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Winkler et al.

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[45] **Feb. 26, 1974**

[54] **PROCESS FOR FABRICATING REAR AXLE HOUSING FOR MOTOR VEHICLES**

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Oct. 10, 1971 Germany .... P 20 49 889.9

[52] **U.S. Cl.** **29/463,** 74/607, 72/405
[51] **Int. Cl.** **B21d 39/02**
[58] **Field of Search** 29/463; 74/607; 72/405

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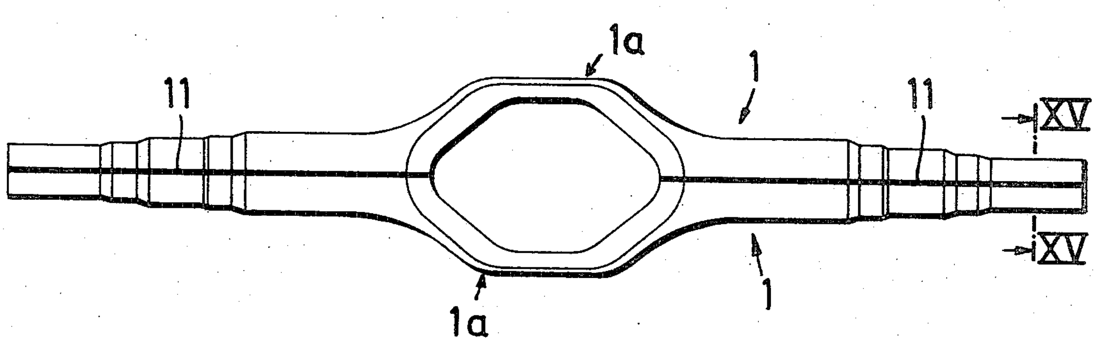
Primary Examiner—Charlie T. Moon
Attorney, Agent, or Firm—Markva & Smith

[57] **ABSTRACT**

A rear axle housing comprises two longitudinal sections welded together, each section being produced by the process of first preshaping a rough billet into the general configuration of a forging blank, forging the blank in several steps into a flat shaped member and then forging the member into the general shape of the housing section. A minimum amount of machining is required to remove the excess material and finish the housing. A special apparatus is provided for performing the intermediate steps of forging the preformed billet into a shaped forging blank.

10 Claims, 23 Drawing Figures



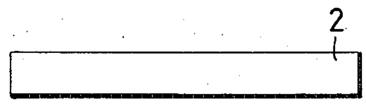


FIG. 1

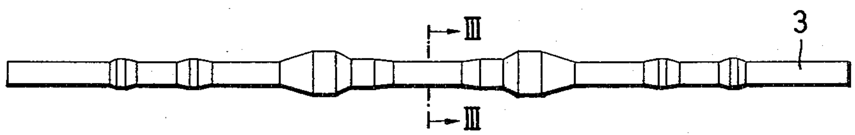


FIG. 2

FIG. 3

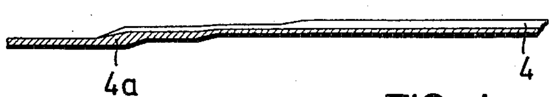


FIG. 4

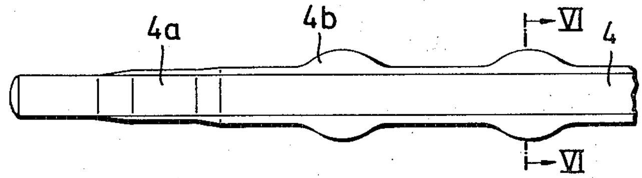


FIG. 5

FIG. 6

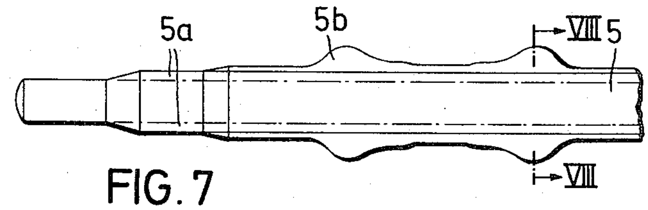


FIG. 7

FIG. 8

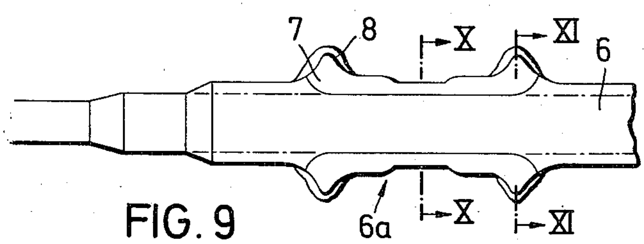


FIG. 9

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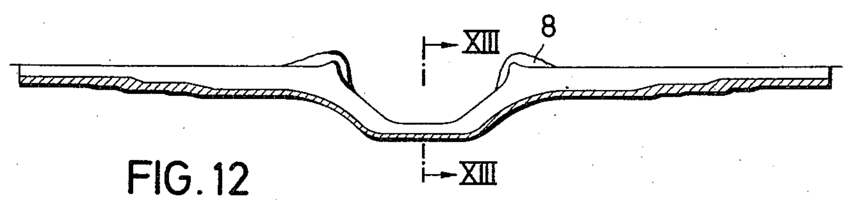

FIG. 12

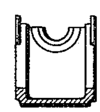

FIG. 13

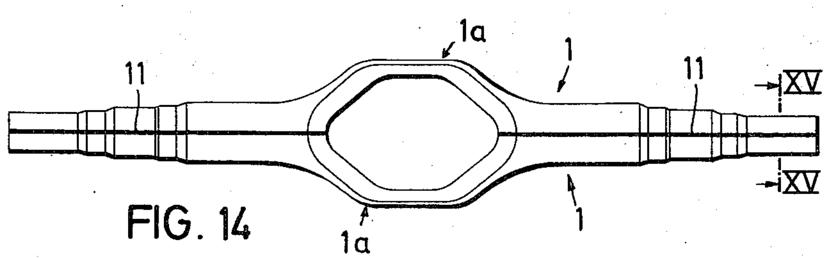

FIG. 14

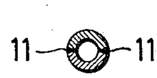

FIG. 15

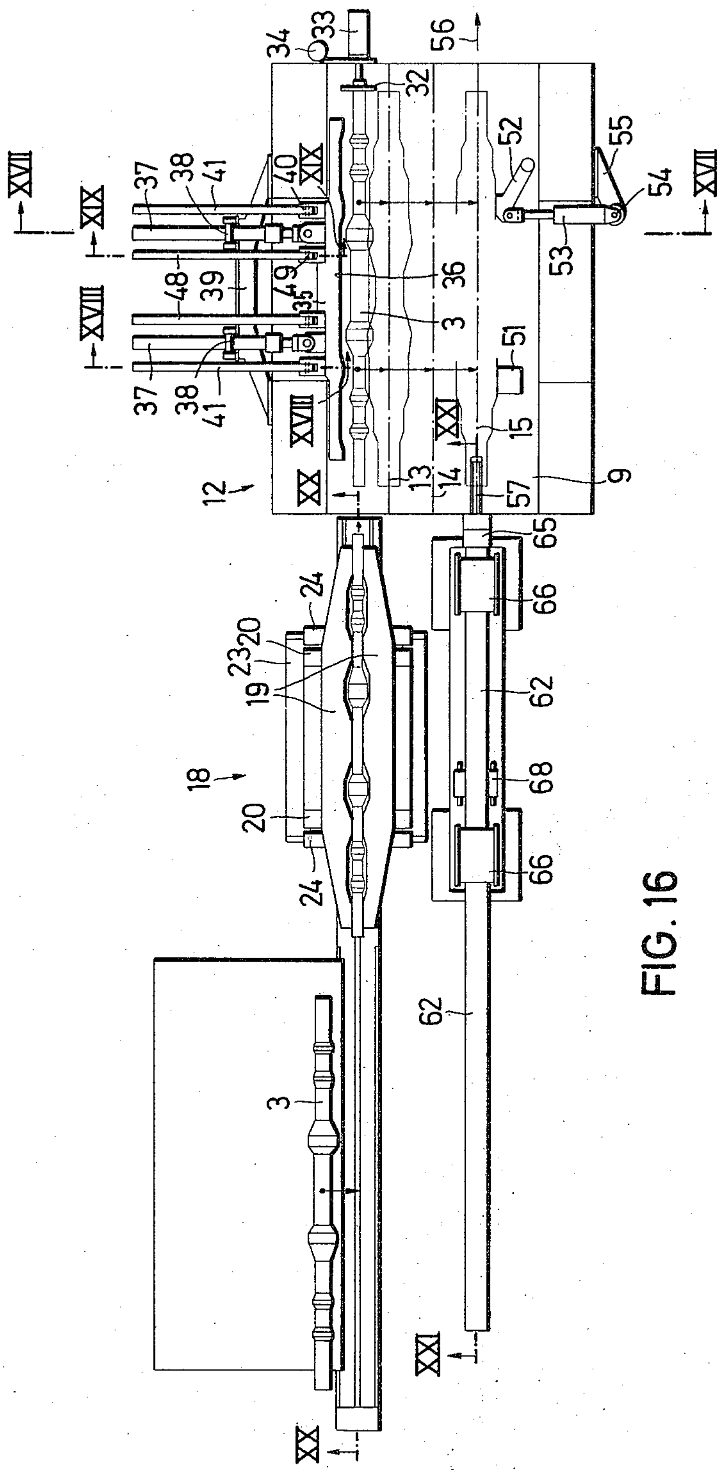

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FIG. 16

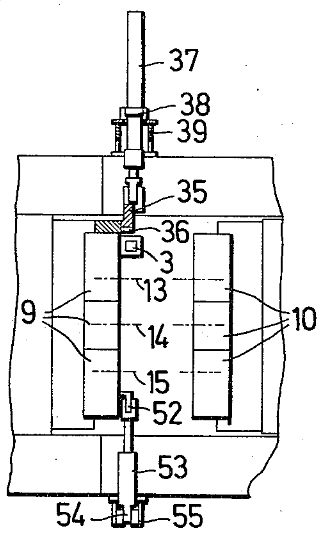

FIG. 17

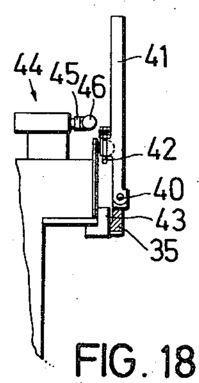

FIG. 18

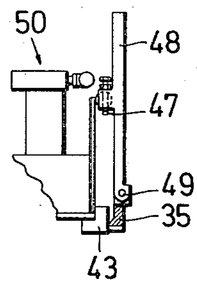

FIG. 19

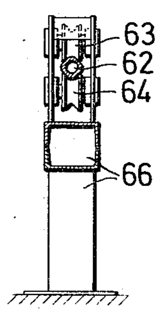

FIG. 23

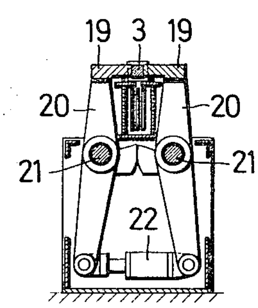

FIG. 22

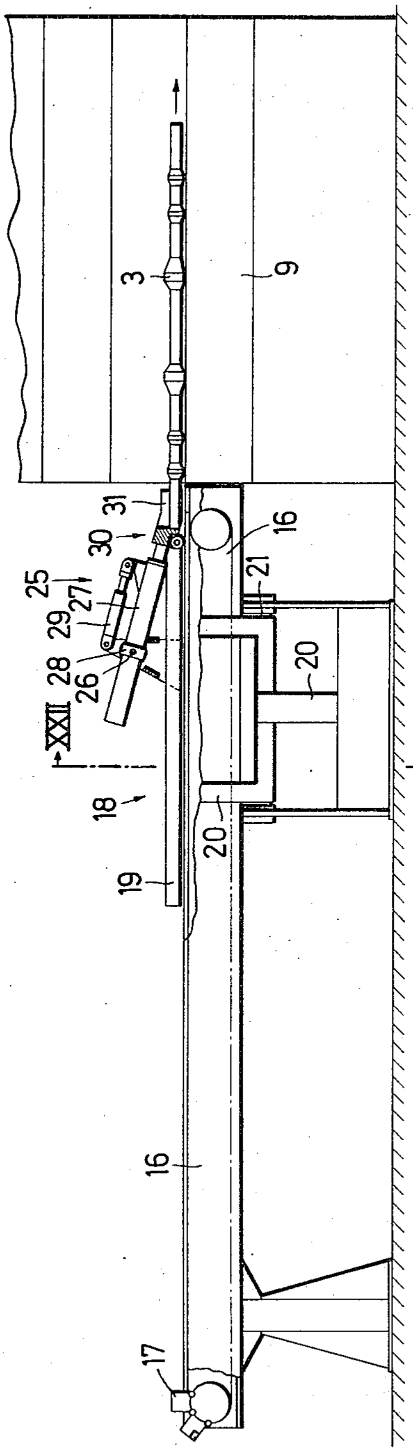
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FIG. 20

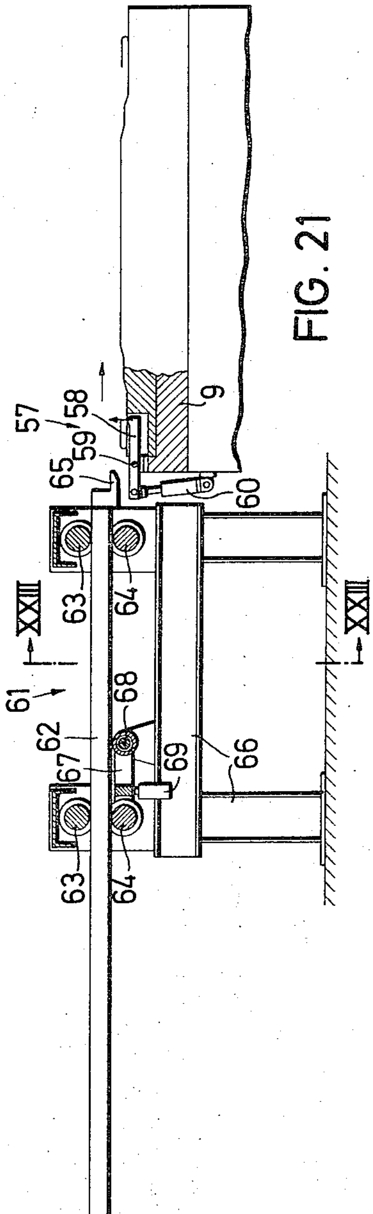
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FIG. 21

PROCESS FOR FABRICATING REAR AXLE HOUSING FOR MOTOR VEHICLES

BACKGROUND OF THE INVENTION

The invention relates to a rear axle housing for motor vehicles and especially for heavy vehicles or trucks and to the process and apparatus for the manufacture of these housings. The conventional rear axle housing consists of an enlarged or bulged center section for housing the differential gear assembly and includes a pair of elongated sections laterally extending from opposite sides of the center section for housing the vehicle axle shafts. At present, these housings are manufactured by a variety of processes. Many of the small axle housings are manufactured in a single piece of hammering and pressing in a forge die. As the vehicle size is increased however, the differential housing size also increases. The large housings are usually fabricated by forging individual elements and then welding these elements into an integral housing.

Two-part designs are well known in the prior art whereby individual parts are manufactured by forging and in some cases by hot-impact extrusion. The upper and lower enlarged portions for the differential housing are formed on the individual cylindrical axle sections, and these parts are welded together to produce a complete rear axle housing. Where the housing is constructed in three parts, the axle sections are individually forged and later welded to the separately manufactured differential housing to afford a single unit.

With these common methods of manufacture, all of these multi-part designs have several common disadvantages. One major disadvantage is that the welding seams which extend transversely of the longitudinal axis of the housing are located in areas receiving high stress. Furthermore, in most heavy rear axle housing applications, varying wall thicknesses are required in the axle housings to obtain the desired mechanical strength. These variations are usually accomplished by extensive and costly machining of the forged and welded housing parts. This requirement for varying wall thickness further precludes the use of economical sheet-type material in the forging operation.

OBJECTS OF THE INVENTION

It is the primary object of this invention to provide a rear axle housing which is so assembled from individual parts that the connecting weld seams are located outside the high-stress zones which are present during use of the housing.

Another object is to provide a rear axle housing fabricated by a forging process which requires less hammer force and thus allows the use of a smaller size forging press to accomplish the needed shaping.

A further object of the invention is to provide a forging process for producing rear axle housings wherein there is less material waste.

A still further object is to fabricate a housing for a vehicle rear axle wherein the individual parts can be fabricated from a rough billet to the semi-finished part in one forging heat operation.

Another object of this invention is to provide an economical forging process for a rear axle housing wherein the housing is fabricated by using open die shapes which are considerably more economical to use than the conventional three-dimensional dies.

THE INVENTION

The rear axle housing of this invention is characterized in that it consists of two halves which are welded together along the central longitudinal axis. The joining seam extends along the entire length of the axle housing. These forged halves have various wall thicknesses in the longitudinal direction depending upon the stress requirements of the housing.

The forging process utilized in this invention results in a semifinished flat blank of irregular external contours and varying thicknesses from which the finished housing half is formed. The manufacturing process starts with a rough billet of square or round cross-section which has been heated to the limits of the forging temperature. The billet is then stretched and rolled until the proper material distribution for the following forging process is obtained. This material distribution is designed so that the necessary thickness and shape of the finished product can be obtained with a minimum of waste.

The preformed billet is moved immediately to the forging dies where it is pressed and hammered in several successive steps into a semifinished flat forging blank. This intermediate forging process first laterally displaces excess material by the use of a narrow tool along the entire length. Using progressively wider tools, the blank is widened to its finished dimension and then central lobes are formed for the differential housing portion. After cutting to the proper length, the semifinished blank is then roll-forged into the finished housing shape. All of this is accomplished in successive steps and in rapid progression so that only a single heating of the original billet is required during the entire forging and shaping process.

The use of the original rough billet instead of sheet material is a substantially cheaper method of manufacturing this type of product. Due to the successive forging steps and the flat forging process, a much smaller forge press is required for the entire shaping operation. All excess material is caused to flow transversely of the longitudinal axis which is the primary reason that lower or reduced press forces are required. The press force can be reduced by as much as two-thirds that of prior art processes. The lobes which form the widest portion of the flat semifinished blank are formed separately in the final stages. The burrs formed at the edges of the lobes act as a forging stroke stop to prevent excessive blank deformation.

The semifinished flat blank is pressed and rolled into the finished form wherein the excess material along the welding seam and at the lobes is removed by a rough machining process.

The halves are then welded to form the finished rear axle housing. It can be appreciated that in a horizontal longitudinal weld seam such as this, the bending stresses in the finished product are distributed across the parent material and are not concentrated in the welded joint.

The apparatus of this invention which is designed for flat forging of the preshaped billet incorporates a bottom and top die member. The die impressions are wider at their surface than the width of the semifinished blank. In this manner, the semi-finished blank or the top die may be displaced rapidly and reliably across the bottom die tool to the various pressing or forging locations. All movement of the blank or top die across the die surfaces is accomplished by mechanical means which rapidly and reliably positions the blank or upper die in the correct position. Thus, the entire process can be accomplished by the single heating of the original billet.

It is to be understood that in this process the blank can be moved across impressions in the bottom die face or the top die face can contain the impressions and be moved in steps across the stationary blank and bottom die.

Other features of this invention will appear in the following description and appended claims, reference being made to the accompanying drawings forming a part of the specification wherein like reference characters designate corresponding parts in the several views.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. **1** through **15** show the progressive shaping of a rear axle housing from the rough billet to the finished product when processed in accordance with this invention;

FIG. **16** shows a top plan view in diagrammatic form of a machine of this invention having three forging locations for forming the preformed billet into the semifinished blank;

FIG. **17** shows a sectional view of the machine taken along the line XVII—XVII of FIG. **16**;

FIG. **18** shows a partial sectional view taken along the line XVIII—XVIII of FIG. **16**;

FIG. **19** shows a partial sectional view taken along the line XIX—XIX of FIG. **16**;

FIG. **20** shows a side sectional view of the machine taken along the line XX—XX of FIG. **16**;

FIG. **21** shows a side sectional view taken along the line XXI—XXI of FIG. **16**;

FIG. **22** shows a sectional view in diagrammatic form taken along the line XXII—XXII of FIG. **20**; and

FIG. **23** shows a sectional view in diagrammatic form taken along the line XXIII—XXIII of FIG. **21**.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Turning now to the drawings and specifically FIGS. **1** through **15**, each half of the rear axle housing **1** of this invention originates from a rough billet **2**. The rough billet **2** after being brought to forging temperature is rolled and stretched to the preformed billet shape **3** shown in FIG. **2**. The preformed billet **3** is designed for optimum material distribution for subsequent forging operations. The billet **3** is then straightened and aligned and positioned within a forging press. In three forging operations or steps, the preformed billet is shaped into a flat blank, shown in stages **4** and **5**, and then to the semifinished flat blank **6**.

In order to accomplish the forging operation with relatively small forging pressure, the first two steps are accomplished with a relatively narrow top die surface in conjunction with a flat bottom die impression so that the portions of the preshaped billet **3** corresponding to the lateral portions **4***a* and **5***a* of the subsequent housing half are pressed to their final dimensions. The remaining portions **4***b* and **5***b* of the blank are left incomplete. The FIGS. **4, 5, 6, 7** and **8** show in detail the external shaping of the flat blank (stages **4** and **5**) in the first two operations.

In the third step, the enlarged central portion **1***a* of the housing for the differential gear assembly is formed. The external shape of this portion of the blank **6** has four lobes **7** in a central portion **6***a*. In order to form the contours of the lobes, the central portion **6***a* is slightly upset or deformed while the pressing or forging operation forms the lobes **7** and the burr **8**. The waste material due to the burr **8** is held to a minimum. Thus, through the preceding steps the final flat blank shape shown in FIGS. **9, 10** and **11** is obtained.

In FIGS. **12** and **13** the rear axle housing half is shaped and forged from the final semi-finished blank **6**. FIGS. **14** and **15** show a rear axle housing fabricated from the housing halves of FIG. **12** and welded together in a horizontal plane. The weld seams **11** are shown extending in a longitudinal direction and lying in a horizontal plane through the longitudinal axis. As can be seen, this seam lies in an area wherein the stresses are minimal with respect to the bending moments applied to the housing during use.

As shown in FIG. **16**, the forging press **12** for the intermediate forging steps is composed of a bottom tool **9** having a plane or profiled surface on which the preformed billet **3** is positioned. The bottom tool or die **9** may be a multi-part die or a single surface having multiple die profile or impression locations such as the three press-forming locations **13, 14** and **15** having central, parallel longitudinal axes. The top die **10** works in conjunction with the press locations **13, 14, 15** forming the preformed billet **3** into the flat semifinished blank **6**. A conveyor device **16** moves the preformed billet **3** into an aligning device **18** where the billet is straightened for the subsequent forming operations. The aligned billet is then positioned in the forging position **13** and then from this position to the subsequent positions **14** and **15**. After the semifinished blank has been completed, the blank **6** is then moved from the forging press by a pusher device **61**.

Before entering the press **12**, the preformed billet is straightened in the aligning device **18**. A conveying device **16** which can be in the form of an endless belt receives the preformed billet **3** and moves the billet to the aligning device **18**. This device has jaws **19** arranged on levers **20** mounted for pivotal movement about the shaft **21**. The elongated jaws **19** are shaped to align with the enlarged sections and the straight sections of the preformed billet and are moved together by a hydraulic cylinder assembly **22**. The levers **20** are connected together by a cross-beam frame **23, 24**. The subsequent rotating and squeezing of the preformed billet **3** between the jaws **19** properly aligns and straightens the billet for the subsequent forging operations.

From the aligning device **18** the straightened billet **3** is moved by the conveyor **16** toward the bottom die **9** and is pushed onto the surface of the die **9** by the pushin device **25**. This device **25** is aligned laterally with the first forge forming location **13**. The pushing-in device **25** is mounted for pivotal movement about the shaft **26** and is pivoted downwardly so that the rod **27** and the guide element **30** can engage the end of the preformed billet **3**. The guide rod **27** is extended by the piston-cylinder unit **29**. The fork-like guide element **30** which consists of the lateral jaws **31** grips the end of the preformed billet **3** and guides it in the longitudinal axis into proper position on the bottom die **9**. An adjustable stop **32** is positioned at the end of the forging position **13** to properly limit the longitudinal movement of the billet **3**. The stop **32** is guided in the retaining means **33** and may be pivoted out of position by the pivotal attachment 34.

Transverse displacement of the preformed billet 3 across the surface of the bottom die 9 is effected by means of a push strip 35. The strip 35 has an outer extending edge which is profiled to correspond to the general contours of the preformed billet 3 and the flat blank stages 4, 5. The strip 35 is connected to a pair of extendable guide rods 37 which are mounted in pivot means 38. The guide rods 37 are designed as piston-cylinder units. The pivot means 38 is secured to a mounting pedestal 39 attached to the side of the forge press 12. In addition, stop rods 41 are hingedly attached to the back edge of the strip 35 and serve for limiting the stroke of the strip 35. Arranged on the rods 41 are adjustable stop screws 42 adapted to abut against a stationary stop 43. As the push strip 35 is extended transversely across the bottom tool 9, the flat blank 4 is moved to the first step position. The adjustable stop screw 42 thus limits the stroke of the strip 35 to properly position the flat blank 4. The push strip 35 is then withdrawn prior to the forging operation. At the conclusion of the first forging step, the flat blank 4 is again transversely moved across the bottom die 9 by the push strip 35. The piston cylinder units 44 have rollers 46 attached to the top of the push elements 45. The rods 41 are elevated so that the adjustable stop screws 42 can no longer engage the stationary stop 43. Thus, the strip 35 can be extended so that the blank 4 can be moved to the second press-forming location 14. A second pair of stop limiting rods 48 is hingedly attached to the back edge of the push strip 35. These rods 48 also include adjustable stop screws 47 which are adjusted to limit the movement of the push rod 35 to accurately position the blank 4 at the second forging location 14. The stop screws 47 impinge against the stationary stop 43.

After the second forging operation, the pressed flat blank 5 is moved to the third forge forming location 15. The stop arms 48 are pivoted upwardly by the extending cylinders 50 so that the stop screws 47 will also pass over the stationary stop 43. To properly position the flat blank 5 at the third forging location 15, a fixed stop 51 and a pivoted stop 52 are provided to limit the transverse movement of the preformed blank 5. The pivoted stop 52 is adapted to be moved by the piston cylinder unit 53 and is mounted on the bracket 55 by the shaft 54. This pivoted stop 52 is necessary in order that the final flat blank 6, which has completed the third forming operation 15, may be extracted and moved in the direction of the arrow 56. The stop 52 impinges against the projecting lobe 7 and the burr 8 to effect this movement.

To aid in the extraction of the semifinished blank 6, a lift-out or extraction device 57 is provided at the end of the flat die position 15. This device consists of a lever 58 which is pivoted about the shaft 59. The free end of the lever 58 is moved by a piston cylinder unit 60. The end of the semifinished blank 6 is lifted above the surface of the bottom tool 9 so that the pushout device 61 with its projecting nose 65 can extend under and engage the bottom surface of the end of the blank 6. The guide rod 62 of the pushout device 61 is formed in a square cross-section to prevent rotation. The sides of the guide rod 62 are guided by rollers 63 and 64. The guide rollers 63 and 64 are mounted on the frame 66. One roller 64 is mounted on the rocker arm 67 which is pivotal about the shaft 68 and biased upwardly by the spring 69. The pair of rollers 63, 64 may be driven by any means such as a motor to extend and retract the push rod 62. The blank 6 thus is moved longitudinally across the bottom die 9 and outwardly in the direction of the arrow 56 to the final forging and shaping operation. The lobes 7 and the burr 8 provide a projecting sliding surface so that the blank 6 can be moved across the forging die impression.

In another embodiment of this invention, the top die can contain a series of die impressions and be stepped across the stationary flat blank resting on the bottom die 9. This top die can be formed from a single die member or combined from a series of die pieces. The guide rods 37 and stop rods 41, 48 can be adapted to move the top die transversely instead of the push strip 35.

While the rear axle housing process and apparatus for the process have been shown and described in detail, it is obvious that this invention is not to be considered as being limited to the exact form disclosed, and that changes in detail and construction may be made therein within the scope of the invention, without departing from the spirit thereof.

Having thus set forth and disclosed the nature of this invention, what is claimed is:

1. A process for manufacturing an elongated rear axle and differential housing for vehicles wherein the portion for housing the differential has a greater cross-section than the remainder of the housing, said process comprising the steps of:
   a. forming complimentary first and second elongated concave members, the edges of which when assembled mate and are contiguous and lie in a plane passing through the longitudinal axis of the housing,
   b. said forming step comprising heating a rough longitudinally extending billet to a predetermined forging temperature and forging the billet into the finished first or second elongated concave member in a series of rapid steps, and
   c. permanently joining said edges of the first and second member to form said housing,
   d. whereby the resulting permanent joint is located where it is subjected to minimum stress during use of said housing.

2. A process for manufacturing a rear axle housing as defined in claim 1 wherein the forging step comprises
   a. shaping the billet into a flat blank having a predetermined thickness with the opposite longitudinal edges thereof having a predetermined contour and
   b. then as a final step rounding the flat blank into the final elongated concave configuration of varying cross-section.

3. A process for manufacturing a rear axle housing as defined in claim 2 wherein after heating said rough billet to the forging temperature the billet is formed with areas of excess material required to form the enlarged and thickened areas in the forged member.

4. A process for manufacturing a rear axle housing as defined in claim 2 wherein the rapid forging steps comprise
   a. forging the billet into a flat elongated blank having ends of predetermined thickness and
   b. forming edge lobes for the enlarged areas in subsequent steps by utilizing the predetermined blank thickness as a forging stroke limiting stop.

5. A process for manufacturing a rear axle housing as defined in claim 1 wherein the only heating of said billet is prior to said forging step.

6. A process for the manufacture of a rear axle housing as defined in claim 1 wherein said forging step comprises reforming said rough billet into a preformed elongated billet in which the material of said billet is optimally distributed along its length with a greater amount of material at the location along its length corresponding to the portion for housing the differential than at other locations along the length of the preformed billet.

7. A process for manufacturing a rear axle housing as defined in claim 6 wherein said preformed elongated billet is flattened into an elongated flat forging blank, such that the width of the blank is greater at said location corresponding to the portion for housing the differential and then forming said flat forging blank into said first or second elongated concave member having an enlarged portion for housing the differential.

8. A process for manufacturing a rear axle housing as defined in claim 7 wherein during the step of forming said elongated flat forging blank, a pair of spaced lobes are formed along the opposite longitudinal edges thereof at said location corresponding to the portion for housing the differential, said lobes forming parts of said portion for housing the differential when said flat forging blank is formed into said first or second elongated concave member.

9. A process for manufacturing a rear axle housing as defined in claim 7 wherein said flat forging blank is formed from said preformed elongated billet by sequentially pressing said billet between pairs of dies for progressively flattening said preformed, elongated billet.

10. A process for manufacturing a rear axle housing as defined in claim 1 wherein said rough billet has a square or round cross-sectional configuration.

* * * * *