lugs 55 in the meantime passing into and along the grooves 56 in the sleeve 57 into the position shown in Fig. 18.

Fluid under pressure, either pneumatic or hydraulic is then admitted by the pipes 44 into the retracting cylinders 40, said fluid operating against the pistons 41 to retract the piston rods 42 which, being connected to the cross head 43 of the ram 25, moves said cross head and said ram in a reverse direction to retract the tool 10 fully from the rolls R1 and R2. Continued rearward movement of the ram 25 withdraws the finishing tool 10 to a position where the end 11 thereof passes beyond the rear end of the trough 9 and permits the tool 10 to drop into the cooling liquid within the container 64, it being understood that in the meantime the tool raising loop 70 has been lowered to permit said tool to drop into contact with the shock absorbing block 65 on the spring 66.

If for any reason the forging does not freely strip from the tool 10 when the air pressure is applied to the piston 21 through the port 24, as above described, the stripping will be effected when the ram 25 is retracted by hydraulic pressure applied to pull-back cylinders 40, through the inlets 44, which will cause the plug 31 in the ram 25 to engage the piston 21 and move the piston rod 20 and tool 10 rearwardly with sufficient force to strip the finished forging from the tool.

Obviously, the various fluid conducting pipes are provided with suitable valves whereby inlet and exhaust of motive fluid to and from the various cylinders may be readily controlled.

The method of the present invention, as described above, constitutes a decided improvement over the methods of the prior art in which the forgings are reduced diametrically and elongated longitudinally by passing them though one or more rings, in that, by the present method a greater reduction in a single pass through the rolls can be made than could be accomplished by any single pass through a draw ring, because in attempting to make a great reduction with a draw ring or in progress steps through a series of draw rings axially aligned and simultaneously engaging the forging, the friction of the ring or rings opposing the force exerted on the end of the piercing by the tool exceeds the tensile strength of the metal between the end of the tool and the ring and causes the metal to thin out in what is termed "necking," which draws the metal out of contact with the surface of the tool and produces an uneven inner surface in the forging and a consequent non-uniform thickness in the wall of the forging; whereas, under the present method the rolls by reason of their rolling contact with the exterior surface of the forging reduces the opposition to the passage of the forging through the throat of the rolls and compresses the metal radially at the same time as the wall of the forging is elongated, whereby the physical character or properties of the metal are increased to an appreciable extent over the resulting product of the old method, and whereby the metal being pressed with such great force against the exterior surface of the finishing tool produces a decided improvement in the character of the finish of the interior wall of the forging, the surface of the wall being extremely smoother with decidedly less scale formation than under the old method.

In the present instance the first set of rolls makes the reduction and in so doing raises fins on the outer surface of the forging while the second set of rolls primarily eradicates the fins and effects little or no reduction in the diameter of the forging.

I claim:

1. The method of making hollow forgings which consists in forming a cavity with a closed end and a cross-section of predetermined shape and dimensions to a predetermined depth inwardly from one end of a heated billet to form a primary forging, inserting a finishing tool of the same shape but of slightly lesser cross-sectional dimensions into the open end of said cavity free from contact with the walls of said cavity to provide an air space between the exterior surface of the tool and the interior surface of the cavity at a relatively high speed until the end surface of the tool engages the closed end surface of said cavity, advancing the tool and the forging through a throat of lesser dimensions than the outside cross-sectional measurements of the billet at a relatively low speed to contact and compress the forging cross-sectionally into contact with the outside surfaces of the finishing tool to finish the forging by reducing the cross-sectional dimensions of the cavity to the cross-sectional dimensions of the tool, and retracting the tool from the finished forging substantially at said relatively high speed.

2. The method of making hollow forgings which consists in forming a cavity with a closed end and a cross-section of predetermined shape and dimensions to a predetermined depth inwardly from one end of a heated billet to form a primary forging, inserting a finishing tool of the same shape but of slightly lesser cross-sectional dimensions into the open end of said cavity free from contact with the walls of said cavity to provide an air space between the exterior surface of the tool and the interior surface of the cavity at a relatively high speed until the end surface of the tool engages the closed end surface of said cavity, advancing the tool and the forging through a throat of lesser dimensions than the outside cross-sectional measurements of the forging at a relatively low speed to contract and compress the forging cross-sectionally into contact with the outside surfaces of the finishing tool to complete the forging by reducing the cross-sectional dimensions of the cavity to the cross-sectional dimensions of the tool, retracting the tool from the finished forging substantially at said relatively high speed and cooling said tool preparatory to its entrance into the cavity of another of said billets.

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