

Jan. 30, 1945.

H. G. WELSFORD ET AL

2,368,603

APPARATUS FOR FORGING BILLETS

Original Filed June 26, 1940

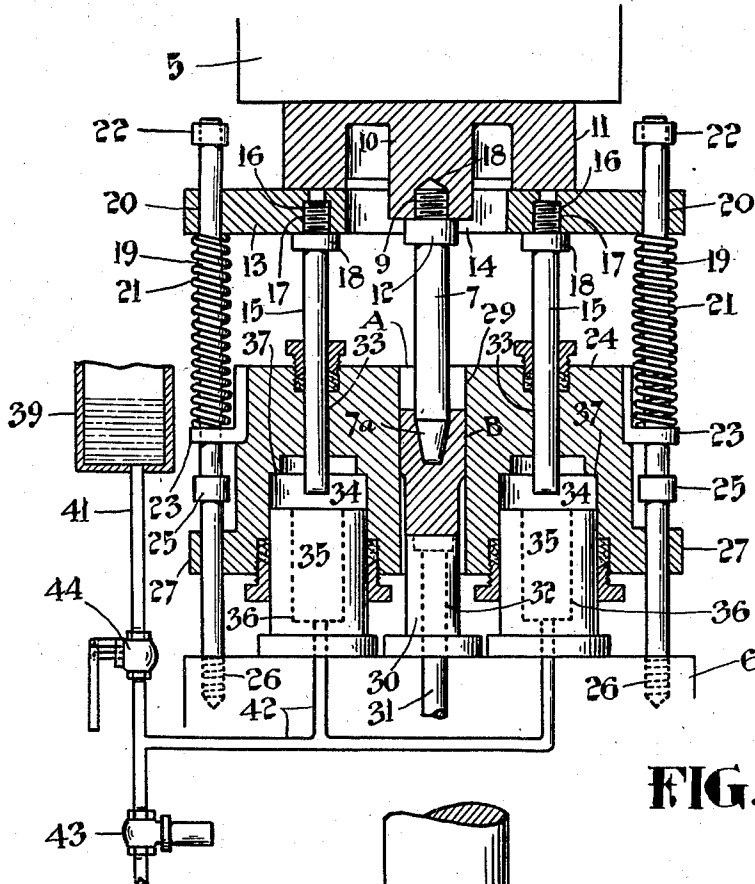


FIG. 1

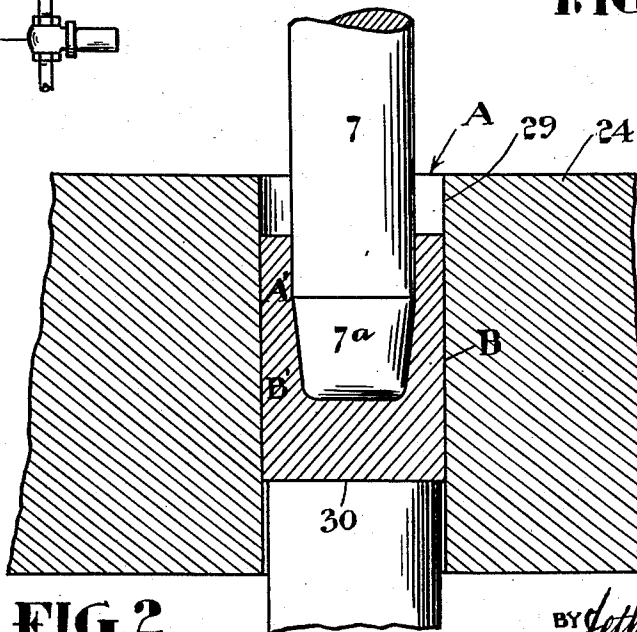


FIG. 2

INVENTORS
H. G. WELSFORD
W. R. MUIR
BY *Fetherstonhaugh & Co.*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,368,603

APPARATUS FOR FORGING BILLETS

Hubert G. Welsford, Westmount, Quebec, and
William P. Muir, Hampstead, Quebec, Canada,
assignors to Dominion Engineering Works Limited,
Lachine, Quebec, Canada

Original application June 26, 1940, Serial No.
342,530. Divided and this application June 30,
1943, Serial No. 492,944

1 Claim. (Cl. 78—9)

This invention relates to improvements in the forging of hollow articles by the billet piercing method and has particular reference to the forging of artillery shells.

The main object of this invention is to provide a method and apparatus whereby a shell forging having a smooth full length forged cavity may be produced by a single stroke of the billet piercing punch without subjecting the punch to excessively high pressures.

According to this invention the die pot in which the billet is forged is automatically lengthened during the forging operation to prevent the development of excessive plastic pressure in the portion of the billet confined in the diminishing space between the bottom of the die pot and the tip of the advancing punch. A distinctive feature of the invention resides in the fact that the bottom wall and the tubular body wall of the die pot are moved relatively to each other in a die pot lengthening direction by the application of a controlled force or pressure which is independent of any die pot lengthening pressure transmitted to these parts by the flowing action of the billet metal displaced during the forging operation.

Shells have been made prior to this invention by forging a billet in a die pot provided with an axially movable body wall which is moved in a die pot lengthening direction by frictional contact with the billet metal which, during the forging operation, is displaced to flow in a direction opposite to the billet piercing movement of the punch. In this case the lengthening of the die pot is due solely to the force exerted by the flowing action of the metal in contact with the body wall of the pot and is resisted by the inertia and/or weight of said wall. In the case of the present invention an external force, other than that exerted by the flow of metal displaced during the forging of the billet, is utilized to effect the desired relative movement of the bottom and body portions of the die pot in a die pot lengthening direction. One advantage of the latter procedure is that it lends itself to the use of a controlled pressure for applying the force necessary to effect the desired lengthening of the die pot. Another advantage is that the lengthening of the die pot by the application of a force other than that exerted by the flowing metal displaced during the forging operation enables the die pot to be lengthened at a rate which is either equal to or greater than the maximum rate of movement or flow of the metal displaced during the forging operation. Obviously, when a force other than that exerted by the flowing metal displaced during the forging operation is applied to lengthen the die pot at a rate which is at least equal to the maximum rate of movement of said flowing metal, the latter is

relieved of the retarding effect due to the inertia and/or weight of that portion of the die pot which is actually moved to increase the effective length of the die pot chamber.

5 In the preferred embodiment of this invention the die pot is provided with a fixed bottom wall and an axially movable tubular body wall. During the forging operation a force, other than that exerted by the flowing billet metal displaced during the forging operation, is applied to the body wall to move it in a die pot lengthening direction. This force may be regulated or predetermined so that the rate of movement imparted to the body wall of the die pot in a die pot lengthening direction is greater than the rate of movement of the metal which, during the forging operation, is displaced to flow in a direction opposite to the billet piercing motion of the punch. In this case a substantial reduction of the pressure to which the punch is subjected during the forging operation is obtained by reason of the fact that the die pot lengthening movement of the body wall of the die pot actually assists the flow of metal over the surface of the punch in a direction opposite to the billet piercing movement of the punch.

The lengthening of the die pot by the application of a force other than that exerted by the flowing metal displaced during the forging operation is particularly important in connection with the forging of shells in which the cavity is formed with a slight taper at the inner or closed end thereof. The forging of such shells requires the use of a punch having a cylindrical body portion of uniform diameter terminating in a tapered billet engaging tip portion which serves to define the shape of the tapered end of the cavity. When such a punch is used the velocity of motion imparted to the metal in the zone between the body wall of the fire pot and the tapered portion of the punch will vary throughout the length of said zone and will have a maximum value greater than that of the metal flowing in the zone between said body wall and the cylindrical portion of the punch. This will be easily understood since the velocity of flow of the metal which is forced past the tapered portion of the punch as the tip of the punch approaches the bottom wall of the die pot will be accelerated by the lateral crowding action to which the metal is subjected by the advancing movement of the said tapered portion of the punch. In this case the use of a die pot provided with an axially movable body wall which is moved in a die pot lengthening direction solely by frictional contact with the flowing metal displaced during the forging operation does not reduce the pressure on the punch to the same extent as it does in the case where the piercing punch is of uniform diameter throughout its

length and does not have the same crowding and pressure increasing effect as the tapered punch. When a tapered punch is used the body wall of the die pot will be moved in a die pot lengthening direction by its frictional contact with the flowing metal but, since the velocity of motion imparted to the metal is not uniform over the length of the punch or throughout the area of contact between the metal and said wall, the die pot lengthening motion of the latter cannot relieve all of the plastic pressure increase due to the previously mentioned crowding action of the tapered portion of the punch. The present invention overcomes this difficulty since it provides a means whereby the body wall of the die pot may be moved in a die pot lengthening direction at a rate such that the frictional contact between said wall and the billet metal is utilized to assist flow of metal over the surface of the advancing punch. When a tapered punch is used the velocity of motion imparted to the body wall of the die pot in a die pot lengthening direction is at least equal to the maximum velocity of motion of the metal flowing over the tapered portion of the punch.

The present application is a division of our co-pending United States application Serial No. 342,530, filed June 26, 1940.

Proceeding now to a more detailed description of this invention reference will be had to the accompanying drawing, in which—

Fig. 1 is a view, partly in section and partly in elevation, of one form of shell forging apparatus which may be used for carrying out the present invention.

Fig. 2 is a diagrammatic view illustrating the conditions obtained when a tapered billet piercing punch is employed in the forging operation.

Referring more particularly to Fig. 1, 5 designates the upper movable platen and 6 the lower stationary platen of a forging press. The billet piercing punch is indicated at 7. This punch is provided with a threaded upper end 8 which is screwed into a threaded socket 9 formed in the central projection 10 of a punch holder 11 which is fastened to the underside of the platen 5. The punch 7 is provided with a shoulder forming portion 12 which is jammed tightly against the lower end of the projection 10 when the threaded portion 8 of the punch is screwed home.

A vertically movable plunger carrying plate 13 is positioned below and in the path of movement of the die holder 11 so that this plate is forced to move downwardly with the die holder during a portion of the downward working stroke of the billet piercing punch 7. Plate 13 carries two plungers 15 arranged at opposite sides of the punch 7, said plungers being provided with threaded upper portions 16 which are screwed into the plate sockets 17 until the shoulder forming portions 18 of the plungers are jammed tightly against the underside of the plate. Plate 13 is guided by a pair of guide rods 19 which pass upwardly through the guide openings 20 provided adjacent the ends of said plate. Springs 21, encircling the guide rods 19 below plate 13, act upwardly against the lower surface of said plate and normally serve to yieldingly support the plate in an elevated position with its upper surface engaging stop nuts 22 screwed onto the upper end of the guide rods. The lower ends of the springs 21 bear against the guide lugs 23 of a vertically movable casting 24 which is also guided by the rods 19. Prior to commencement of the forging operation the casting 24 is disposed

in its lowermost position with the lugs 23 resting on the supporting enlargements 25 of the guide rods 19, the lower ends of said guide rods being screwed into sockets 26 provided in the lower stationary platen 6. Casting 24 is also provided with additional guide lugs 27 which slide on the portions of the guide rods located below the enlargements 25.

The central portion of casting 24 is pierced by a central cylindrical bore 29, the wall of which constitutes the body wall of the die pot chamber A in which the billet B is forged during the working stroke of the punch 7. The bottom of chamber A is formed by a cylindrical member 30 which is fixed to the stationary platen 6 and is slidably fitted in the lower portion of the bore 29. Member 30 is provided with a stripper pin 31 working in the guide bore 32.

The plungers 15 are slidably fitted in guide bores 33 which are provided in the upper portion of the casting 24 and which communicate, at their lower ends, with chambers 34 provided in the lower portion of said casting. Stationary plungers 35 are fastened to the platen 6 so that they extend upwardly into the chambers 34. These plungers 35 are provided with cavities 36 into which the lower portions of the movable plungers 15 are forced by the downward movement of the plate 13. The upper portions of the chambers 34 are reduced in diameter to provide shoulders 37 which rest on the upper ends of the stationary plungers 35 when casting 24 is disposed in the lowermost position which it occupies prior to commencement of the forging operation.

When plate 13 and casting 24 are in the position which they occupy prior to commencement of the forging operation, the chambers 34 and the communicating cavities 36 are completely filled with liquid which is supplied from tank 39 by way of pipes 41 and 42, the pipe 41 being provided with a pressure relief valve 43 and a manually operable filling valve 44, the latter being located between valve 43 and the tank 45.

The plate 13 and the casting 24 remain in their initial positions during the downward or working stroke of the punch 7 until the die holder 11 contacts the upper surface of plate 13. When this occurs the plate 13 moves downwardly with the punch 7 until the latter has completed its working stroke and is retracted to its starting position above and clear of the die pot chamber A. During the downward movement of plate 13 the plungers 15 are advanced into the chambers 34 and into the cavities 36 of the stationary plungers 35. The hydraulic pressure in the chambers 34 and cavities 36 is thus intensified so that the casting 24 is forced to move upwardly in a die pot lengthening direction against the slight resistance of the springs 21 and this lengthening of the die pot continues until the punch 7 has completed its working stroke. The parts are preferably designed so that the upward die pot lengthening movement of casting 24 proceeds at a velocity which is at least equal to the maximum velocity of the billet metal which is caused to flow upwardly around the tapered portion 7a of the punch as the punch proceeds beyond that point of its working stroke at which the full length of the billet is expanded into frictional contact with the die pot wall 29 as shown, for example, in Fig. 2.

When the punch 7 has completed its working stroke it is raised above and clear of the die pot chamber A by the return stroke of the press

platen 5 so that the billet B may be expelled from the die pot chamber by operation of the stripper pin 31. As the die holder 11 is raised to its initial starting position the plate 13 is forced upwardly by the springs 21 to withdraw the plungers 15 from the cavities 36 and the chambers 34 so that the hydraulic pressure acting against the casting 24 is reduced to permit the casting to gravitate to its lowermost position.

While the herein described method of lengthening the die pot chamber A during the forging of the billet B is of particular advantage when using a punch with a tapered tip, it is also capable of useful application in cases where shell forgings are made with a punch which is of uniform diameter throughout its length. In the latter instance the raising of the die pot by the hydraulic pressure developed in the chambers 34 and the cavities 36 by the downward movement of the plungers 15 serves to take the weight of the axially movable body portion of the die pot off the billet and, at the same time, utilizes the friction between the billet metal and the upwardly moving wall of the die pot chamber to assist in drawing the metal upwardly over the surface of the punch.

It is thought that the following explanation of the conditions obtaining when the forging operation is carried out with the aid of a punch having a tapered tip portion will be conducive to a clearer understanding of the functioning and advantages of the invention described herein. In this connection reference will be had to Fig. 2 in which the punch 7 is shown advanced to that point of its working stroke at which the billet B is upset or expanded so that the whole length of the billet is in frictional engagement with the surrounding portion of the body wall of the die pot. As the punch advances beyond this point the resulting diminution of the space between the bottom wall 30 of the die chamber A and the advancing tip of the punch causes the metal of the billet to flow upwardly along the surface of the punch. The shape of the tapered portion 7a prescribes that the metal at a point B' must be further compressed to flow toward the point A' and this results in a rise or upward flow of the metal between A' and B' at varying velocities relative to the punch and in a direction opposite to the billet piercing motion of the punch. Obviously, as the punch advances the metal must rise with increasing velocity relative to the tapered portion of the punch and the surrounding wall of the die pot until it reaches the point A' and passes to the zone between the body wall of the die pot and the cylindrical surface of the punch where no further reduction of the shell wall takes place by reason of the advancing motion of the punch. Due to the fact that the metal flowing directly from zone B' to zone A' is forced to do so by reason of the plastic pressure existing under the tip of the punch and transmitted to the metal at the point B' by its partial fluidity and due to the crowding action of the tapered punch portion 7a, extrusion can only take place under this condition with plastic pressure increasing from A' to B' and this increase in plastic pressure aggravates the resistance to such motion due to friction on the punch and die surfaces with which the metal is in contact and causes a building up of such pressure between A' and B'.

It may be pointed out here that it is the decrease in volume from B' to A' with consequent increase in the velocity of motion of the particles of the metal from B' to A' which defeats, to a large extent, the beneficial effect of using a die pot provided with an axially movable body wall which is carried upwardly solely by the flowing action of the displaced billet metal in frictional contact therewith. In this instance the axially movable body wall of the die pot will be carried upwardly by the extruded or upwardly flowing metal in frictional contact therewith but, as the velocity of the metal is not constant from B' to A', such upward movement of the body wall of the die pot cannot relieve all of the crowding effect of decreasing areas from B' to A'. The present invention is based on the discovery that this difficulty may be overcome by imparting to the axially movable body wall 24 of the die pot a motion relative to the bottom member 30 which is in excess of that motion which the body wall would have solely by reason of its frictional contact with the retarded or upwardly flowing metal. To this end the present invention, as previously explained, provides means whereby the upward movement of the body wall of the die pot is effected by the application of a controlled force other than the force exerted by the upwardly flowing metal in contact with said wall. In the latter instance the friction grip of the metal on the die pot wall is utilized to assist the motion of the metal relative to the punch from zone B' to A'. With this arrangement a state of tension is created in the metal which partially offsets the compression of the metal due to the reducing areas of cross section which the metal is forced to traverse in flowing from B' to A' and the result of this is to effect a considerable reduction in the plastic pressure under the tip of the punch and in zone B' with consequent further reduction in the frictional resistance to flow of the metal on the surface of the punch. This, in turn, has the effect of reducing the scoring effect on the punch surface so that the useful life of the punch is considerably prolonged, in addition to making feasible, in a single forging operation, the production of forgings having full length smooth or finished cavities.

Having thus described our invention, what we claim is:

Apparatus for forging shells or other hollow articles comprising a billet receiving die pot provided with relatively movable bottom and body wall portions, a piercing punch and means including a power actuated punch holder for advancing and retracting said piercing punch so that, during the advancing movement thereof, the punch is forced against a billet contained in said die pot to form a cavity in said billet and to expand the billet into frictional contact with the body wall of the die pot, hydraulic pressure applying means operable to effect relative movement of the bottom and body wall portions of the die pot in a die pot lengthening direction during the forging operation, and means actuated by said punch holder for operating said hydraulic pressure applying means when the holder has advanced the piercing punch to a predetermined point of its working stroke.

HUBERT G. WELSFORD.
WILLIAM P. MUIR.