

Filed May 6, 1949

FORGING PROCESS AND APPARATUS

8 Sheets-Sheet 1

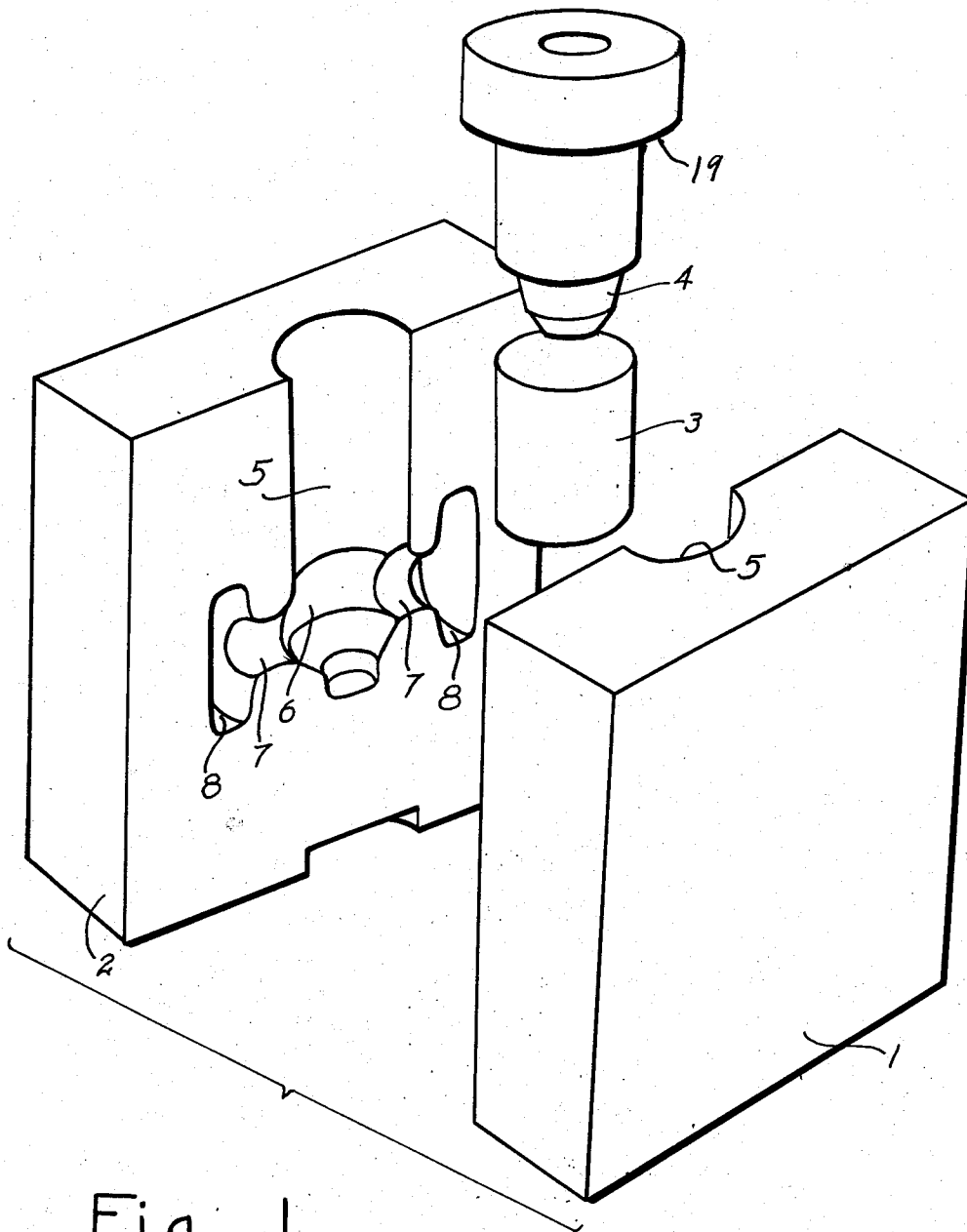


Fig. 1.

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2,663,205

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8 Sheets-Sheet 2

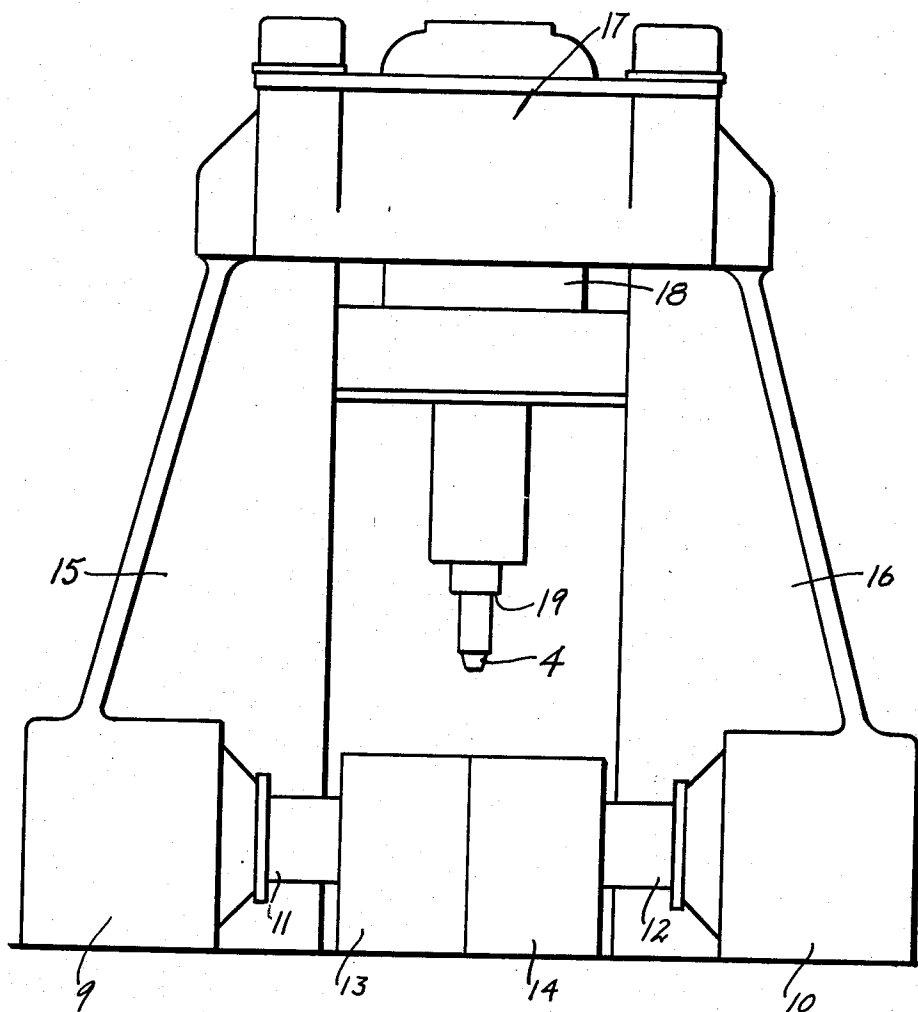


Fig. 2.

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8 Sheets-Sheet 3

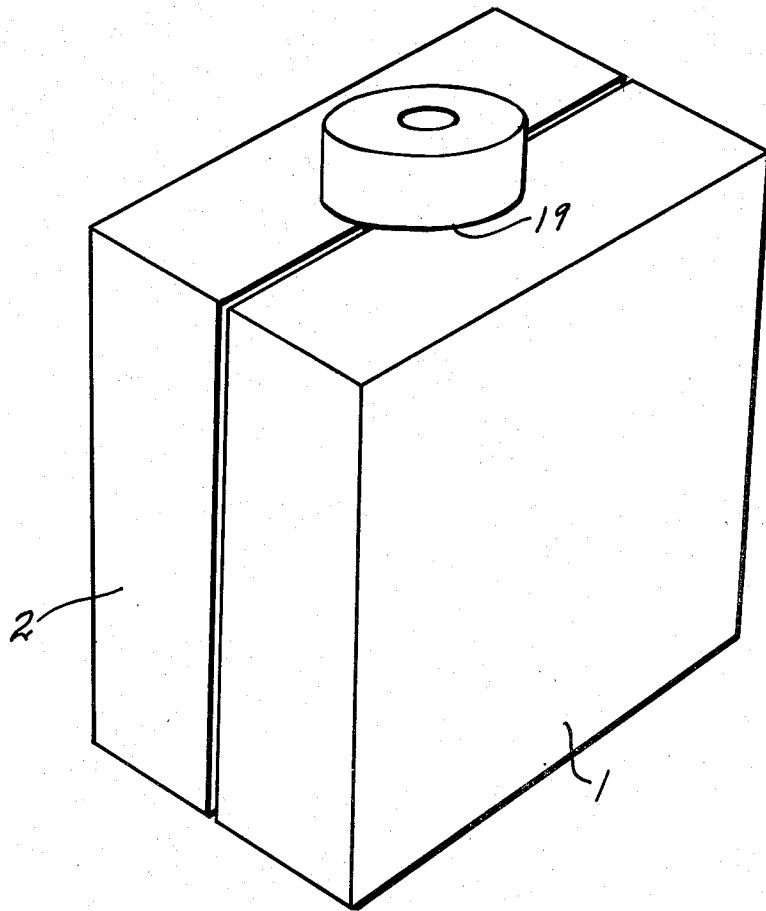


Fig. 3.

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8 Sheets-Sheet 5

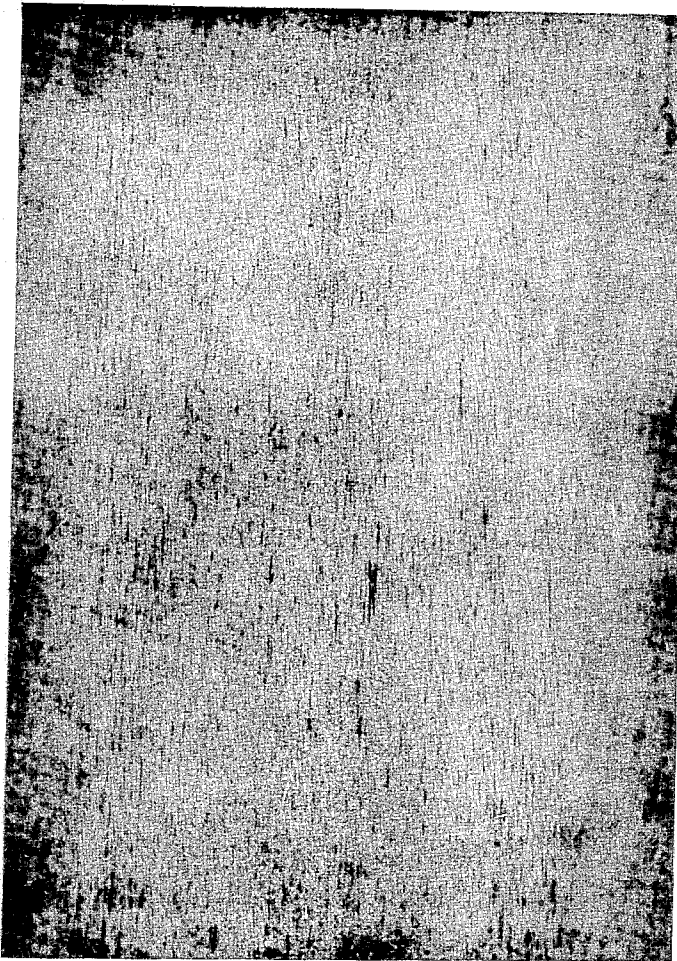


Fig. 6.

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8 Sheets-Sheet 6

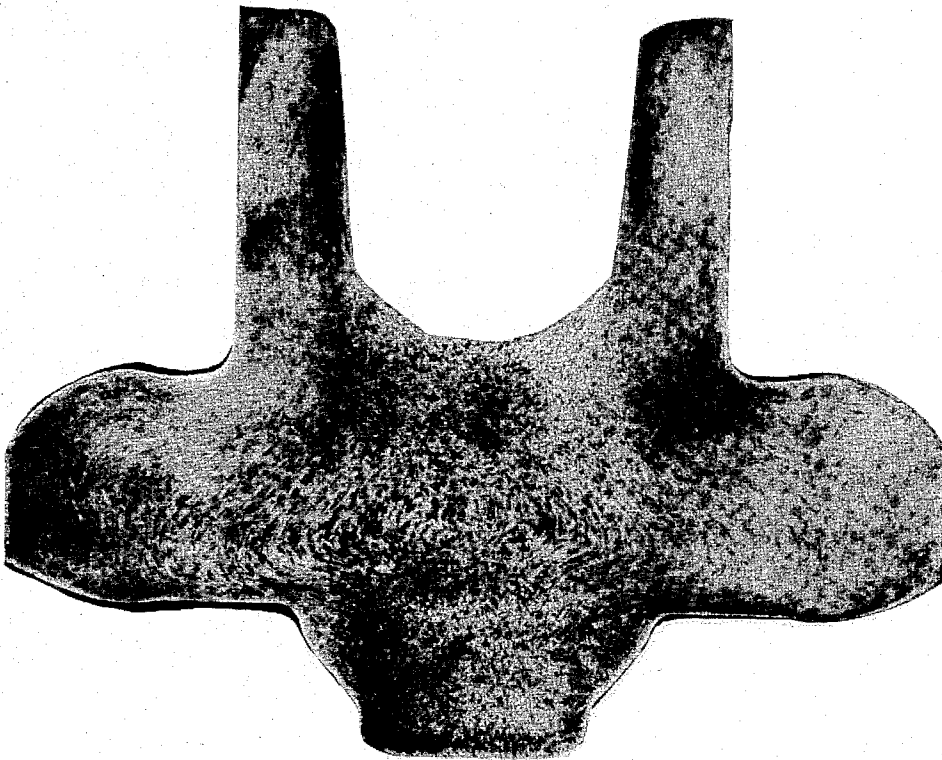


Fig. 7.

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8 Sheets-Sheet 7

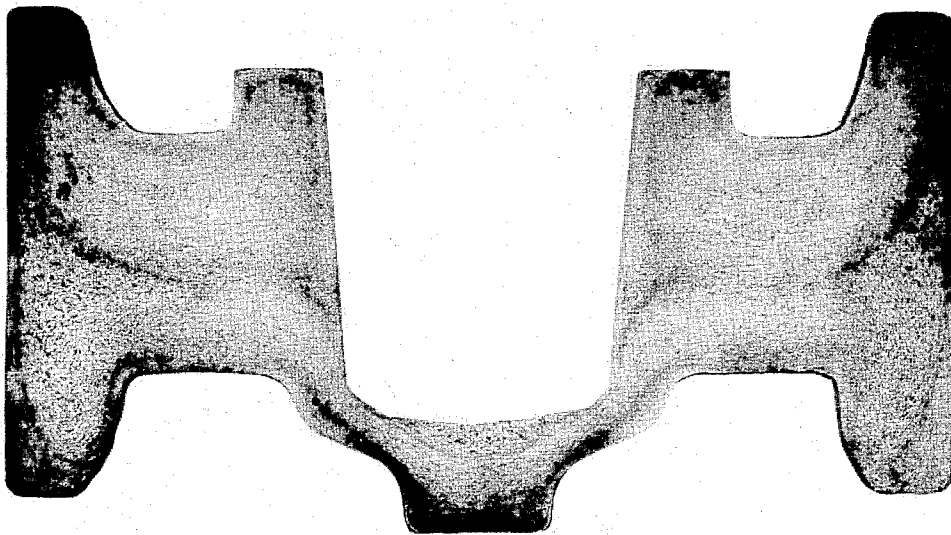


Fig. 8.

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8 Sheets-Sheet 8

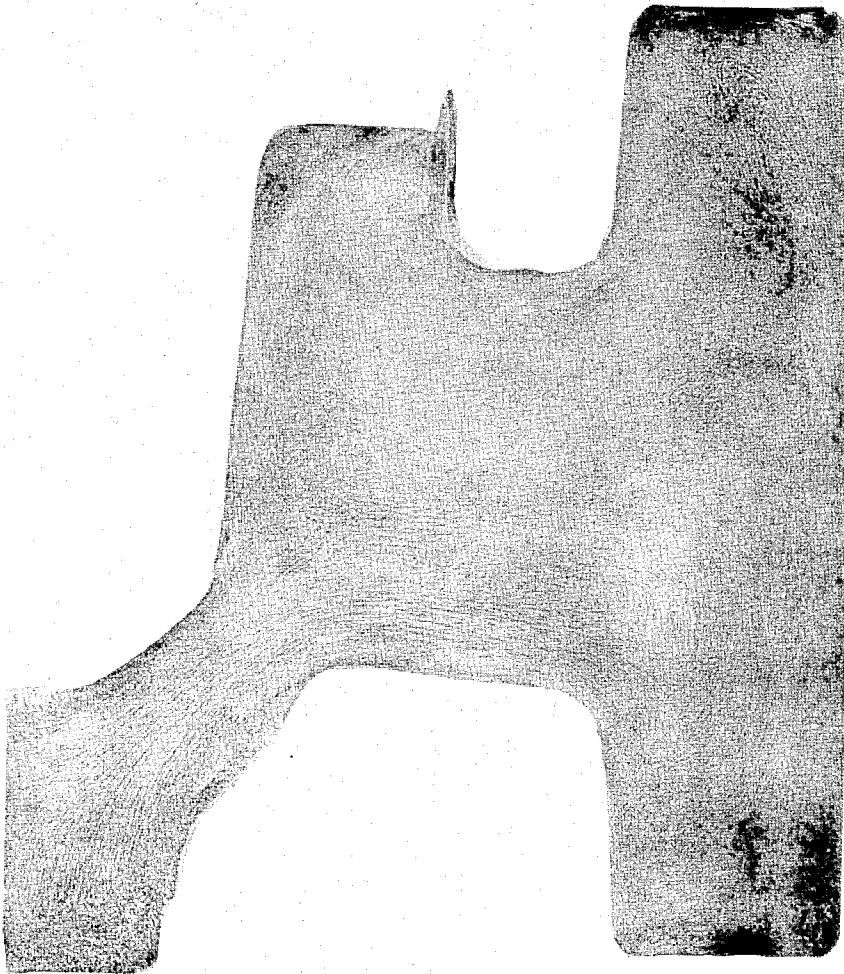


Fig. 9.

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UNITED STATES PATENT OFFICE

2,663,205

FORGING PROCESS AND APPARATUS

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Application May 6, 1949, Serial No. 91,767

4 Claims. (Cl. 78-60)

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This invention relates to press forging of rolled or worked steel and other forgeable materials of similar fibrous structure, and apparatus for use therein, and has for its general object the forging of intricate shapes such as flanged valve bodies.

Forging operations performed on steel and the like have in the past been directed either to hammering or pressing into the shape desired a body of the material at forging temperature, or to the forcing of a billet of the material at forging temperature directly into a die chamber to cause it to conform to the shape thereof. Such metals have also been extruded through orifices to produce elongated extruded parts. It has also been proposed to forge such intricate shapes as flanged pipe T's by upsetting the ends and central part of a single billet of metal and then punching the upset central portion to extrude the same and form a leg for the T, but such methods have not proven successful.

Although suitable presses have long been available and many have sought an economical way of producing intricate forgings of steel, such as flanged T's, valve bodies, and the like, it has not been possible by methods hitherto known to produce by press forging from a single billet of steel or the like in one operation a satisfactory forging having two or more enlarged parts connected by a part of smaller cross-section. Nor has it been possible to produce a forging shape of such material having an enlarged part with the fibres adjacent all portions of the surface thereof disposed generally parallel to the surface and following the contour of the forging.

It is an object of this invention to provide a method and apparatus for making possible the production of such forgings having the most desirable characteristics, and to make possible such production in more economical fashion than heretofore.

In accordance with this invention, it has been discovered that rolled or worked steel or the like may be squeezed or extruded through an orifice without the production of faults either in the body of steel adjacent the entrance to the orifice due to slippage of the fibres longitudinally over each other, or in the part extruded, provided the initial disposition of the fibres in the body adjacent the orifice is across the entrance to the orifice so that the extrusion will be lateral with respect to the fibres. This manner of extrusion produces an extruded part in which all the fibres adjacent the surface are substantially parallel to the surface and follow the contour of the forg-

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ing. It has further been discovered in the making of this invention that when steel or the like is so extruded, the extruded part emerging from the orifice may be confined by a die, and that by thereafter continuing to extrude material from the original body through the orifice, the extruded confined part may be caused to expand or grow until it fills and assumes the configuration of the confining die, which may be much larger and of different shaped cross-section from the orifice. It has further been discovered that the entire extruded part thus formed retains the characteristic of having all its fibres adjacent the surface disposed generally parallel to the surface and following the contour of the forging.

The best results thus far obtained have been with the extrusion produced by application of pressure to the original body longitudinally of its fibres and with the principal pressure supplied to the central portion of the exposed ends of the fibres so as to tend to displace material from the interior of the body opposite the orifice entrance and cause it to flow into and through the orifice.

Steel valve bodies having a main body with a valve chamber forged therein and having flanges joined to the main bodies by necks for providing inlet and outlet ports for the finished valves, have been press forged under the applicant's supervision in accordance with this invention from single steel billets in one operation, and have been found to have the most desirable fibre disposition characteristics and to be free from faults, cracks and pipes. At the same time, the metal wastage has been reduced to a minimum.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings wherein is set forth by way of illustration and example one embodiment of this invention.

In the drawings:

Fig. 1 is an exploded view of the two portions of a die, the billet from which the forging is to be produced, and the punch for forcing the billet into the die, all in accordance with this invention.

Fig. 2 illustrates a side elevation of a forge press with the dies and punch in place for making a forging in accordance with this invention.

Fig. 3 is a view of the die sections and punch illustrated in Fig. 1 after the same have been brought together as in a forging operation.

Fig. 4 is a view similar to Fig. 1 but showing the die sections and punch moved apart and the

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completed forging removed from but still located between the die sections.

Fig. 5 is a vertical cross-section through the forging illustrated in Fig. 4, showing the two flanged end enlargements and the recess formed in the central body part.

Fig. 6 is a photograph of a central longitudinal section through the steel billet shown in the upper central portion of Fig. 1, etched to show the microstructure.

Fig. 7 is a photograph of a similar cross-section through a partly completed forging, similarly etched to show the changed disposition of fibers and direction of fibre flow at this stage of the forging operation.

Fig. 8 is a photograph of a similar cross-section, similarly etched, through a forging which has been nearly completely filled out; and

Fig. 9 is a photograph of a similar cross-section, similarly etched, through one-half of a completed forging.

Referring more in detail to the drawing, Fig. 1 shows in separated or exploded relation to each other the two halves 1 and 2 of the die which are held together in the forge press to provide the complete die, the billet 3 from which the forging is to be formed, and the forging punch 4 which is forced into the die against the billet with such force as to cause the material of the billet to flow as hereafter described and conform to the die to provide the final forging.

Each of the die parts in the illustration employed is identical with the other and each is provided with hollowed out portions complementary to the other, these portions in the present instance consisting of a semi-cylindrical die chamber 5 leading from the upper end of the die part downwardly to a point where it communicates with the somewhat smaller die chamber 6 in which is formed the main body portion of the valve forging for which these die parts 1 and 2 are designed. It will be understood that the diameter of the die chamber 5 is preferably substantially as great as the largest portion of the die chamber 6 so that a body of metal being forced from the die chamber 5 into the die chamber 6 will be forced to a somewhat reduced cross-section area and into close conformity with the die chamber throughout.

Connecting with the die chamber 6 and extending in opposite directions therefrom are reduced portions which may be termed necks or orifices 7, these opening at their outer ends into die chambers 8 in which the flanges of the valve body are formed.

It is to be understood that while the die parts just described are intended for the production of a valve body having flanged inlets and outlets, the dies may be provided with chambers for the purpose of making forgings of different shapes and for different purposes, and that the dies illustrated are shown for purposes of illustration only.

The billet 3, of forging material which may be steel or other forgeable material of fibrous structure similar to that of steel, is heated to press forging or extruding temperature and placed within the die chamber 5, while the two die sections are held together. In this position its fibres are substantially parallel to the direction of travel of the punch. The punch 4 is then forced downwardly against the billet forcing it into and making it conform to the die chamber 6. At this stage, the fibres of the billet extend across the orifices 7. Further movement

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of the punch 4 will force the punch into the conformed billet and will cause the metal from the interior of this billet to flow through the orifices 7 into the die chambers 8, where the forging metal thus extruded will be confined and caused to assume the shape of the die chambers 8, thereby providing the flanged ends on the valve forging.

With reference now to Fig. 2, there is illustrated a forge press having a frame which includes a base with opposed portions 9 and 10 forming supports for hydraulic rams 11 and 12. These rams hold the die holders 13 and 14 in place against the forging pressure.

This frame of the forge press likewise includes upright pillars or side members 15 and 16 respectively on top of which is mounted a cross beam 17. Beam 17 supports the main hydraulic ram 18 which forces downwardly the punch 4.

In passing, it may be stated that the hydraulic rams 11 and 12 respectively are of such a capacity that the force they will exert upon the die holders 13 and 14 will be more than sufficient to hold the dies in contact with each other under pressure from the punch such as may be necessary to force the metal into all parts of the die chambers. However, these rams 11 and 12 are preferably incapable of holding the die holders 13 and 14 against the maximum pressure which the ram 18 is capable of exerting through the punch 4. Under these circumstances, it will be seen that when the punch 4 is forced to enter the die and exert pressure upon the metal of the forging, it will first exert such pressure as will be necessary to force such metal into all parts of and into complete conformity with the die chambers within the dies. After the forging metal has been forced to completely conform to the dies, additional pressure upon the punch 4 will cause the increase of pressure in the forging metal until the dies will separate slightly, overcoming the force exerted by the hydraulic rams 11 and 12, and will thus permit the excess metal from the forging to "flash" out between the two sections of the die and leave the main body of the die with the proper amount of metal therein. In this connection, the punch is formed with a shoulder 19 adapted to engage with the upper surface of the die, and limit the amount by which the punch 4 may enter the forging material. The movement of the punch being thus limited, the punch will be unable to cause a greater amount of metal to "flash" than should be "flushed" and this will prevent the punch from making an excessive recess within the forging.

It will be appreciated that the volume of the metal contained in the billet 3 may be calculated so as to practically provide the exact amount of the metal required for the finished forging. However, a slight amount is necessarily added to the amount required for the finished forging in order to take care of scaling or the like, and in order to be sure that a sufficient excess amount is added for the purpose of taking care of scaling, it is necessary in each case that there be a small amount of additional material in the billet over and above that required to actually fill the die. Hence, the separation of the die parts and the "flash" hereinbefore described.

In Fig. 3 there is illustrated the slight separation of the die sections 1 and 2 which occurs when the punch 4 is driven home and the shoulder 19 seated against the ends of the die sections, this separation of the die sections permit-

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ting the "flash" which takes care of the excess metal in the billet 3.

In Fig. 4 the same apparatus is shown as was illustrated in Fig. 1, but in this case, instead of the billet 3, there is shown the completed forging made from the billet 3. This forging, as above stated, is the valve housing for a valve or similar structure and consists of the main portion of the body 20 which is connected by means of small reduced portions or necks 21 to the flanges 22 respectively.

It will also be noted that the body 20 which is formed within the die chamber 6 has a recess 23 in its upper surface, which recess was produced by the punch 4. This recess serves as the valve chamber in the finished valve body as will be readily apparent to one familiar with such bodies.

It is further to be noted in connection with Fig. 4 that the forging illustrated has extending therefrom along the parting line of the two die sections, a thin extrusion 24 of metal which has "flushed" during the making of the forging in the manner hereinbefore set forth. This "flash" is, of course, trimmed off in the finished forging.

By reference to Fig. 5, it will be seen what the appearance of a cross-section longitudinally through the completed forging is like. In this view, the "flash" has been removed and the finished forging is ready for machining. All that is necessary in order to produce the finished valve body is to machine the inside of the recess 23, bore the inlet and outlet openings through the necks 21 and flanges 22, face the flanges, provide the proper bolt holes therein, and face and tap the metal rim around the open end of the recess 23 so that the valve cover may be secured thereto.

It is to be noted that in making forgings by the process and with the apparatus in accordance with this invention, the action is what may be described as a transfer or extrusion of the metal. Furthermore, it is such as will require the shortest possible travel of the punch 4 compared with the volume of metal to be extruded in the forging. It is to be noted that the die chamber 5 in which the metal billet is first placed at the forging temperature, is of relatively large diameter as compared with any portion of the finished forging. Especially is this true with regard to the cross-section area of the die chamber 6 in which the major portion of the finished forging is formed. However, the billet, being thus of a relatively large cross-section may be made very short so that the punch 4 need not travel an excessive distance in order to accommodate the volume of metal required. The billet is placed in the chamber 5 with its fibre lines, clearly shown in Fig. 6 of the drawing, parallel to the axis of the chambers 5 and 6 and at right angles to the orifices 7. The billet is squeezed into the die chamber 6 until it conforms to this chamber. Thereupon the punch 4 begins to enter the billet a substantial amount, being applied to the central portion of the exposed ends of the fibres of the billet, and to displace portions of the interior of the billet, causing such portions to be extruded through the narrow sections 7 of the die. In this action, the fibres of the billet bulge laterally and fold into the passageways 7. These narrow sections or passageways thus act as orifices in connection with the extrusion or transfer of the forging metal from the die chamber 6 into the die chambers 8. The extruded portions of metal

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as they enter the chambers 8 have their principal fibres extending parallel to the axes of the orifices 7 as clearly shown in Fig. 7. Furthermore, they loop back at the ends of these extruded portions so that all the fibres adjacent the surfaces of these extruded parts are generally parallel to such surfaces and follow the contour of the forging. In the die chambers 8, the metal which is extruded through the openings 7 is confined to the shape which is desired in the finished forging so that the extruded metal is forced to change its shape from the relatively small diameter which it necessarily assumes in passing through the orifices 7 and to become of relatively larger diameter flowing again in planes which are substantially parallel to the direction of movement of the punch 4.

By reference to Fig. 8, it will be seen that during this additional flow or expansion within the chambers 8, the disposition of the fibres changes so that they continue to be generally parallel to the adjacent surfaces of the extrusion and to follow the contour of the forging despite the changed shape of the extrusion, and reference to the enlarged showing of Fig. 9 will show that this even holds true in the completed forging.

It is further to be noted that the process and apparatus described make possible the forging of shapes of the general nature described with one operation of the die press. It is unnecessary first to roughly form the billet and then to bring it to final form in a second or third operation. The entire process may be carried on in one continuous operation of the punch, and requires but one heating. The elimination of more than one heating saves time, fuel and loss of material and deterioration of forged surfaces due to scaling.

It may be stated that it has been found that in making forgings by the process described, the use for lubricating the punch of any substance having any substantial amount of volatile or other constituents capable of producing a gas at the temperatures and pressures involved is apt to form pipes. This has been experienced in the use of coal dust as a lubricant for the punch, the pipes extending from the central recess formed by the punch back through the narrow necks and actually into the flanges 22. The omission of the lubricant or the use of a completely non-volatile lubricant having no constituents capable of producing a gas under the actual conditions of operation, eliminated such pipes.

It has further been found that in the making of forgings by the process just described, frequency of permissible use of the die sections and hence the economy of the operation can be greatly improved by the provision of means for cooling the dies with a steam spray or by the circulation of a coolant about the die sections, or both. Such cooling means have not been illustrated but it will be understood that the coolant may be sprayed by means of any suitable nozzle properly supported or may be circulated through hollows within the die sections 1 and 2 if that method of cooling be preferred.

In addition to the foregoing, attention is directed to the fact that the rams 11, 12 and 13 are capable of providing power not only for urging the die sections 1 and 2 toward each other and for forcing the punch into the die, but also for retracting the die sections 1 and 2 away from each other and for lifting the punch 4 and ex-

tracting it from the forging once the forging has been formed. Under these circumstances, it will be seen that the necessity for draft in the dies is substantially eliminated and on the punch is minimized because the completed forging may be held against lateral movement by the punch while the dies are forcibly removed therefrom by means of the power supplied by the rams 11 and 12, while the punch 4 may be removed from the forging by merely gripping the forging lightly between the die sections and causing the ram 12, which operates the punch to be retracted, thereby extracting the punch from the forging. This feature makes it possible to shape the forging more nearly exactly the way it is desired for the finished product to be shaped, and thus to reduce or avoid the waste of metal involved in making up the extra metal thickness required for draft. Waste of metal is avoided also by careful calculation of the volume of the billet 3 and by providing for the exact degree of travel of the punch 4 into the recess in the forging, this being accomplished by the stop 19 on the punch.

From the foregoing, it will be seen that a method and apparatus has been provided for carrying out and accomplishing all the objects and advantages sought by this invention. It will be appreciated, of course, that variations and departures therefrom may be made within the scope of the appended claims without departing from the spirit or scope of this invention, and that the drawings and the foregoing description are by way of illustration and example only and are not to be taken by way of limitation.

The invention having been described, what is claimed is:

1. Forging apparatus comprising, in combination, a plurality of complementary die sections each having a portion of a die chamber therein and being adapted when together to form a die chamber adapted to receive a billet to be forged, a die chamber substantially smaller than said first die chamber adapted to mould a part of the forging, an orifice communicating with said second die chamber and extending therefrom in a direction substantially at right angles to the axis of said first die chamber, and a third die chamber communicating with the opposite side of said orifice, a punch not larger than the first of said die chambers and adapted to be moved into such first die chamber, and cooperating means on said die sections and punch for limiting the movement of said punch into said die chamber.

2. The method of forging in a single forging operation a steel valve body having a central valve chamber portion spaced intermediate two enlarged end connection flanges and integrally connected to each flange by substantially cylindrical sections of smaller cross-sectional area than the flanges and the central valve chamber portion which comprises: heating a steel billet having longitudinally disposed fiber lines to forging temperature; applying an endwise pressure to one end of said billet in a direction parallel to said fiber lines to force the other end of the billet into a central die cavity of the form of said central valve chamber portion; confining the resulting partly shaped billet against lateral flow except at separate openings situated on opposite sides of the partly shaped billet and intermediate its ends which openings correspond to the location and size of said sections of smaller cross-sectional area; continuing the application of said endwise pressure to cause steel to extrude principally from the interior of and outwardly from

said partly shaped billet through said openings as a solid extrusion with fiber lines adjacent the exterior surfaces of the extruding portions extending parallel to such exterior surfaces and joined together at the outer ends of the extruding portions to form closed loops; limiting the extent of outward movement of said extruding portions by abutting the outer ends thereof respectively against surfaces disposed normal to the longitudinal axes of said extruding portions while leaving a part of said extruded portions next adjacent their abutted ends free to expand circumferentially, thereby forming extruded portions extending oppositely from the billet portion within said central die cavity; still continuing the application of said endwise pressure to cause steel to flow from the billet portion in said central die cavity through the extruded portions toward their abutted ends and then radially outwardly of said extruded portions at said part next adjacent their abutted ends to form said flanges, while confining the remainder of said extruded portions against such radially outward flow; and continuing said endwise compression until said flanges are fully formed.

3. The method of forging in a single forging operation a steel valve body having a central body portion spaced apart from an enlarged end connection flange and integrally connected thereto by a section of smaller cross-sectional area than the central body portion and the end flange which comprises, confining against lateral flow the end portions of a steel billet at forging temperature and having longitudinally disposed fiber lines, applying endwise compressing force to said billet in a direction parallel to the fiber lines therein and extruding laterally out of the billet to form a solid extruded portion, the extruding being caused by applying said endwise force while confining the flow of steel into the extruding portion to be principally from the interior of the billet and outwardly through only a portion of the circumference of said billet intermediate its ends with the fiber lines adjacent the surface of the extruding portion extending longitudinally and joining together at the end of the extruding portion to form closed loops, limiting the extent of said extruding by abutting the end of said extruding portion against a surface while leaving a part of said extruding portion next adjacent its abutted end free to expand laterally to form said flange, and continuing to apply said endwise force and causing sufficient steel to flow from said billet through the extruded portion and then laterally from all sides of said extruded portion at said part next adjacent its abutted end to fully form said end flange while confining against such lateral flow the remainder of said extruded portion.

4. The method of forging a steel valve body having end connection flanges which comprises; compressing in a direction parallel to its fiber lines a rolled or worked steel billet at forging temperature and of a volume slightly greater than that of the valve body forging desired, to force one end of said billet into a die chamber of the form of the valve chamber portion of the valve body; continuing said compression and forcing a hollow in the other end of the resulting partly shaped billet while confining the partly shaped billet against lateral expansion except at the locations where inlet and outlet ports are desired on the valve chamber portion of the valve body, to cause the partly shaped billet to bulge at said locations and metal from the in-

terior of the partly shaped billet to extrude at said locations and to flow laterally with respect to the fiber lines in the steel of the partly shaped billet thereby forming extruded portions; continuing said compression and abutting the outer ends of the extruded portions against surfaces respectively forming one wall of die cavities corresponding to the size, shape and location of the end flanges for the inlet and outlet ports; and further continuing said compression to cause metal from the interior of the billet portion within said die chamber to flow outwardly therefrom through said extruded portions and thence laterally at the abutted ends of the extruded portions to fully fill said flange die cavities.

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