

May 10, 1938.

C. S. SWANSON
FORGING APPARATUS
Filed May 9, 1936

2,116,804

6 Sheets-Sheet 1

Fig. 1.

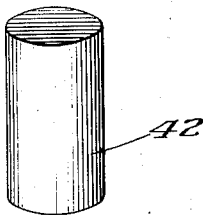


Fig. 2.

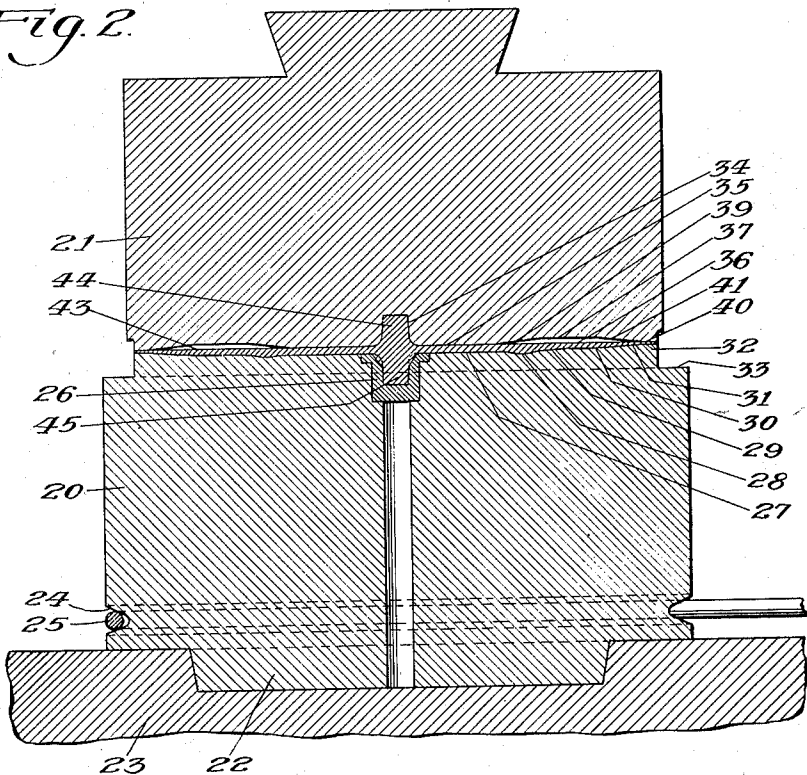
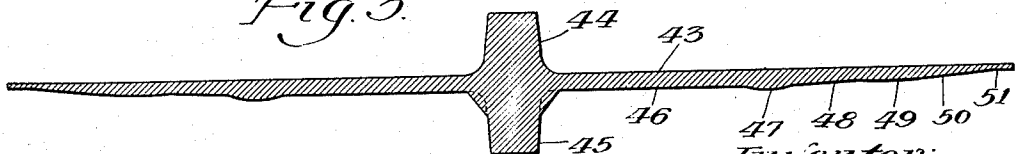


Fig. 3.



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6 Sheets-Sheet 2

Fig. 4.

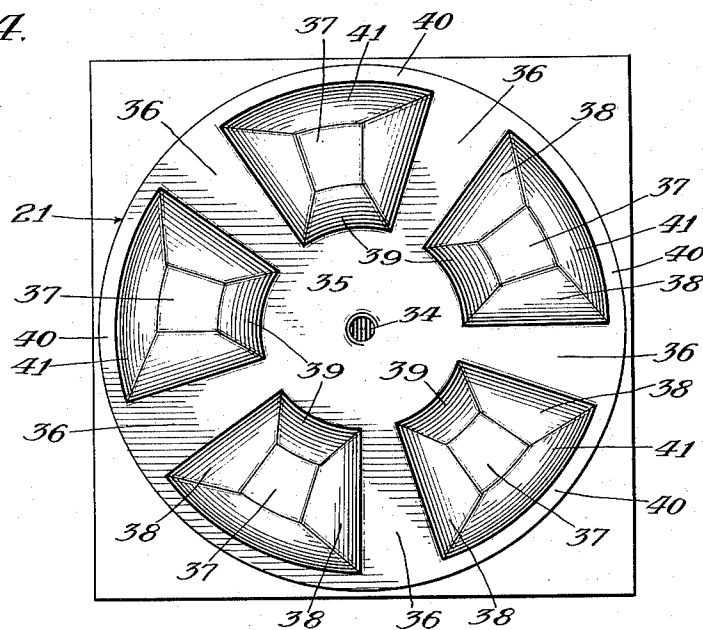
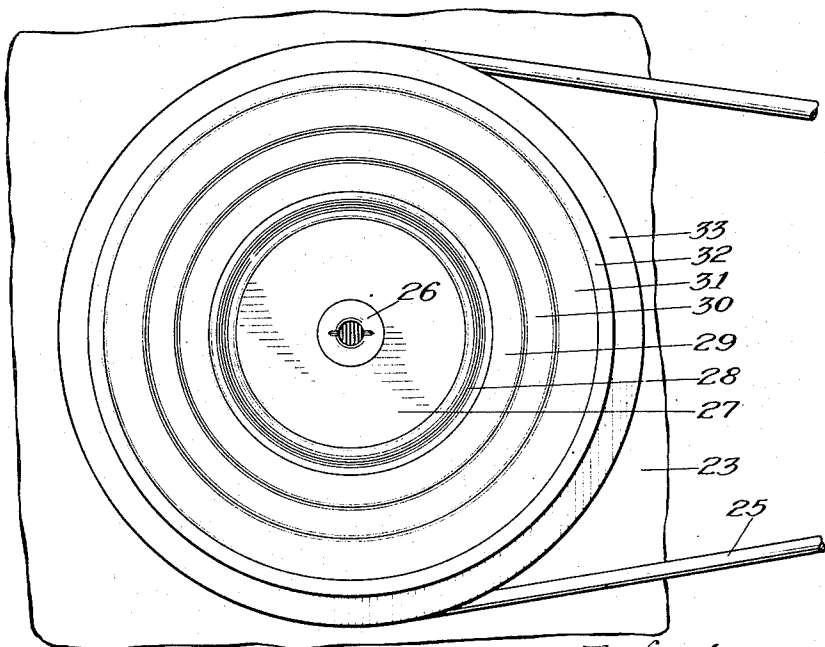


Fig. 5.



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6 Sheets-Sheet 3

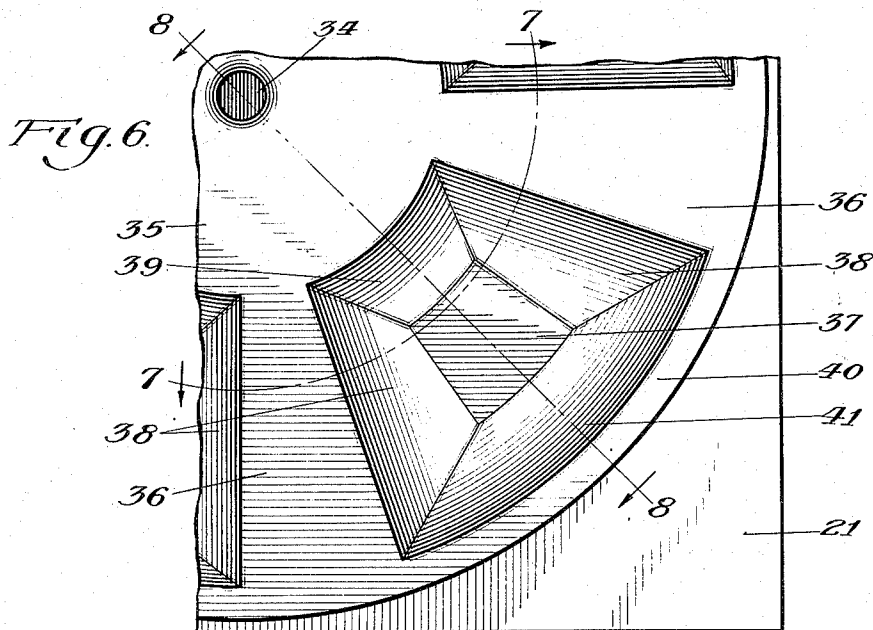


Fig. 7.

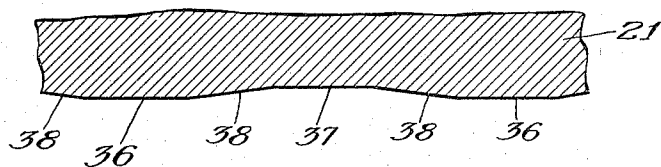
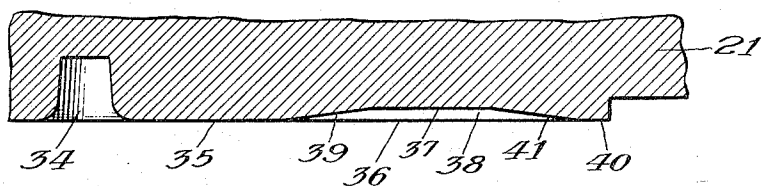


Fig. 8.



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6 Sheets-Sheet 4

Fig. 9.

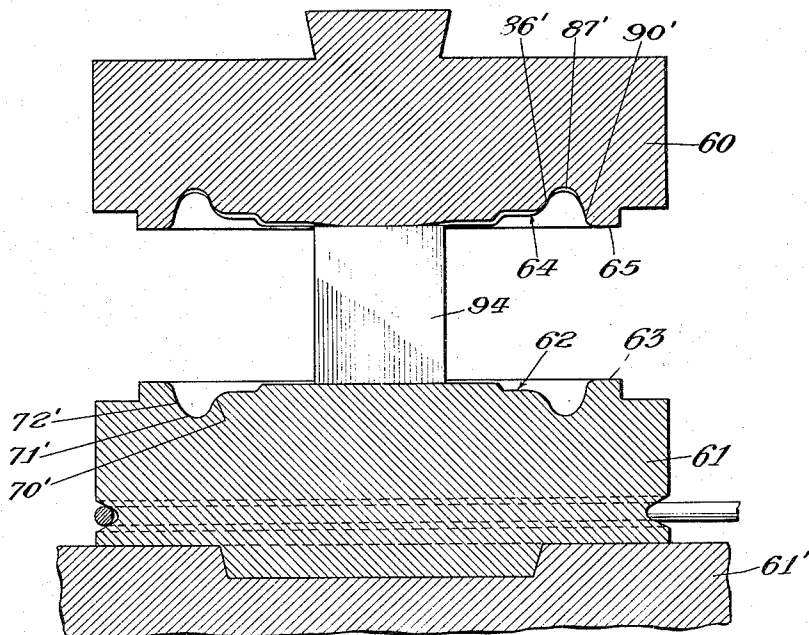
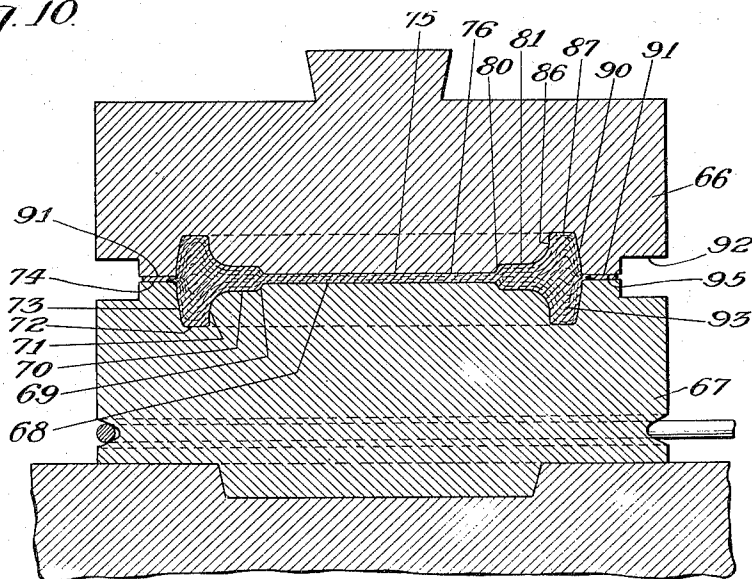


Fig. 10.



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6 Sheets-Sheet 5

Fig. 11.

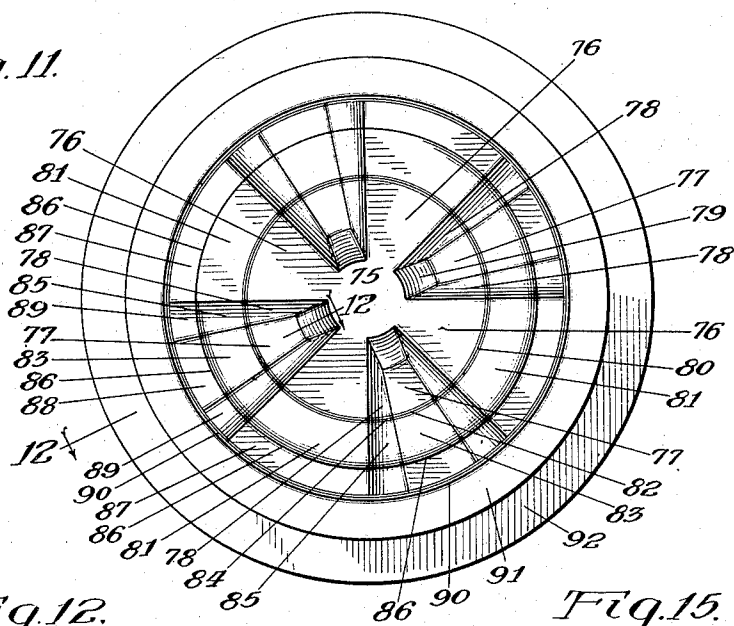


Fig. 12.

Fig. 15.

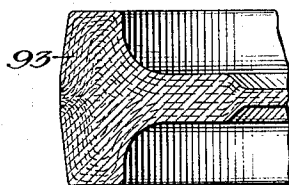
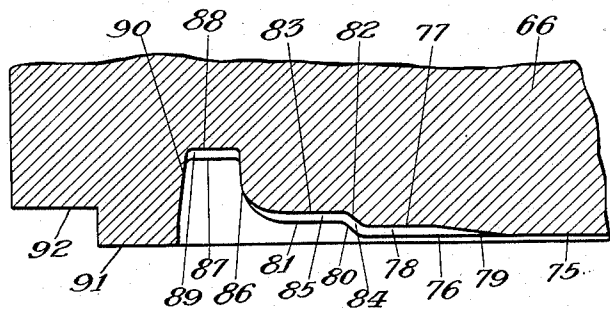
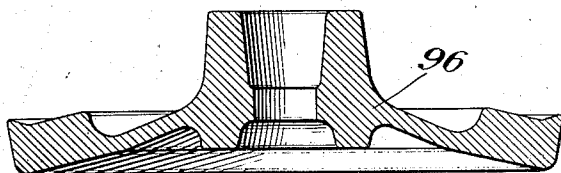


Fig. 16.



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6 Sheets-Sheet 6

Fig. 13.

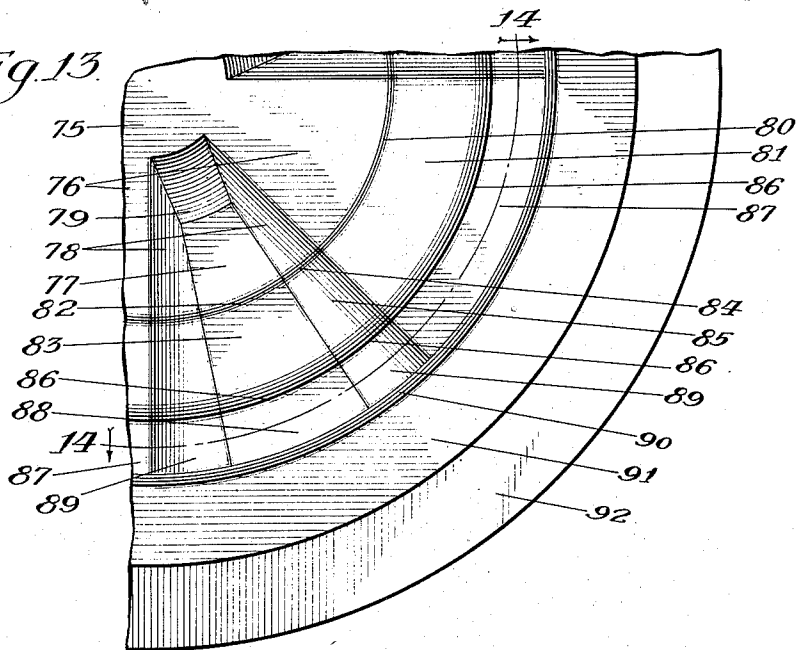


Fig. 14.

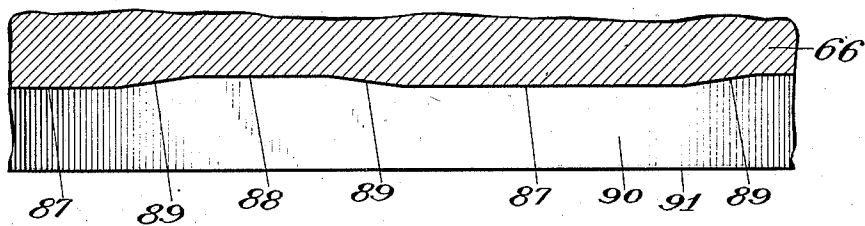
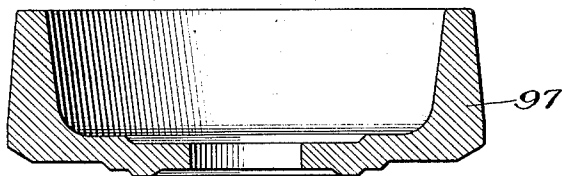


Fig. 17.



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UNITED STATES PATENT OFFICE

2,116,804

FORGING APPARATUS

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mesne assignments, to Standard Forgings Cor-
poration, Chicago, Ill., a corporation of Dela-
ware

Application May 9, 1936, Serial No. 78,859

11 Claims. (Cl. 78—80)

This invention relates to apparatus for forging steel discs, gears and the like, and to the method of producing forgings of the character described.

One of the objects of the invention is to produce forging apparatus comprising a lower die and an upper reciprocating die, one of which is rotatable about a vertical axis, for speedily and efficiently producing a relatively large, thin forging, such as a disc or gear, from a relatively narrow, thick billet of hard forging steel. Said means comprises a lower die having concentric surfaces adapted to support and shape the work, and a reciprocating upper die having a face as large as or slightly larger than the forging to be produced, provided with three or more segmental, spaced apart striking surfaces occupying approximately one-half of the face of the die. Said striking surfaces are preferably four or five in number, and merge with intermediate non-striking areas by gently inclined portions. The form, location and size of the striking surfaces and their relationship to the non-striking areas enable me to obtain great reduction in thickness of the metal being worked, without the use of unduly powerful or large hammer-operating equipment.

Another object is to provide means in the apparatus for maintaining the striking surfaces of the upper die in their intended planes, to insure uniform striking and working of the metal by the spaced apart striking surfaces as they contact the work on the lower die. By the means to be described hammer marks on the forging are avoided and very smooth forgings as well as close duplication of discs as to thickness from center to perimeter are assured.

An important advantage of the method of forging herein described is the fact that the forgings produced are of superior strength and durability and are characterized by the long grain flow lines inherent in the thick billet used in their production. These grain flow lines, vertical in the billet, extend radially in the forging and impart to the disc, gear or other forging a radial or spoke-like reinforcement.

The apparatus and method herein described enable me to use billets of hard forging steel which are initially about twice as deep as their width or diameter, and to work the metal into a relatively thin forging such as a disc or gear, whereby great reduction in thickness is obtained and long radially extending grain flow lines are preserved in the forging, and this result is produced without increasing the size and power of hammer supporting and operating equipment

over that heretofore used for substantially less upsetting of the metal.

Not only are the forgings thus produced highly superior in strength, durability and appearance, but a substantial saving is effected due to the decreased loss of metal resulting from sawing through a relatively narrow bar of rolled steel to form a deep, narrow billet as distinguished from a shorter, wider billet.

In the drawings:

Fig. 1 is a perspective view of a billet such as is preferably used for making a forged disc embodying the invention.

Fig. 2 is a vertical sectional view of the dies constituting the apparatus for forging a wheel disc, which is shown between the dies.

Fig. 3 is a vertical sectional view, on an enlarged scale, of the disc shown in Fig. 2.

Fig. 4 is a plan view of the face of the upper die of the apparatus.

Fig. 5 is a plan view of the face of the lower die.

Fig. 6 shows a portion of the face of the upper die of Fig. 4 on an enlarged scale.

Fig. 7 is a sectional view taken on the curved line 7—7 of Fig. 6.

Fig. 8 is a sectional view taken on the line 8—8 of Fig. 6.

Fig. 9 is a vertical sectional view of a pair of dies, with a billet between them, used for the roughing operation in the forging of gears.

Fig. 10 is a vertical sectional view of a pair of dies embodying the invention, used for the finishing operation in the forging of gears, and showing a gear between them.

Fig. 11 is a plan view of the face of the upper finishing die of Fig. 10.

Fig. 12 is an enlarged section of part of the upper finishing die, taken on the line 12—12 of Fig. 11.

Fig. 13 is an enlarged plan view of part of the face of the die shown in Fig. 11.

Fig. 14 is a sectional view taken in the plane of the curved line 14—14 of Fig. 13.

Fig. 15 is an enlarged vertical sectional view of part of the gear shown in Fig. 10.

Fig. 16 is a vertical sectional view of another form of gear which may be produced by apparatus embodying this invention.

Fig. 17 is a view similar to that of Fig. 16, showing another form of forging, namely, a flywheel.

The preferred apparatus embodying this invention for forging discs for vehicle wheels is shown in Figs. 2 to 8, inclusive. In this embodiment the lower die 20 is rotatable about a vertical axis and the upper die 21 is reciprocable, but

either the upper or lower die may be rotatable. The lower die is provided on its bottom with a male member 22 which fits into a complemental recess in the anvil 23. Near the bottom of the lower die a sheave groove 24 is machined in the circumferential wall to accommodate a flexible steel driving cable 25 for rotating the die. The face of the die will be formed to produce any desired configuration of one surface of the disc.

10 In the present embodiment said face has a central recess into which is fitted a cup shaped member 26 which serves to prevent cracking of the die 20. The usefulness of the die is lengthened by replacement of the member 26 when it becomes fractured or worn. The member 26 is notched or roughened to prevent movement of the billet or forging relatively to the die. Surrounding the center, the face of the lower die is provided with an annular flat portion 27. Outwardly of the portion 27 is a radially narrow annular depressed portion 28, surrounded by a radially inclined, annular, web-forming region 29, a second narrow depressed portion 30 and an inclined portion 31. A flat narrow ring or surface 32 in a single horizontal plane, surrounds the inclined part 31 of the die. Offset from the operating face of the die is a shoulder 33. The surfaces 26 to 32, inclusive, are concentric and complemental to one surface of the disc to be forged.

The upper die 21 is mounted in any suitable manner in a reciprocable support, not shown, with its face in juxtaposition to the face of the lower die. The face of the upper die is best shown in Figs. 4 and 6. It has a central recess 34 surrounded by a central striking surface 35 disposed in a horizontal plane. Continuous with and in the same plane as the central striking surface 35, are five radially extending striking surfaces 36. Intermediate said striking surfaces 36 are five non-striking surfaces 37. The non-striking surfaces lie in a plane slightly above the plane of the striking surfaces 36 when the die is in operative position. Said surfaces 37 each merge with the striking surfaces 36 through gently inclined surfaces 38 at each side and merge at one end with the central striking surface 35 through a gently inclined surface 39. The striking surfaces 36 and non-striking surfaces 37 gradually increase in circumferential width from the center toward the perimeter of the die. At the peripheral annular portion directly above and registering with the ring 32 of the lower die, the upper die is provided with a flat horizontally disposed surface 40 in the same plane as the striking surfaces 36. Said peripheral flat surface 40 merges with the non-striking surfaces 37 by gently inclined portions 41. The non-striking surfaces 37 are thus surrounded by gently inclined surfaces which join each of them with the central striking surface 35, with adjacent striking surfaces 36, and with the peripheral flat surface 40.

The surfaces 35, 36 and 40 are preferably in one horizontal plane, and the surfaces 37 are in a plane only about one-quarter inch above the plane of the surfaces 35, 36 and 40. Since the inclined surfaces 38, 39 and 41 which join the surfaces 37 to those in another plane are two or more inches in the direction of their respective inclinations, the result is that said surfaces 38, 39 and 41 are very gently inclined. This construction and contour of the face of the striking die 21 produce great and rapid upsetting of the metal, together with a smooth surface on the forging, and freedom from hammer marks. The

registering ring surfaces 32 and 40, respectively, on the dies 20 and 21, insure uniform striking and working of the metal by maintaining the dies in their intended planes, and cooperate with the other novel features of the apparatus to produce smooth forgings, free from hammer marks, and close duplication of the successively forged pieces.

In Fig. 1 is shown a billet 42 cut from a rolled bar, in this instance cylindrical in cross section, the grain flow lines of the metal being vertical in the billet. Preferably the billet 42 is 6 to 8 inches high and $4\frac{1}{2}$ inches in diameter, for making a forged disc $23\frac{1}{4}$ inches in diameter. In Fig. 3 is shown the forged disc in which the upper surface 43 is flat and smooth and is provided with a central boss 44. The lower surface is complemental to the face of the lower die, and has a central boss 45, a surrounding flat annular portion 46, thickened annular portion 47, radially inclined region 48, slightly thickened annular member 49, radially inclined portion 50 and peripheral flat, narrow fin surface 51.

Certain features of construction of this disc, particularly the central bosses 44, 45, the contour of the disc and forming thereof into wheel shape are the subject of a copending application, Serial No. 78,860 filed herewith.

For purposes of the present invention, emphasis is laid upon the production of smooth, finished forgings having long radial grain flow lines in the metal, produced from billets of greater depth than width or diameter, by means of apparatus which quickly and efficiently upsets the metal and obviates hammer marks, non-uniformity and other defects in the forgings. The gently undulating surface (the combination of the striking and non-striking surfaces and the intermediate inclined surfaces) of the face of the upper die, together with the registering single plane peripheral surfaces 32 and 40 on the lower and upper die faces, respectively, between which the fin of the disc is formed, cooperate to produce the smooth, mark-free, uniform forgings herein described.

Referring to Figs. 9 to 15, inclusive, the apparatus therein shown is adapted for the forging of gears and similar shapes. Preferably two sets of dies are used, although some gears can be forged by means of one set of dies. In Fig. 9 the upper roughing die is indicated at 60 and the lower roughing die at 61. They are mounted in suitable supports, such as a reciprocable support (not shown) for the upper die and an anvil 61' for the lower die. One of the dies is rotatable. The face 62 of the lower die 61 is complemental to one surface of the rough forging to be formed and is surrounded by a peripheral flat ring surface 63. The face of the upper roughing die is indicated at 64 and it has a peripheral flat ring surface 65. The registering surfaces 63 and 65 of the dies, between which the thin fin of the forging is formed, function to retain the die faces in their intended planes and assure uniform thickness and smooth surfaces free from hammer marks in the forgings. Since the finishing dies indicated at 66 and 67 in Fig. 10 are identical in many respects to the roughing dies 60 and 61 of Fig. 9, and since the said finishing dies are shown in greater detail in the drawings (Figs. 11, 12, 13 and 14), said dies 66 and 67 will be described first and then the differences between the two sets will be explained.

The face of the lower finishing die 67 comprises a central, circular, flat web-forming portion 68, 75

which merges at 69 with a concentric, depressed flat portion 70, a concentric, downwardly curved portion 71, a flat depressed portion 72, joining through an upwardly inclined wall 73, a peripheral horizontally disposed flat ring 74. Each of these surfaces is circumferentially in one plane, and each plane is concentric. The peripheral surface 74 is in a higher plane than the other surfaces of the face of the lower die.

The upper die 66 has a face adapted to cooperate with that of the lower die 67 to shape the forging. It has a plurality of striking surfaces which are sectors of the circular face of the die and correspond with the registering part of the face of the lower die 67. Said upper die face comprises a central, circular, flat portion 75. Surrounding the center 75 is an annular portion consisting of four circumferentially spaced striking surfaces 76 on the same plane as the center 75. Between the flat striking surfaces 76 are non-striking surfaces 77 also flat, but in a slightly higher plane than the surfaces 76. The surfaces 76 and 77 are joined by gently inclined surfaces 78 (Figs. 11, 13, 14), the inclinations being in a circumferential direction, and the surfaces 75 and 77 are joined by gently inclined surfaces 79, the inclinations being in a radial direction. Four striking surfaces 76 and four non-striking surfaces 77 are preferred in this embodiment of the invention, but five may be used to advantage. Each of the surfaces 76, 77 and 78 is flat in a radial direction. The striking surfaces 76 merge at 80 with other striking surfaces 81 in a slightly higher horizontal plane; the non-striking surfaces 77 merge at 82 with other non-striking surfaces 83 in a slightly higher horizontal plane; and the surfaces 78 also merge at 84 with other circumferentially inclined surfaces 85 which join the surfaces 81 and 83 together in the same manner that the inclined surfaces 78 join together the surfaces 76 and 77.

All the radially extending and gradually widening surfaces 81, 83 and 85 merge into a concentric, radially and upwardly curved surface 86 which extends upwardly to an annular portion consisting of flat horizontally disposed surfaces lying in two planes. That is, striking surfaces 87 are radial continuations of the striking surfaces 76—81, and non-striking surfaces 88 are radial continuations of the non-striking surfaces 77—83. The surfaces 87—88 are joined together circumferentially by gently inclined surfaces 89, which are radial continuations of the circumferentially inclined surfaces 78—85.

The annular portion consisting of the surfaces 89, 88, 89, 87, etc. merges into the downwardly inclined concentric wall 90 which extends downwardly to a peripheral horizontally disposed flat ring surface 91. An offset shoulder 92 surrounds the face of the die 66.

From the foregoing it will be understood that the face of the upper die 66 comprises a flat center 75 and a peripheral flat single plane surface 91, and that between these parts are a plurality of concentric annular portions which may be flat or inclined or curved in a radial direction and which are undulating in a circumferential direction, whereby striking and non-striking sectors are formed. Each striking surface on the upper die thus comprises the parts 75—76, 80, 81, 86, 87, 90 and 91 and these surfaces correspond with the face surfaces 68, 69, 70, 71, 72, 73 and 74 of the lower die, as clearly shown in Fig. 10.

Reverting to the roughing dies of Fig. 9, it will be seen that the faces of the dies 60 and 61 are

identical with the faces of the finishing dies 66, 67, respectively, excepting that some of the contours are more rounded or curved in the dies 60 and 61. For example, the groove defined by the walls 70, 71 and 72 in the finishing die 67 is not quite so angular in cross section in the roughing die 61, as indicated at 70', 71' and 72'. Likewise, in the upper roughing die 60 the concentric groove defined by the walls 86', 87' and 90' is more curved and less angular in cross section than the corresponding groove formed by the walls 86, 87 and 90 in die 66. In each set of dies the face of the lower die is complementary to one surface of the forging and the face of the upper die has striking areas, spaced apart circumferentially, which striking areas are complementary to a sector of the forging to be produced, and together with their intermediate non-striking areas and inclined joining surfaces constitute a face as large as or slightly larger than the forging.

By the use of apparatus such as shown in Figs. 9 to 14, inclusive, the forging metal may be turned upside down in the course of the operation and successively receive the impact of the upper die on each face of the work, so that the grain flow lines of the metal will be evenly and radially disposed as indicated in the part of a gear 93 shown in section in Fig. 15.

For a gear which is to be approximately 26 inches in diameter, trimmed, having a relatively thin web portion, and 5 inches thick in its peripheral portion, a billet approximately 14 to 15 inches high and 9 inches square may be used. In Fig. 9 the billet 94 is being upset between the roughing dies, either one of which may be rotatable, by the impact of the upper die 60. When the billet has assumed the contour of the face of the lower die and the striking surfaces of the upper die, the rough forging is moved to the finishing dies 66 and 67 and after subjecting each side to blows from the reciprocating die 66, the gear 93 is produced. The fin 95 formed between the peripheral flat surfaces 91—74 of the dies will be trimmed off, and the center of the gear punched as desired, and teeth cut in the peripheral edge.

Fig. 16 shows another form of gear 96 which may be forged in apparatus such as described for producing the gear 93, the faces of the dies being modified accordingly, but nevertheless embodying the striking and non-striking areas of the upper dies and the cooperating peripheral flat surfaces of the upper and lower dies. Fig. 17 shows a flywheel 97 which may be forged in one operation by means of one set of dies such as the dies 66, 67, with the faces modified to produce the desired shape.

It will be understood by those skilled in the art that the invention is not limited to any particular configuration of the faces of the forging dies, nor to the use of billets of any specified proportions. The invention resides in the construction of the dies, particularly the relative location, form and proportions of the striking and non-striking areas of the upper die, whereby spaced apart sectors of the entire upper surface of a billet may be simultaneously subjected to the impact of a hammer die while the work is supported on another die, one of said dies being rotated. The rotation is subject to control but preferably it is continuous excepting when the upper die is in contact with the work. The speed of rotation is adjusted to obtain smooth surfaces on the forging. The apparatus and method described permit of the use of billets which are relatively deep, sometimes

approximately twice as high in the direction of the grain flow lines of the rolled bar as the diameter or width, and quickly and economically upset the metal to produce smooth forgings in which are preserved and radially disposed the long grain flow lines inherent in a tall billet of the character described.

Changes may be made in details of construction without departing from the scope of my invention and I do not intend to be limited to the exact form shown and described, except as set forth in the appended claims.

I claim:—

1. Forging apparatus comprising a pair of dies, one of said dies being reciprocable and having a face provided with circumferentially adjacent striking sectors and intermediate non-striking areas, each striking sector having surfaces in a plurality of planes, each non-striking area having surfaces in a plurality of planes, and said circumferentially adjacent striking and non-striking surfaces being in different but substantially parallel planes.

2. Forging apparatus comprising a pair of dies, one of said dies being reciprocable and having a face provided with circumferentially adjacent striking sectors and intermediate non-striking areas, each striking sector having surfaces in a plurality of planes, each non-striking area having surfaces in a plurality of planes, and said circumferentially adjacent striking and non-striking surfaces being in different but substantially parallel planes and each of said dies having a peripheral, flat surface in a horizontal plane, registering with and spaced a short distance from the corresponding surface of the other die when the dies are in their most proximate operative position.

3. Forging apparatus for disc wheels comprising a pair of dies, one of which is rotatable, and one of said dies being reciprocable and having a face substantially equal in area to the forging to be produced, said face being provided with a plurality of striking surfaces and circumferentially intermediate non-striking surfaces, said surfaces being located in substantially parallel planes approximately one-quarter inch apart in a vertical direction and joined together by relatively wide and gradually inclined surfaces approximately two inches wide which merge with said striking and non-striking surfaces.

4. Forging apparatus for disc wheels comprising a pair of dies, one of which is rotatable, and one of said dies being reciprocable and having a face substantially equal in area to the forging to be produced, said face being provided with a central striking surface, a plurality of striking sectors and intermediate non-striking areas occupying the face of the die between said striking center and the perimeter, relatively wide surfaces gradually inclined in a radial direction for connecting the non-striking areas to the center, and relatively wide surfaces gradually inclined in a circumferential direction for connecting the striking sectors and non-striking areas, said striking and non-striking surfaces being located in substantially parallel planes approximately one-quarter inch apart in a vertical direction.

5. Forging apparatus comprising a pair of dies, one of which is rotatable, and one of said dies being mounted for reciprocation to and from the other die and having its striking face substantially equal in area to that of the forging to be produced thereby, said striking face being provided with a plurality of sector-shaped striking surface portions and non-striking areas between

said striking surface portions, the striking surface portions occupying approximately one-half of the area of the striking face and merging with the intermediate non-striking areas by relatively wide and gradually inclined surfaces which latter surfaces occupy substantially two-thirds of the area between the adjacent sides of the striking surface portions.

6. Forging apparatus comprising a pair of dies, one of which is rotatable, and one of said dies being mounted for reciprocation to and from the other die and having its striking face substantially equal in area to that of the forging to be produced thereby, said striking face being provided with a plane relatively wide central striking surface having a plurality of radial striking surface portions extending therefrom at widely spaced points and relatively shallow non-striking areas extending between the radial striking surface portions and the periphery of the central striking surface, the striking surface portions occupying approximately one-half of the area of the striking face and merging with the non-striking areas by relatively wide and gradually inclined surfaces which latter surfaces occupy substantially two-thirds of the non-striking areas.

7. Forging apparatus comprising a pair of dies, one of which is rotatable, and one of said dies being mounted for reciprocation to and from the other die and having its striking face substantially equal in area to that of the forging to be produced thereby, said striking face being provided with a wide central striking surface portion and a relatively narrow marginal striking surface portion surrounding said central surface portion and connected thereto by a plurality of sector-shaped striking surface portions, and relatively shallow non-striking areas between the sides of the connected striking surface portions and merging therewith by relatively wide and gradually inclined surfaces which latter surfaces occupy substantially two-thirds of the non-striking areas.

8. Forging apparatus comprising a pair of dies, one of which is rotatable, and one of said dies being mounted for reciprocation to and from the other die and having its striking face substantially equal in area to that of the forging to be produced thereby, said striking face being provided with a relatively wide central striking surface portion having a plurality of radial striking sector portions and relatively shallow non-striking areas occupying the face of the die between the central and radial striking surface portions, said striking surface portions being connected with said non-striking areas by relatively wide and gradually inclined surface portions which extend in both radial and circumferential directions.

9. A forging apparatus comprising a reciprocable die and a non-reciprocable die, one of said dies having a face provided with a plurality of radial striking surface portions, a continuous peripherally disposed striking surface portion joining the outer ends of said radial striking surface portions, and relatively shallow non-striking areas between said striking surface portions, and the other of said dies having a face provided with a continuous peripherally disposed striking surface portion registering with and spaced a short distance from the correspondingly formed peripheral surface portion of the first mentioned die when said dies are in their most proximate operative relation to each other.

10. Apparatus for forging discs for vehicle wheels and the like, comprising a pair of cooperating dies one arranged above the other and one of which is rotatable, the lower die having a face complementary to one side of the disc to be produced, and the upper die being reciprocable and having a face approximately as large as the disc to be forged, said latter face being provided with sector shaped striking surfaces in one horizontal plane and non-striking areas between said striking surfaces, said surfaces and areas being connected by relatively wide surfaces gradually inclined in a circumferential direction.

11. Apparatus for forging discs for vehicle wheels and the like, comprising a pair of cooperating dies one arranged above the other and one of which is rotatable, the lower die having a face complementary to one side of the disc to be pro-

duced surrounded by a continuous single plane horizontal, peripheral surface, and the upper die being reciprocable and having a face approximately as large as the disc to be forged, said latter face being provided with sector shaped striking surfaces in one horizontal plane and relatively shallow non-striking areas between said striking surfaces, said surfaces and areas being connected by relatively wide surfaces gradually inclined in a circumferential direction, and a peripheral single plane surface bounding the outer side of the non-striking areas and in the same plane as the surface of the striking surfaces, vertically aligned with and spaced a short distance from the peripheral surface of the lower die when said dies are in their most proximate operative position.

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