United States Patent

Martin

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[54] HEAVY PRESS FORGING APPARATUS AND METHOD

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[73] Assignee: **United States Steel Corporation**

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[21] Appl. No.: **880,628**

[52] **U.S. Cl.** **72/377,** 72/448, 72/470

[51] **Int. Cl.** **B21j 9/02**

[58] **Field of Search** 72/448, 377, 376, 306, 412, 72/418, 453, 470; 29/159.2

[56] **References Cited**

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Assistant Examiner—Gene P. Crosby
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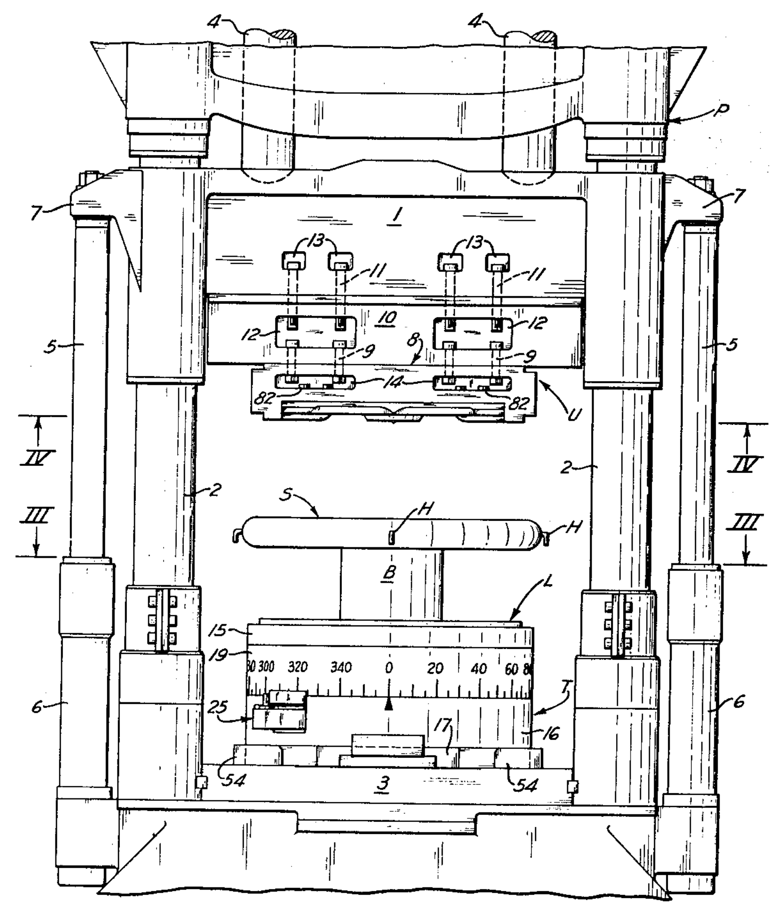
[57] **ABSTRACT**

A heavy press forging apparatus and method according to which a contoured lower die in a fixed vertical position is rotated in a horizontal plane relative to a contoured upper die, which is vertically reciprocated to forge a heated blank on the lower die, the contours of the upper and lower dies being formed to the desired shape of opposite sides of a forging. The upper die has a smaller working surface compared to that of the lower die, and the rotating movement of the lower die between vertical forging strokes renders the upper die effective to forge a heated bloom over the entire surface of the lower die.

21 Claims, 15 Drawing Figures



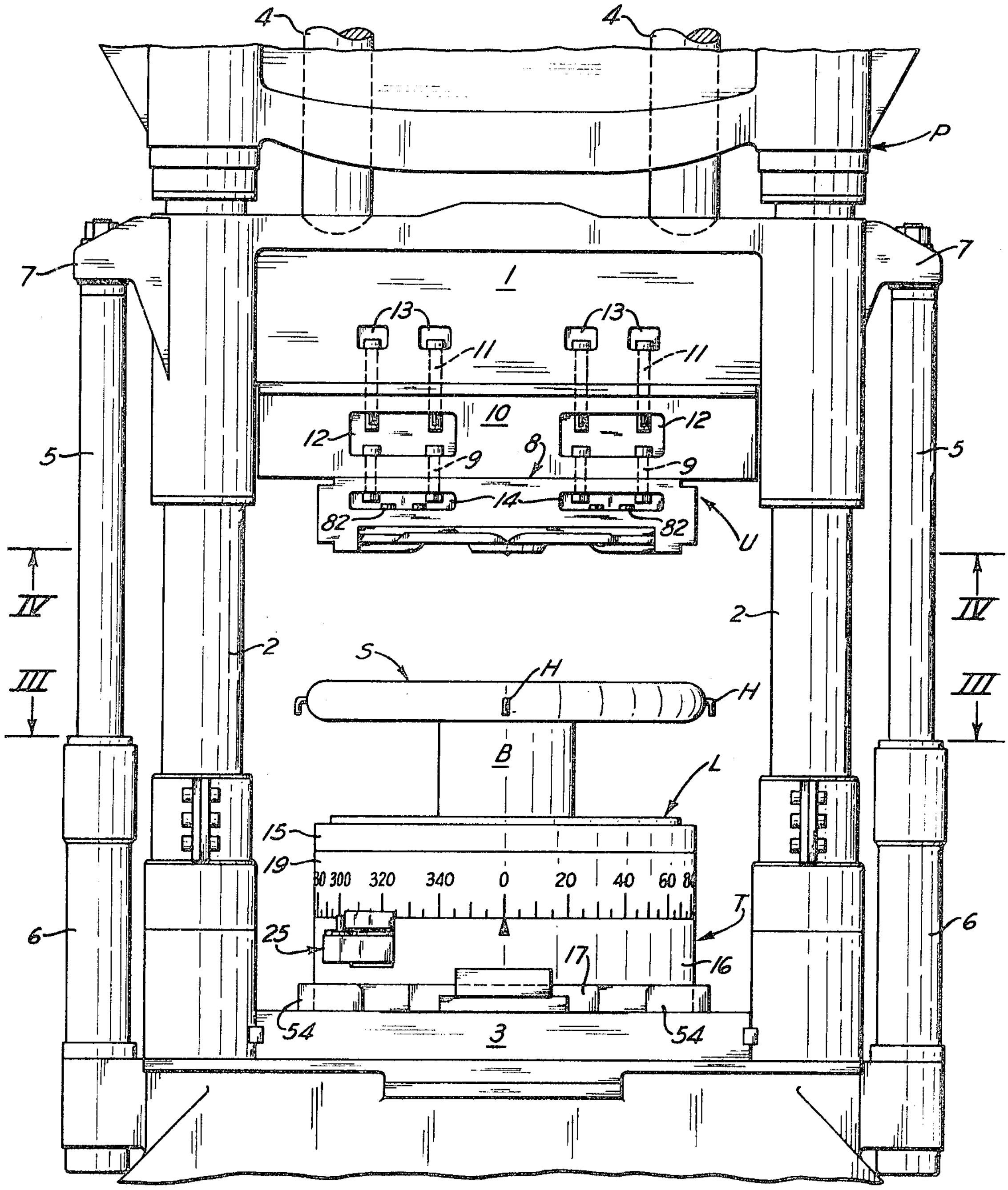


Fig.1

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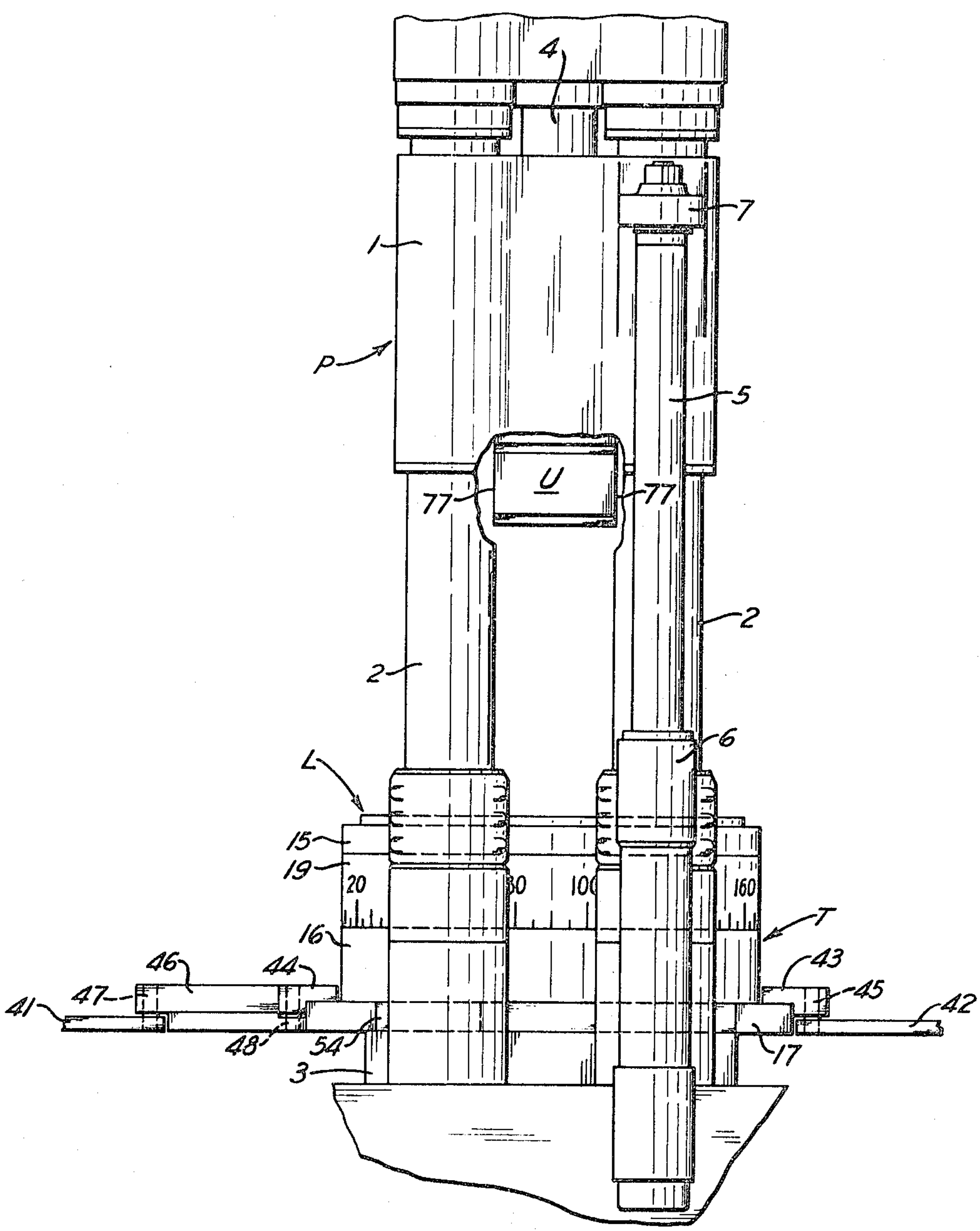

Fig. 2

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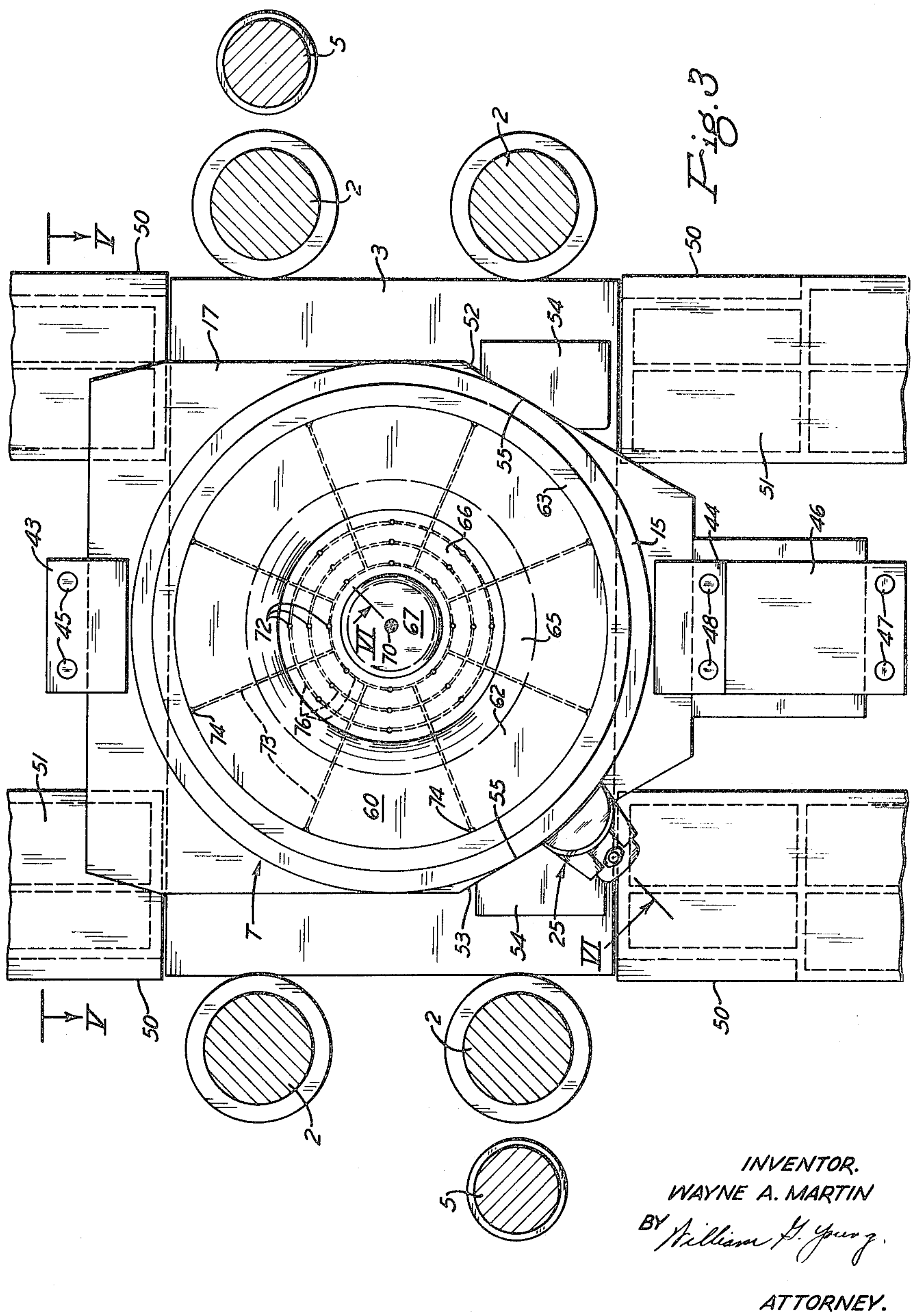

Fig. 3

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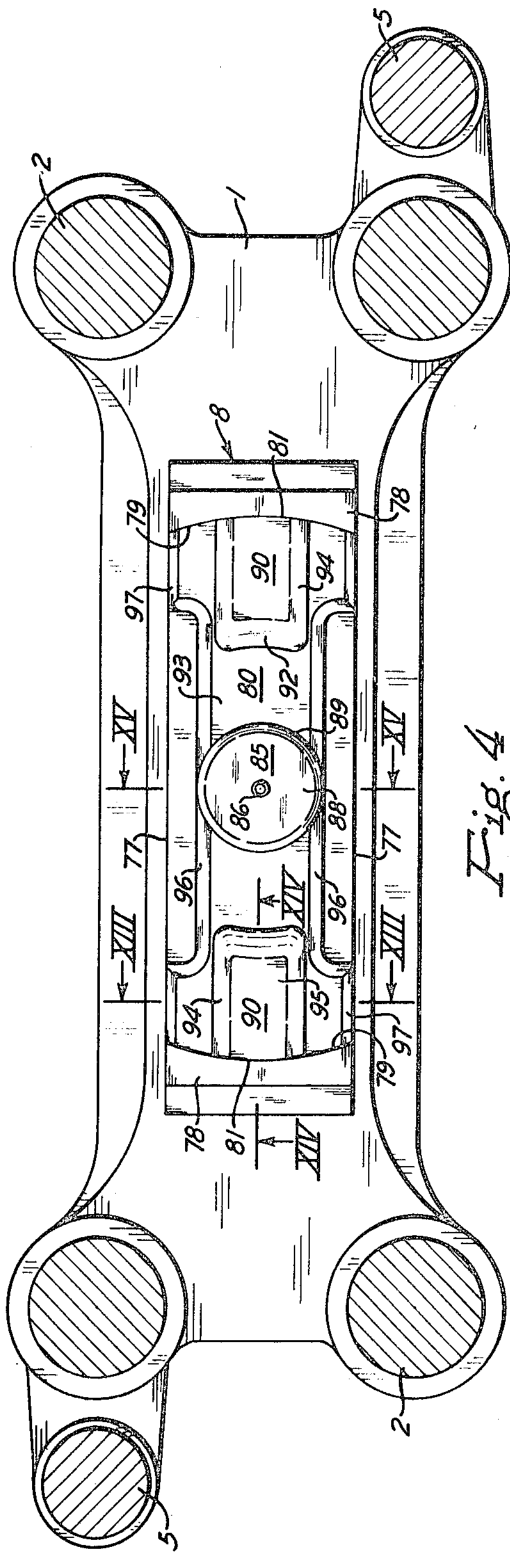

Fig. 4

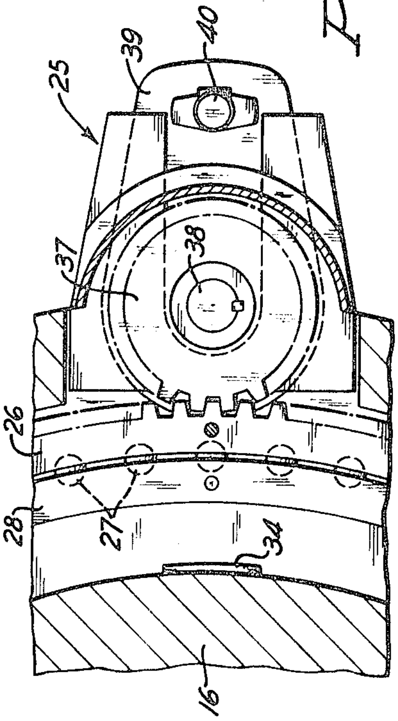

Fig. 7

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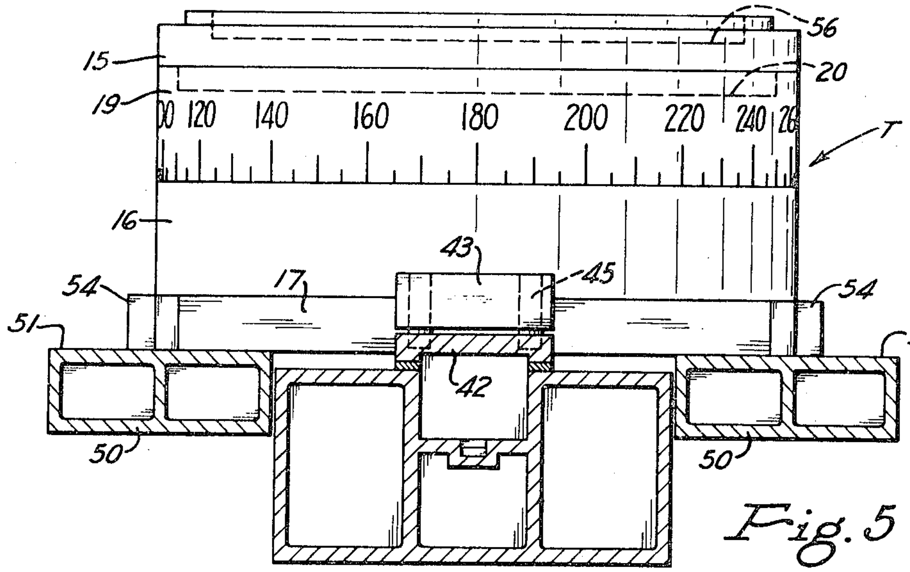

Fig. 5

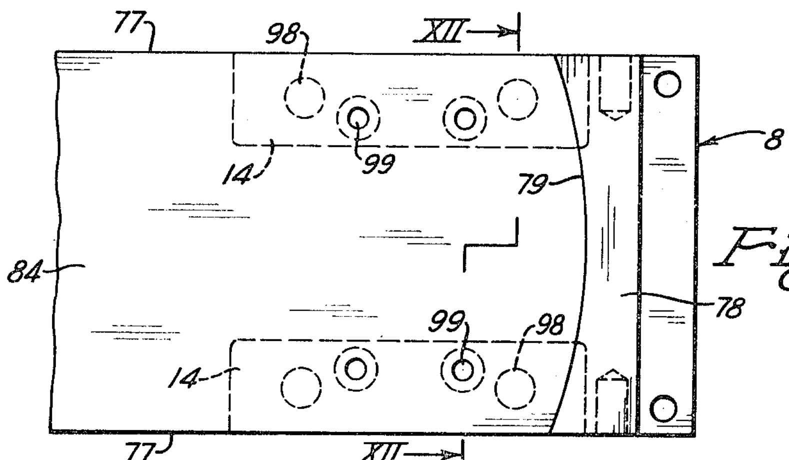

Fig. 10

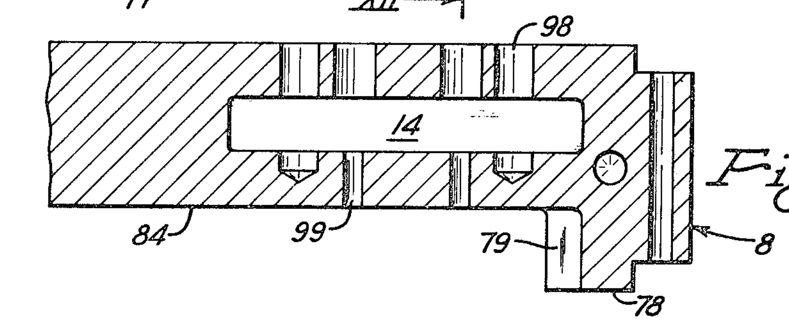

Fig. 11

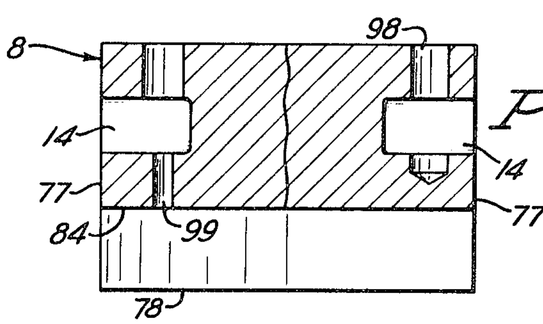

Fig. 12

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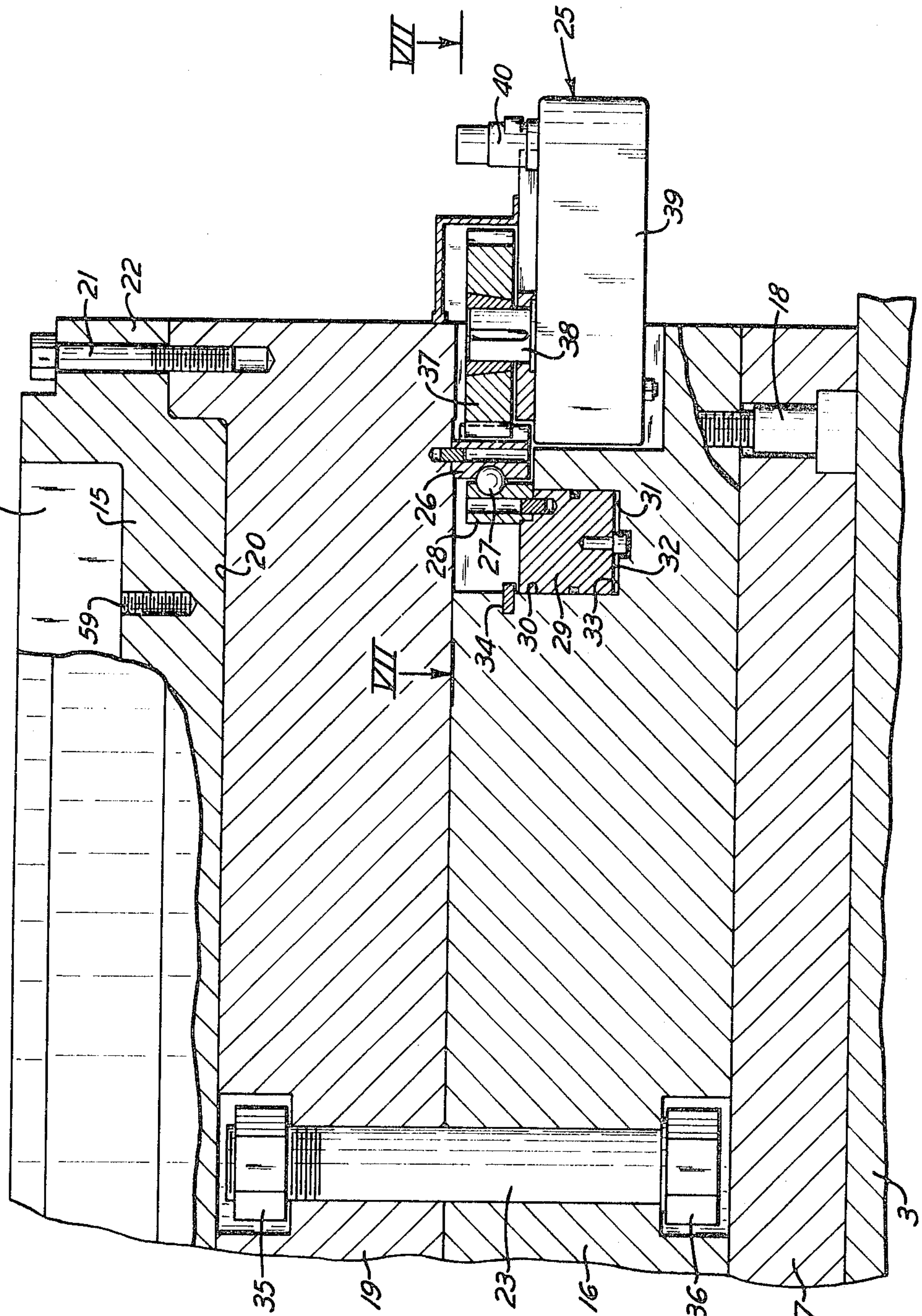

Fig. 6

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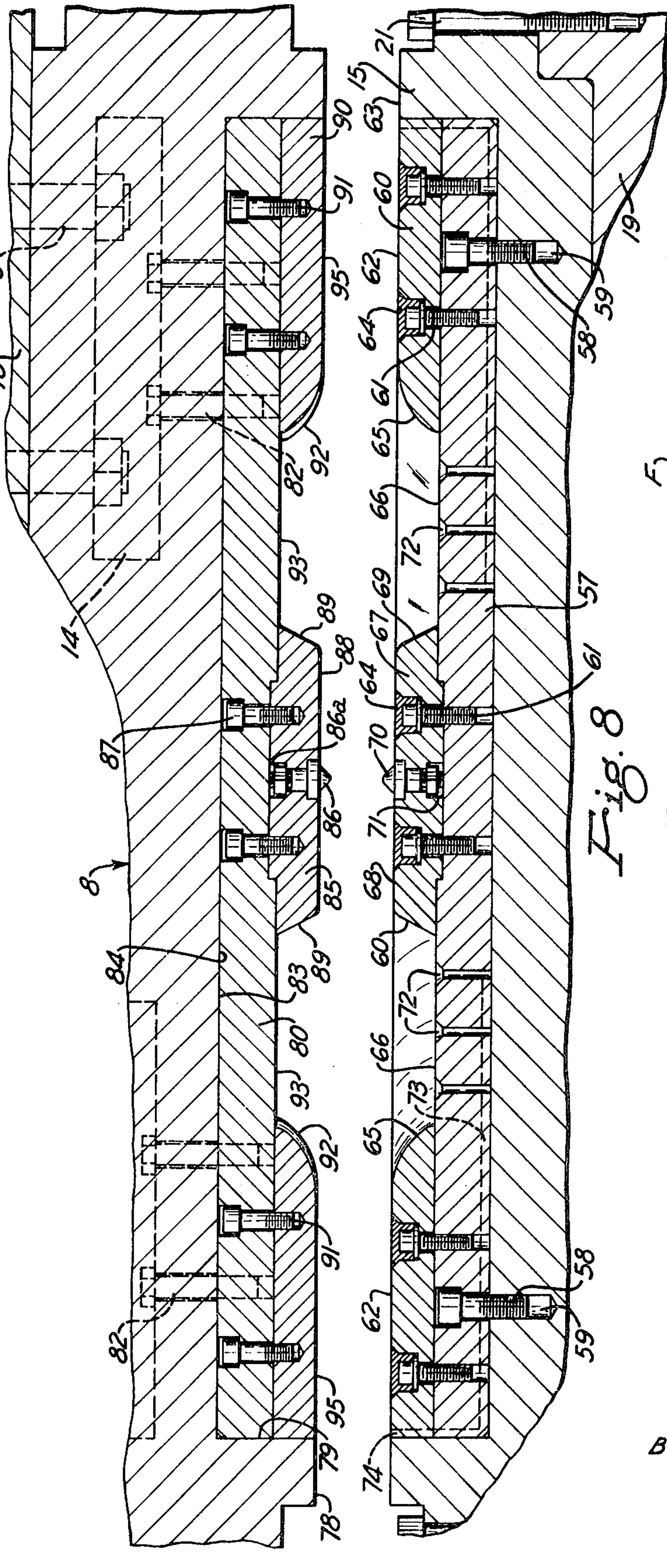

Fig. 8

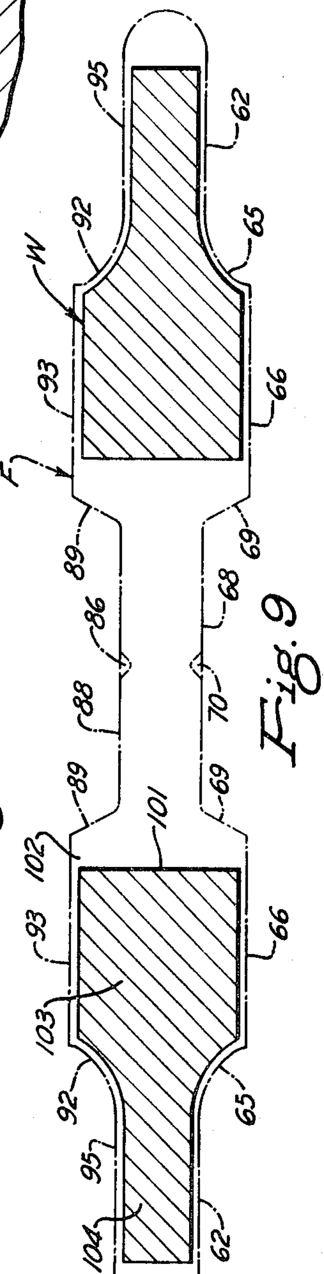

Fig. 9

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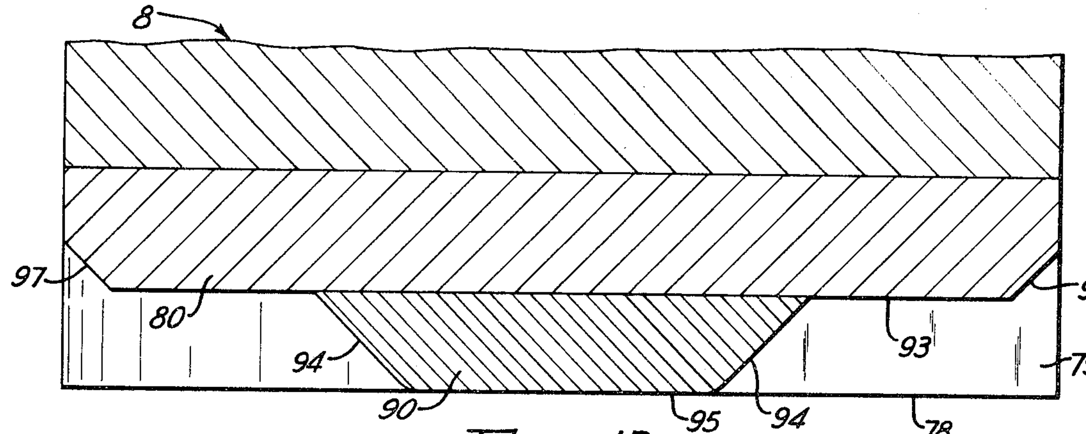

Fig. 13

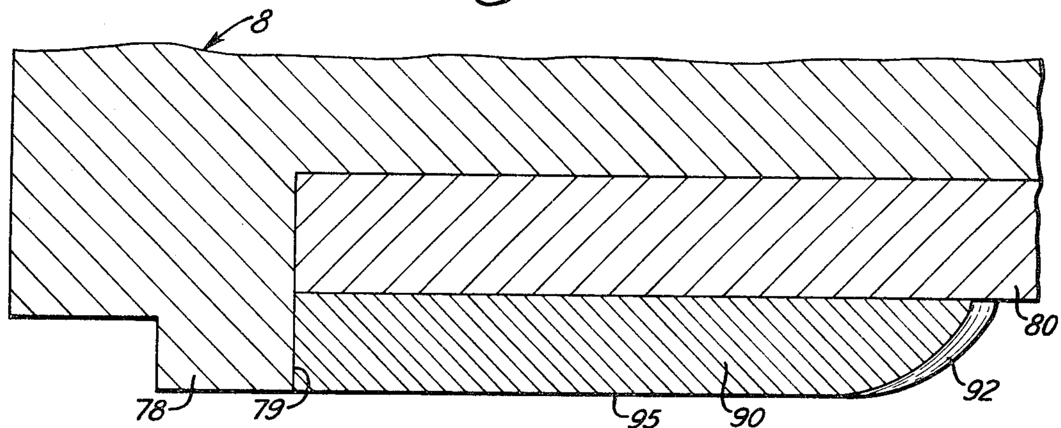

Fig. 14

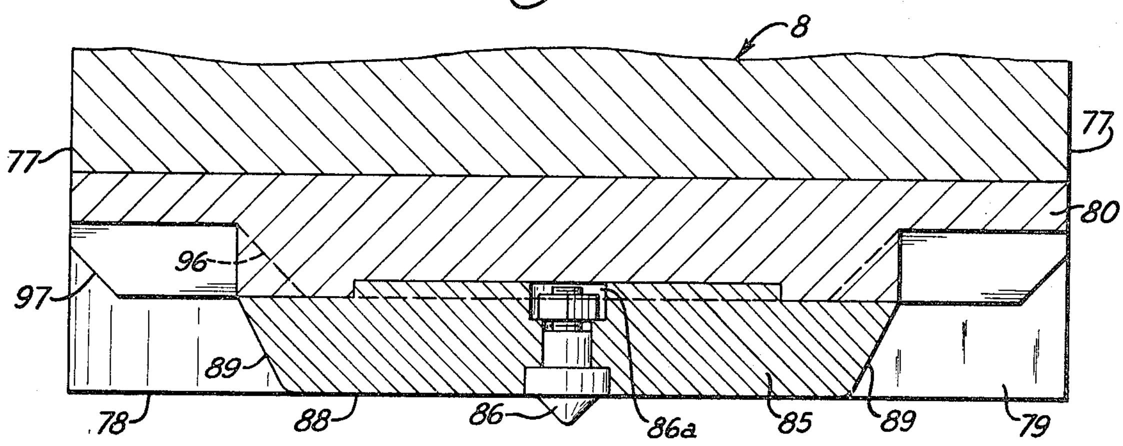

Fig. 15

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HEAVY PRESS FORGING APPARATUS AND METHOD

This invention relates, as indicated, to a heavy press forge, and, more particularly, to an improved method and apparatus for producing forgings, such as wheels, circular forgings, or forgings of other configurations, which have opposite sides thereof shaped to desired contour. In a manner to be described, the improvements of this invention utilize open die procedures for producing forgings having the quality and characteristics of those produced by closed die procedures, and enable their production on presses which are significantly smaller than those previously considered necessary.

For purposes of definition, the term "heavy press" as used herein is intended to mean hydraulic forging presses having a capacity in excess of 2,000 tons and, more specifically, those having capacities in the range of 5,000 to 12,000 tons. Such presses are commonly used with flat, swage or vee dies to forge large ingots into cylindrical forms such as blooms, turbine and generator shafts, rolls, and the like. They are also used with closed dies to forge wrought steel railway wheel blanks, and in such case the upper and lower dies are shaped to the contour of opposite sides of the wheel. Generally stated, wheel forgings having diameters of from 26 to 46 inches are forged from rolled blooms of 15 to 18 inches in diameter, and require 5,000- to 12,000-ton presses to operate the closed dies in which they are forged.

One of the principal objects of this invention is to produce circular forgings, or forgings of other shapes, of much larger sizes on smaller presses than those previously considered necessary. A further and related object of the invention is to produce such larger forgings with close dimensional tolerances that according to previous forging practices required closed die procedures.

This invention, more specifically, is especially adapted for producing high-temperature turbine bucket wheel forgings that having a diameter and a weight much larger than railway wheels of the size mentioned above, and to forge them on presses of the same capacity, namely 5,000 to 12,000 tons. The use of closed dies for producing bucket wheels having a diameter of 2–3 times the diameter of a 46 inch railway wheel that can be forged in closed dies on a press of 12,000 tons capacity would require a press having a capacity many times greater. By the same token, the forging apparatus and procedures of this invention will enable the production of railway wheels of the size mentioned above on heavy presses having capacities smaller than those previously considered necessary.

Although this invention is especially suited to the forging of circular shapes, such as turbine bucket wheels, and the following description specifically describes the invention for this purpose, it will be understood that the principles of this invention are applicable to forgings that have other shapes, and that the production of such other shapes are contemplated.

Other objects and advantages of the invention will become apparent from the following description.

In the drawings, there is shown a preferred embodiment of the invention. In this showing:

FIG. 1 is a front elevational view which shows the upper and lower forging dies of this invention in their operative positions on a heavy hydraulic forging press;

FIG. 2 is a side elevational view taken in a direction looking from the right of FIG. 1;

FIGS. 3 and 4 are enlarged views taken substantially along the lines III—III and IV—IV of FIG. 1;

FIG. 5 is an elevational view of the indexing table support for the lower die which is taken looking in the direction of the line V—V of FIG. 3;

FIG. 6 is a fragmentary sectional view, drawn to an enlarged scale, which is taken substantially along the line VI—VI of FIG. 3;

FIG. 7 is a fragmentary plan view of the indexing table drive which is taken substantially along the line VII—VII of FIG. 6;

FIG. 8 is an enlarged vertical sectional view showing in detail the construction of the upper and lower dies, the section being taken in a vertical plane containing the longitudinal centerline of the upper die and a diameter of the lower die;

FIG. 9 is a view showing schematically by broken lines in side elevation the contour of a circular forging that is produced by the apparatus shown in the preceding figures, this view further showing in section along a diameter the shape of a bucket wheel which is machined from such forging;

FIG. 10 is a plan view looking upwardly in the direction of the line IV—IV in FIG. 1 of one end of the upper dieholder;

FIG. 11 is a sectional view taken longitudinally of the holder shown in FIG. 10 (along the line XI—XI of FIG. 10);

FIG. 12 is a sectional view taken along the line XII—XII of FIG. 10; and

FIGS. 13–15 are fragmentary sectional views drawn to an enlarged scale and taken respectively along the lines XIII—XIII, XIV—XIV and XV—XV of FIG. 4, which show in detail the shape and contour of the die elements or inserts that are mounted on the upper dieholder shown in FIGS. 10–12.

By way of example, the shape of a circular forging F, which may be produced by the apparatus of this invention, is shown in FIG. 9, and from which a bucket wheel W for a turbine to be powered by a nuclear reactor may be machined. In a manner to be described, the forging F has the shape and characteristics of a closed die forging, but is produced by open die forging procedures in accordance with the principles of this invention. The forging apparatus and procedures of this invention, moreover, enable the production of the forging F on a heavy press of much lower capacity than would be required to produce the forging F by closed die procedures.

Generally stated, the apparatus of this invention, as shown in the drawings, comprises a heavy hydraulic press P for moving an upper die assembly U with respect to a lower die assembly L to produce the forging F from a forged cylindrical bloom B that is supported on the lower assembly L. The lower die assembly L is mounted on and forms a part of an indexing table T which is operated to rotate the assembly L to different angular positions that render the upper die assembly U effective to forge the blank B over the entire die surface of the lower assembly L and to thereby produce a circular forging F. The construction of the press P is conventional and has therefore been shown only fragmentarily and somewhat diagrammatically in the drawings. When operated with the dies U and L of this invention in a manner to be described, a press P having a capacity of 10,000 tons can be used to produce a wheel forging F having an outer diameter of approximately 104 inches and a weight of approximately 18,000 pounds. From this, it will be apparent that the forging F is several times larger than the maximum size of a 46 inches diameter railway wheel that can be produced by closed die procedures on a heavy press of this size.

The press P comprises a crosshead 1 that is mounted for guided vertical movement on columns 2, which are arranged in laterally spaced pairs at opposite sides of a bolster 3 that forms part of the forge and covers the area between the columns 2 and under the crosshead 1. Downward movement of the crosshead 1 to perform a forging operation is effected by a pair of piston rods or plungers 4 which are actuated hydraulically by the usual fluid pressure cylinders or accumulators (not shown) customarily provided for this purpose in heavy presses. After downward movement by the piston rods 4 to perform a forging operation, return movement of this crosshead 1 is effected by piston rods 5 which project upwardly from fluid pressure cylinders 6 at opposite sides of the press and have their upper ends connected at 7 with the crosshead 1. The structure of the press P and its operation to perform a forging operation as described above are conventional.

In accordance with the principles of this invention, the upper die assembly U is secured in a fixed position to the crosshead 1 for vertical movement therewith, and the lower die assembly L is supported by the table T on the bolster 3 in a vertically fixed and centered position under the assembly U. For this purpose, the assembly U comprises a forged dieholder

8 that is secured by bolts 9 to the bottom of a false plate 10, which in turn is secured by keybolts 11 to the crosshead 1. Openings 12 in the false plate 10 and openings 13 in the crosshead 1 provide access to the ends of the bolts 11 for attachment of the false plate 10 to the crosshead 1. The openings 12 in the crosshead further cooperate with openings 14 in opposite sides of the dieholder 8 to provide access to the bolts 9 for attachment of the holder 8 to the false plate 10. The crosshead 1, false plate 10 and dieholder 8 have a symmetrical construction about their respective longitudinal centerlines, which are located in a common vertical plane that extends centrally of the space between the columns 2 at opposite sides of the press. The lower die assembly L comprises a forged dieholder 15, which has a circular shape as shown in FIG. 3 and is supported by the table T on the bolster 3. In the operative forging position of the table T shown in the drawings, the center axis of the dieholder 15, and of the table T, extends vertically and intersects with the longitudinal centerline of the upper die assembly U at a point centrally between opposite ends of the dieholder 8.

The table T comprises a stationary supporting member 16 in the form of a cylinder which is a forging and is mounted on a flat baseplate 17, the member 16 and plate 17 being secured together by bolts 18 (FIG. 6) at angularly spaced intervals around the circumference of the member 16. A rotatable supporting member 19, which is also in the form of a forged cylinder, is stacked in a concentric position on the member 16, and has an upwardly facing cup-shaped or cylindrical recess 20 in which the dieholder 15 is received as shown in FIGS. 5, 6 and 8 of the drawings, the dieholder 15 being secured to the member 19 by bolts 21 at circumferentially spaced intervals about its peripheral flange 22. In operation, the forces generated by a forging operation are transmitted from the dieholder 15 through the members 19 and 16 to the baseplate 17 and thence to the bolster 3 where they are absorbed in the foundation for the press P. The cylindrical members 16 and 19 are secured in a centered position relative to each other by an axially extending bolt 23 that provides for limited axial movement of the rotatable member 19 relative to the stationary supporting member 16, so that the member 19 may be elevated and rotated about the bolts 23 in a manner to be described.

An indexing drive for rotating the supporting member 19 and dieholder 15 on the stationary supporting member 16 is designated as a whole in the drawings by the numeral 25. As best shown in FIGS. 6 and 7, the indexing drive 25 comprises a ring gear 26 which is secured to the member 19 and forms the outer race of a ball bearing assembly that includes ball bearings 27 and an inner race 28. The inner race 28 is mounted on the upper end of an annular piston 29 that is supported for vertical movement in an annular groove 30 machined in the stationary member 16. The bearing parts 26–28 and the annular fluid pressure motor parts 29–30 are of course concentric about the axis of the table T to provide for rotation of the member 19 about such axis and the bolt 23. Upon admission of hydraulic fluid through a suitable control valve (not shown) to the space 31 between the lower end 32 of the piston 29 and the bottom 33 of the groove 30, the piston 29 will move upwardly, and the bearing parts 26–28 will operate to elevate the member 19 with respect to the stationary member 16. A stop 34 limits the upward movement of the piston 29 and thereby the elevation of the rotatable member 19. This elevation of the member 19 need be only a very small amount which is sufficient to move it out of frictional engagement with the stationary member 16 to facilitate its being rotated by the ring gear 26. The nut 35 on the upper end of the bolt 23 is axially spaced with respect to the head 36 at the lower end of the bolt 23 so that the nut 35 will not interfere with elevation of the member 19. After elevation of the member 19, a drive gear 37, which has meshing engagement with the ring gear 26, is operated to change the angular position of the member 19 on the underlying member 16. The gear 37 is keyed on a drive shaft 38 which is rotated by a fluid pressure motor 40 through speed reduction gearing (not shown) in a housing 39. Operation of the motor 40 is controlled by suitable indexing controls which can be set to control the movement of the member 19 and dieholder 15 to any desired angular position. Indexing drives for controlling the angular indexing movement of rotary tables are known, and it will be understood, accordingly, that the specific construction of the drive comprising the parts 26–40 forms no part per se of this invention, and that other known indexing drives may be used for this purpose, as explained in U.S. Pat. No. 3,241,351 to L. A. Hautau et al.

In its operative forgoing position, the table T is supported on the press bolster 3, with its axis centered under the crosshead 1 and upper dieholder U as best shown in FIGS. 1–3. Movement of the table T to and from this position is effected by drawbars 41 and 42, which are customarily provided in heavy presses, such as the press P, and are actuated by hydraulic motors (not shown) in push-pull relation for moving anvils to operative forging positions on the bolster 3. For movement of the table T in this manner, opposite ends of the baseplate 16 have connectors 43 and 44 welded thereto. The connector 43 is coupled to the drawbar 42 by a pair of connector pins 45, and the connector 44 is coupled to the drawbar 41 through an intermediate connector 46 which has pairs of coupling pins 47 and 48 at opposite ends thereof which respectively form operating connections between the connector 44 and drawbar 41. As best shown in FIGS. 3 and 5, a supporting framework 50 at each of the four corners of the press, which is a part of the floor structure or foundation of the forge shop, provides skid surfaces 51 over which the baseplate 16 may slide to positions at either of opposite sides of the bolster 3. This is necessary in order that the table T may be removed and replaced on the skid surfaces 51 by the mill crane. At one end, the sides 52 and 53 of the baseplate 16 converge in a direction toward the connector 44. As the table T is moved onto bolster 3, the converging sides 52 and 53 of the baseplate 16 engage with a pair of stops 54 that are secured in laterally spaced positions on the upper surface of the bolster 3. The stops 54 have surfaces 55 which engage the sides 52 and 53 of the baseplate 16 and thus operate to both stop the movement of the table T and center its position under the upper die assembly U. After movement to its operative position in this manner, jack-stands (not shown) are applied against opposite sides of the baseplate 16 to hold the table T against movement on the bolster 3 during a forging operation.

The lower die assembly L comprises the circular dieholder 15 which is bolted to the rotatable supporting member 19 of the table T as described above. The dieholder 15 is cup-shaped to provide an upwardly facing circular recess 56 in the bottom of which a circular backing plate 57 is received as best shown in FIG. 8. The plate 57 is secured to the holder 15 by bolts 58 which have threaded engagement in threaded openings 59 at angularly spaced intervals about the holder 15. An annular die 60, which is secured to the plate 57 by bolts 61, has an upper surface 62 that is flush with the upper end 63 of the dieholder 15. Metal caps 64 cover the upper ends of the bolts 61 to prevent the metal of a forging from working into the openings in which the bolts 61 are received. The upper ends of the caps 64 cooperate with the upper end of the die 60 to provide a smooth and continuous die surface 62. The inner peripheral edge 65 of the die 60 is curved so that it tapers into the upper surface 66 of the backing plate 57, which further has a circular die 67 mounted thereon in a centered and concentric position with respect to the annular die 60. The circular die 67 is secured to the backing plate 57 by bolts 61 which have caps 64 over their upper ends such as those employed to secure the annular die 60 to the plate 57. The circular die 67 and bolt caps 64 provide a circular die surface 68 at the upper end of the die 67. The peripheral edge 69 of the die 67 is tapered and coverages into the die surface 66 on the backing plate 57. A center punch 70 projects upwardly from the die surface 68 and is secured in an opening 71 formed in the circular die 67.

Openings **72** are drilled through the backing plate **57** for the escape of gas that may be trapped into the space between the dies **67** and **60** during the forging operation. The lower ends of the vents **72** are connected by radially extending grooves **73** with axially extending grooves **74** in the outer edges of the backing plate **57** and annular die **60** to vent gas from the openings **72** to the atmosphere. The vent openings **72** are further connected with each other by circumferentially extending grooves **76** as best shown in FIG. **3** of the drawings.

The upper die assembly U comprises the dieholder **8** which is secured to the crosshead **1** of the press P by the false plate **10** as described above. The end portions of the holder **8** extending outwardly from its transverse centerline are identical, one of such end portions being shown in FIGS. **8–10** to illustrate the specific construction of the holder **8**. As shown in these figures and in FIG. **4**, a dieholder **8** has a rectangular shape, opposite sides **77** of which are parallel and spaced outwardly equal distances with respect to its longitudinal centerline. Opposite ends of the dieholder **8** have downwardly extending rims **78**, the facing surfaces **79** of which have a curvature about the center of the dieholder **8** as a radius, which is the same as the outer radius of the annular die **60**. As best shown in FIGS. **4** and **8**, a backing plate **80**, which has curved ends **81** corresponding to the curvature of the surfaces **79**, is secured to the holder **8** by bolts **82** with its inner surface **83** abutting against the bottom surface **84** of the dieholder **8**. A circular center-die **85** and a center punch **86** mounted in an opening **86*a***, which are identical to and concentrically arranged with respect to the center-die **67** and center punch **70** of the lower die, are secured to the backing plate **80** by bolts **87**. The center-die **85** provides flat circular die surface **88** and tapered side surfaces **89** which are similar to the die surfaces **68** and **69** on the center-die **67** of the lower die assembly. At opposite ends of the dieholder **8**, dies **90**, which preferably have a shape as shown in FIG. **4**, are secured to the backing plate **80** by bolts **91**. Adjacent ends **92** of the dies **90** are curved as shown in FIG. **14** and taper into the flat surface **93** of the backing plate **80**. Each of the dies **90** has its opposite sides **94** tapered between the flat surface **93** and the surface **95**, which faces downwardly opposite the corresponding and upwardly facing surface **62** of the lower die assembly. The die surfaces **95** are flush with the lower ends of the rims **78** at the ends of the holder **8**. The backing plate **80**, as shown in FIG. **4**, has a portion removed by flame-cutting along opposite edges to provide a center portion of reduced dimension between opposite sides **96**, which are tapered between the backing plate surface **93** and the surface **84** of the dieholder **8**, the tapered edges **96** extending substantially tangentially with respect to opposite sides of the circular center-die **85**. Opposite edges **97** of the backing plate **80** adjacent their curved ends **81** are tapered in a manner similar to the edges **96**.

FIGS. **8–10** show the arrangement of the bolt access openings **14** in opposite sides of the dieholder **8**. These figures also show the location of the openings **98** for the bolts **9** which secure the holder **8** to the false plate **10**, and of the openings **99** for the bolts **82** which secure the backing plate **80** to the holder **8**.

As viewed in FIG. **8**, it will be noted that the dimension of the upper die assembly U between the curved surfaces **79** of the holder **8** is the same as the outer diameter of the annular die **60** and backing plate **57** of the lower die assembly L. The width of the upper die assembly U between its sides **77** as viewed in FIG. **2** is substantially less than the diameter of the die parts of the lower assembly L. From the above description, and the showing of FIG. **8** in particular, it will be apparent that the contours of the facing die surfaces on the assemblies U and L, in any vertical plane parallel to the centerline of the upper assembly U, are identical. By reason of this, and indexing rotation of the table T after each forging stroke of the upper assembly U by the press P, it will be further apparent that opposite faces of the resulting forging F will be identical. In this respect, and with reference to the diagrammatic showing of FIG. **9**, it will be noted that the finished forging F has a shape corresponding to that of the space between the facing die surfaces of the upper and lower die assemblies U and L as shown in FIG. **8**. In this showing, the surfaces of the forging F, which correspond to the die surfaces shown in FIG. **8**, are designated by corresponding numerals and broken lead lines.

In operation, the upper die assembly U is secured to the crosshead **1** of the press P as described above, and the table T with the lower die assembly L thereon is carried by the mill crane to a position at one side of the space between the posts **2** where it is lowered and supported on the skid surfaces **51** of the floor structure **50**. The drawbars **41** and **42** are then coupled to the connectors **43** and **44** as described above for movement of the table T to a position supported on the bolster **3** in which it is centered under the upper die assembly U. Before the table T is moved to an operative forging position in this manner, the cylindrical block or bloom B, which has been headed to forging temperature, is placed in a centered position on the lower die assembly L, and a circular stoving or upsetting plate S, in the form of a flattened steel disc is placed on the upper end of the bloom B. Steel hooks H extending outwardly from the periphery of the stoving plate S facilitate its handling by the mill crane. With the bloom B and stoving plate S in this position, the drawbars **41** and **42** are actuated to move the table T to a centered position under the upper die assembly U as shown in FIG. **1**. The press P is then operated to lower the crosshead **1** and move the assembly U into pressing engagement with the stoving plate S. The press P is then operated several times to flatten the bloom B on the die assembly L into a disc having an axial dimension, which is less than half that of its initial length, and is a few inches greater than the final hub thickness between the surfaces **93** and **66** of the forging F as shown in FIG. **9**. During initial forging of the bloom B by the stoving plate S in this manner, the surfaces **66**, **69**, **68** and **70** of the forging F will begin to take shape. When the metal of the bloom B bridges the space between the lower dies **67** and **60**, gas trapped in such space will be vented through the ports **72–74** to the atmosphere, and will thus be ineffective to interfere with shaping of the forging F by the die surfaces of the lower die assembly L. After the bloom B has been flattened to the desired extend, the drawbars **41** and **42** are operated to withdraw the table T from underneath the press crosshead **1** and die assembly U so that the stoving plate S may be removed by the mill crane. The table T is then returned to its centered and operative forging position on the bolster **3** so that the forging operation may be completed by the upper die assembly U.

When the table T is returned to its operative forging position on the bolster **3**, the press P is operated to move the assembly U into forging engagement with the partially forged blank B on the lower assembly L. Initial engagement of the assembly U with the flattened blank B will be effective only to forge a portion of the upper surface of the metal on the lower assembly L, since it will be recalled that the longitudinal centerline of the assembly U is positioned over a diameter of the assembly L, while opposite sides **77** of the assembly L are spaced apart a distance considerably less than the diameter of the lower die assembly L. By reason of this spacing of the sides **77**, the upper assembly U may be characterized as having the shape of a diametral segment in which the sides **77** extending between the curved surfaces **79** at opposite ends of the dieholder **8** are in effect chords positioned vertically with respect to chords of the lower circular die assembly L. After the initial forging stroke of the die assembly U to shape the forging, the indexing table T is rotated 90° for a second forging stroke of the assembly U, which will engage the centerline of the upper die surfaces with the forging along a line at right angles to its line of engagement therewith during the initial forging stroke. Following the second forging stroke, the table T is rotated 45° for a third stroke, after which the table T is rotated 90° for a fourth forging stroke. The relative angular positions of the table members **16** and **19** is shown by indicia about the side of the rotatable member **19**, which expedite rotation under manual control of the lower die assembly L to a desired position relative to the upper assembly U. This pattern of indexing the rotation of the table T for the first four strokes of the press is necessary to maintain the circular shape of the forging blank, after which the indexing rotation of the table T is reduced to about 15° between each forging operation of the press P to assure that the die surfaces of the upper assembly U overlap the area forged on the previous stroke of the press P. The tapered sides of the die parts, such as the surfaces **94, 96, 97** as described above, are effective to prevent the formation of folds on the surface of the forging as the result of indexing rotation of the table T to rotate the blank B to different angular positions relative to the upper die assembly U. The forging operation of the press P is continued until opposite surfaces of the forging F have the desired shape, as determined by the facing die surfaces of the upper and lower assemblies U and L as shown in FIGS. **8** and **9** of the drawings. After completion of the forging operation, the table T is removed from the bolster **3** and the forged wheel F is then removed therefrom and permitted to cool to a designated temperature, after which it is heat-treated and then machined to the finished size.

Attention is particularly directed to the fact that the facing center dies **67** and **85** reduce the amount of metal that must be removed to form the inner surface or bore **101** of the wheel W and, in addition, provide an improved forging action on the metal at the corners **102** of the hub of the wheel. It will also be noted that the centering points **70** and **86** facilitate centering the forging F on the flame cutting machine for removal of this metal and subsequent formation of the surface **101** on a boring mill. The remaining die surfaces **66–93, 65–92,** and **62–95,** together with the provision of the rotating indexing table T for rotating the lower die assembly L enable the production of a finished forging F which requires a minimum amount of machining to produce the hub **103** and the flange or web **104** of the wheel W.

From the foregoing it will be apparent that the forging F, is produced by what is essentially an open die forging procedure, and that this is accomplished on a heavy press of considerably smaller size than would be required for a closed die operation. For example, a forging F having a size as indicated above can be produced according to the principles of this invention on a 10,000-ton press, and it is estimated that a 40- to 50,000-ton press would be required to produce the forging F if closed die procedures were employed.

Although the above furnishes a description of the invention for the production of a bucket wheel W of a specific size for high temperature turbines, it will be understood that the principles of the invention are applicable for the production of forgings F of different sizes and shapes, and that a linear movable support conceivably may be substituted for the rotatable support provided by the indexing table T in the forging of other shapes.

While one embodiment of my invention has been shown and described, it will be apparent that adaptations and modifications may be made without departing from the scope of the appended claims.

I claim:

1. In a heavy press forging method, the steps which comprise supporting a first die in an upwardly facing fixed vertical position, supporting a second die in downwardly facing fixed horizontal position, providing said dies with working surfaces respectively having substantially different sizes, reciprocating said second die over a vertical path to forge a blank on the said working surface of said first die, and rotating said first die horizontally between successive forging strokes of said second die to render said second die effective to forge said blank over the entire surface of said first die.

2. The method defined in claim **1** characterized by forming said first die with a circular working surface and mounting it for rotational movement about a vertical axis extending through the center of said circular working surface and through the center of the said working surface of said second die.

3. The method defined in claim **2** characterized by forming the said working surface of said second die in the shape of a diametral segment with its longitudinal centerline in a vertical plane containing a diameter of said circular working surface in all rotational positions of said first die.

4. A heavy press forge comprising, in combination, a hydraulic press having a vertically movable crosshead, an upper die secured to said crosshead for vertical movement therewith, a lower die supported in a vertically fixed position underneath said upper die, said dies having working surfaces respectively contoured to the shapes of opposite sides of the forging to be produced thereby, the said working surface of said lower die having an area larger than the area of the working surface of said upper die, and means for rotating said lower die horizontally to render said upper die effective to forge a blank over the entire area of the said working surface of said lower die.

5. A forge as defined in claim **4** characterized by the said working surface of said lower die being circular.

6. The forge defined in claim **5** characterized further by the said circular working surface of said lower die having a vertical axis, and by said upper die having the shape of a diametral segment with its longitudinal centerline intersecting said vertical axis and lying in a vertical plane containing a diameter of said lower die working surface.

7. The forge defined in claim **6** characterized further by said moving means comprising means for rotating said lower die about said vertical axis, said rotating means being operated between forging strokes of said hydraulic press crosshead.

8. In a forging apparatus, the combination with a heavy press of the type having a bottom bolster, a pair of laterally spaced guide columns extending upwardly at each of the opposite sides of said bolster, a crosshead mounted for vertical movement on said guide columns, and hydraulic means for moving said crosshead on said columns, of an upper die mounted in a fixed position on said crosshead for vertical movement therewith, said upper die being symmetrically positioned on said crosshead with its longitudinal centerline extending centrally between each of said pairs of columns, a lower die, said lower die having a working surface shaped to the contour of one side of the forging to be produced thereby, said upper die having a working surface the area of which is smaller than the area of the said working surface of said upper die, and means mounting said lower die on said bolster including means for rotating it horizontally relative to said upper die to render said upper die effective to work a forging over the entire working surface of said lower die.

9. In a forging apparatus, the combination with a heavy press of the type having a bottom bolster, a pair of laterally spaced guide columns extending upwardly at each of the opposite sides of said bolster, a crosshead mounted for vertical movement on said guide columns, and hydraulic means for moving said crosshead on said columns, of a rotary indexing table mounted under said crosshead with its axis extending vertically and centrally with respect thereto, said table comprising a base in a fixed position on said bolster under said crosshead, a dieholder supported on said base for rotational movement about said vertical axis, a circular lower die mounted on said dieholder in a concentric position with respect to said axis, and means for rotating said dieholder and said lower die about said axis, and an upper die mounted on said crosshead with its longitudinal centerline arranged vertically above and parallel to a diameter of said lower die, said rotating means being operated between forging operations of said upper die by said crosshead to rotate said lower die and render said upper die effective to work a forging over the entire surface of said lower die.

10. Forging apparatus as defined in claim **9** characterized by said table comprising a cylindrical supporting member mounted on said base in a concentric position with respect to said vertical table axis, means mounting said dieholder on said member, and means for elevating said member with respect to said base to render said rotating means effective to rotate said member and said dieholder about said vertical axis.

11. An apparatus as defined in claim 9 characterized by said upper die having the shape of a diametral segment with opposite sides thereof spaced outwardly from and parallel to its said centerline.

12. An apparatus as defined in claim 11 characterized by said upper and lower dies respectively including circular central die elements for forming circular recesses on opposite sides of and centrally of the hub of a wheel forged by said dies.

13. An apparatus as defined in claim 12 characterized further by each of said central die elements having a center punch projecting axially outwardly therefrom for forming center points in opposite sides the wheel forged thereby.

14. The apparatus defined in claim 12 characterized by said lower die having an annular die element mounted concentrically of its said central die element for shaping one side of the flange of said wheel.

15. The apparatus defined in claim 12 characterized by said upper die having a pair of die elements at opposite ends thereof and respectively spaced outwardly with respect to its said central die element, said pair of die elements being effective for shaping the other side of the flange of said wheel.

16. In a forging apparatus, the combination with a heavy press of the type having a bottom bolster, a pair of laterally spaced guide columns extending upwardly at each of the opposite sides of said bolster, a crosshead mounted for vertical movement on said guide columns, and hydraulic means for moving said crosshead on said columns, of a rotary indexing table comprising a baseplate, a supporting member secured to said baseplate, a dieholder supported on said supporting member for rotational movement about a vertical axis, a circular lower die mounted on said dieholder in a concentric position with respect to said axis, and means for rotating said dieholder and said lower die about said axis, an upper die mounted on said crosshead with its longitudinal centerline extending centrally of the space between each of said pairs of columns, said rotating means being operative to rotate said dieholder and lower die a predetermined angular distance between downward forging operations of said upper die by said crosshead, and means supporting said table for horizontal movement to an operative forging position on said bolster with said vertical axis centered under said longitudinal centerline.

17. Forging apparatus as defined in claim 16 characterized by said baseplate supporting means comprising horizontal skid surfaces over which said baseplate moves with a sliding action to said operative forging position on said baseplate.

18. Forging apparatus as defined in claim 17 characterized by the provision of means in the path of movement of said table over said skid surfaces for stopping it in said operative forging position.

19. Forging apparatus as defined in claim 18 characterized by said table stopping means comprising a pair of laterally spaced stops on said bolster, and by said baseplate having angularly converging sides for movement between and into engagement with said stops to stop the movement of said table and center it in said operative forging position.

20. In a forge of the character described, the combination with a heavy press having a vertically movable crosshead and a bottom bolster, and an upper die secured to said crosshead for vertical movement therewith, of a rotary indexing table mounted on said bolster in a centered position under said crosshead, a lower die mounted on said table for rotation thereby, and means for operating said table to rotate said lower die relative to said upper die.

21. In a forge of the character described, the combination with a heavy press having a vertically movable crosshead, of a rotary indexing table centered under said crosshead, upper and lower dies respectively mounted on said crosshead and indexing table, said upper die being secured in a fixed position on said crosshead for vertical movement therewith, said indexing table having an axis extending vertically and centrally with respect to said crosshead and the said upper die mounted thereon, and means for operating said indexing table to rotate said lower die relative to said upper die.

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