Feb. 28, 1956 E. H. HARMON 2,736,674

FORGING ALUMINUM ALLOY DISC WHEELS

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Fig. 1.

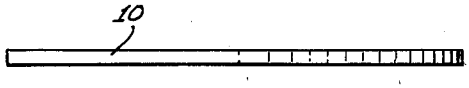


Fig. 2.

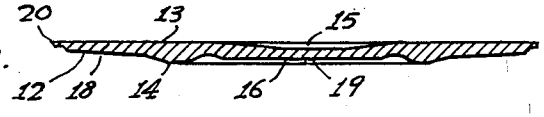
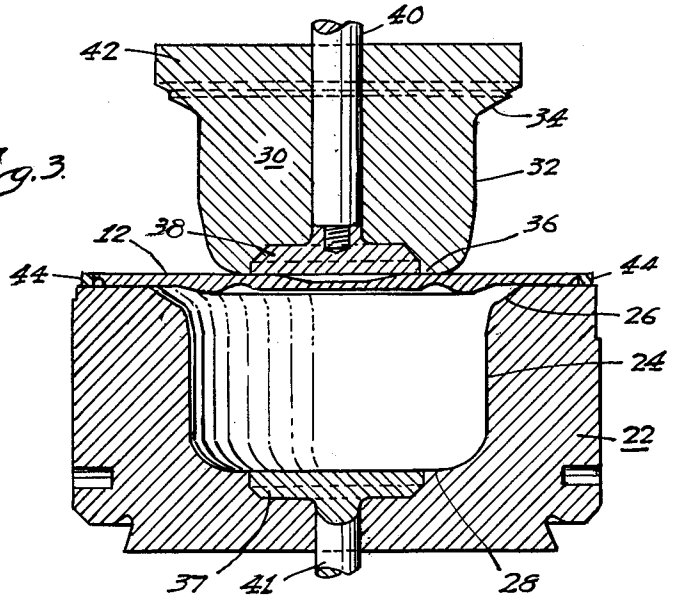


Fig. 3.



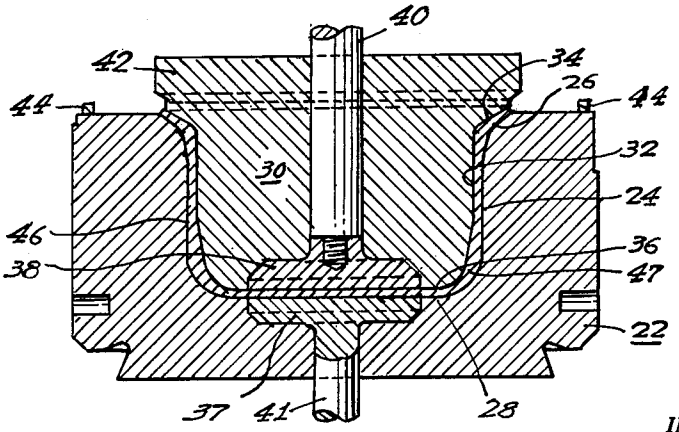


Fig. 4.

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Fig. 5.

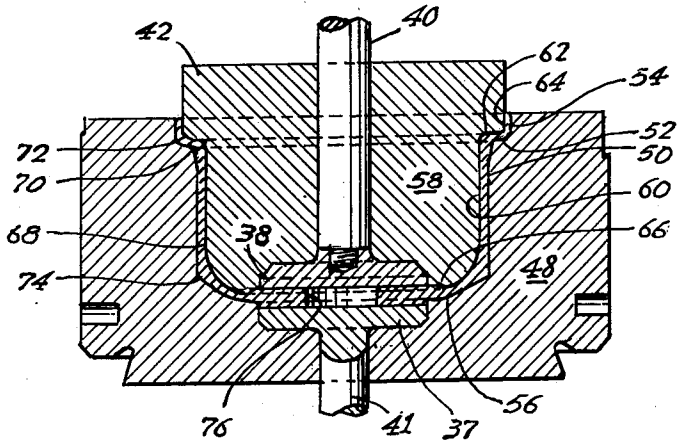


Fig. 6.

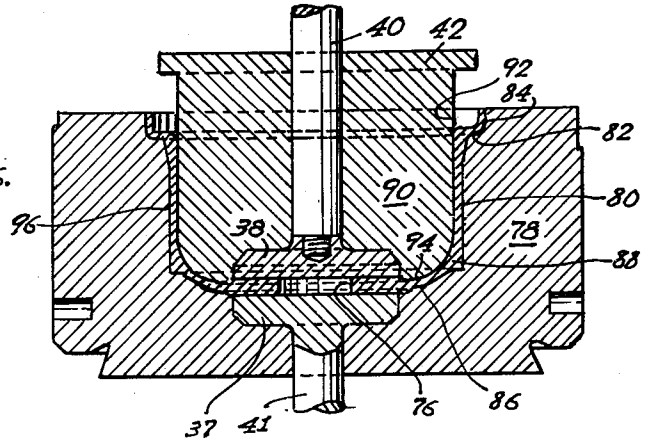
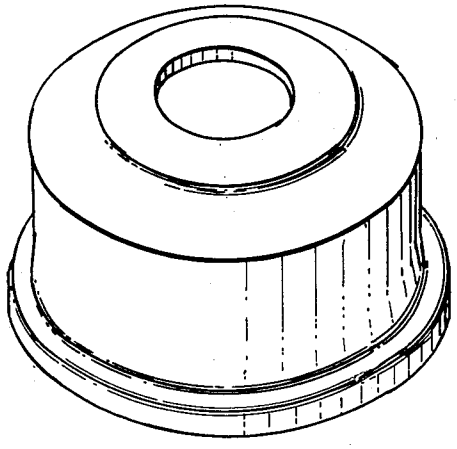


Fig. 7.



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FORGING ALUMINUM ALLOY DISC WHEELS

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Application October 18, 1954, Serial No. 462,915

7 Claims. (Cl. 148—12.7)

This invention is concerned with the production of aluminum base alloy forged disc wheels for trucks, buses and other vehicles and it more particularly relates to forged wheels made of those alloys which must be solution heat treated and precipitation hardened to develop their maximum mechanical properties.

The design of wheels for automotive vehicles and the materials used in their construction have undergone great change over the past half century. Originally, the wheels were of relatively large diameter with small hubs, long spokes and narrow rims. Wood was the major structural material. As the size and speed of the vehicles increased, smaller wheels were adopted and steel eventually replaced all of the wood. More recently, the spoke type of wheel has been supplanted in large part by the current disc design. Both the spoke and disc type steel wheels have been made in two parts, namely, the rim and the hub section with attached spokes or web. It has been necessary, therefore, to assemble the two parts and fasten them together, usually by riveting or other mechanical means. Such assembly work is of course expensive and introduces the possibility of failure of the means used to join the two parts.

The common metal employed for wheel construction has been steel because of its strength and availability at relatively low cost. However, with the demand for increased pay loads and the need for more effective dissipation of heat especially in heavy duty service in truck and bus operation, attention has been given to the replacement of steel by other metals. In addition, from a fabrication standpoint, steel plate has not been adapted to the production of deep drawn articles in a few steps. It has been found that a long series of operations are required to make deep drawn steel products which, of course, increase their cost.

Solution heat treated and precipitation hardened aluminum base alloys, on the basis of their properties, offer distinct advantages over steel for vehicular wheel construction. Such wheels are lighter in weight, have adequate strength and possess a higher thermal conductivity than steel, the last named property being particularly advantageous in dissipating heat generated both from brakes and tires. However, the fabrication of such wheels has presented difficult problems since the strong aluminum base alloys cannot be readily bent and drawn to a desired shape as is the case with non-heat treated alloys used in making cooking utensils. Furthermore, to forge the wheels according to conventional procedure would require at least five or six working operations with a corresponding number of dies and the labor incident to handling of the wheel between the various stages of fabrication.

My invention is directed to a method of making deep drawn aluminum base alloy forged disc wheels in the solution heat treated and precipitation hardened temper. One of the objects of my invention is to provide a method of hot shaping aluminum alloy wheels whereby a minimum amount of metal is wasted through trimming and

punching. Another object is to provide a fabrication procedure which can utilize various types of worked aluminum alloy stock. A further object is to provide a method of forging wheels which gathers sufficient metal in the region of sharp bends to prevent an undue thinning out or weakening of the wheel. A particular object is to provide a forging method which permits production of a wheel shape in only two drawing steps. Another special object is to integrate the heat treatment of the aluminum alloy forged wheel with the drawing operations whereby the finished wheel is dimensionally accurate, free from warpage and possesses the requisite of high strength. It is also an object of my invention to provide a method of fabricating forged aluminum alloy wheels which includes a slight amount of cold working in the final shaping operation.

The foregoing objects and others are realized in my method of making forged disc wheels which is more particularly described in the following specification and illustrated in the accompanying figures where

Fig. 1 is a side view of a flat circular plate.

Fig. 2 is a cross sectional view of a shaped disc forged from the circular plate.

Fig. 3 is a sectional view of the forged disc in position between the punch and die before the first pressing operation.

Fig. 4 is a sectional view of the same punch and die upon completion of the pressing operation.

Fig. 5 is a sectional view of a second punch and die at the end of the second pressing operation.

Fig. 6 is a sectional view of the die and punch used to stretch and straighten the wheel after it has received a solution heat treatment and has been quenched, and

Fig. 7 is a perspective view of the finished forged wheel.

The method of forging heat treatable aluminum base alloy disc wheels according to my invention broadly consists in first providing a circular wrought plate of suitable thickness, forging the circular shape into a shaped disc, hot pressing the disc to substantially the maximum required depth, subjecting the thus shaped cup to a further pressing to develop a detailed wheel shape, solution heat treating the drawn product. quenching it, straightening and stretching the quenched article at room temperature and finally precipitation hardening the wheel. Each of the foregoing steps contributes to developing the required sectional thickness, shape and properties of the final product. The finished wheel is of one piece construction and can be of a depth which is more than 50% of the diameter. This is a greater depth than has been produced in any steel disc wheel with which I am acquainted. Solution heat treated and precipitation hardened wheels made in accordance with my invention have such typical mechanical properties as 68,000 p. s. i. tensile strength, 57,000 p. s. i. yield strength, 13% elongation, a Brinell hardness of 130 and an endurance limit of 18,000 p. s. i. In addition, these wheels are of lighter weight than steel wheels used for the same service and therefore reduce the unsprung load of the vehicle.

The aluminum base alloys employed for the production of forged disc wheels should be of the type that requires solution heat treatment and precipitation hardened to develop a high strength. A variety of such alloys are available, the choice of any one being dependent on the particular properties desired and ease of working. Broadly speaking, alloys of the aluminum-copper-magnesium-manganese, aluminum-magnesium-silicon or aluminum-zinc-magnesium-copper types are adapted to being forged. It has been found that those alloys of the first type possess the best combination of forging characteristics and ultimate strength properties. In particular, two alloys have been found to be very successful, namely, one composed of 3.9 to 5.0% copper, 0.5 to 1.2% silicon,

0.4 to 1.2% manganese, 0.2 to 0.8% magnesium and balance aluminum and impurities; and the other composed of 3.8 to 4.9% copper, 1.2 to 1.8% magnesium, 0.3 to 0.9% manganese and the balance aluminum and impurities.

The alloys may be fabricated to convenient plate form by any conventional hot working method, such as by rolling, forging, pressing or by extrusion. Rolled plate is generally the most convenient and cheapest form of stock to use. The plate is fabricated to a thickness slightly greater than that of the major portion of the subsequently forged disc. Circles or similar shapes may be cut from such plate stock by any conventional method. The diameter and thickness of the wheel stock should be great enough to permit the formation of some flash at the periphery of the disc and thus insure complete filling of the disc forming dies as well as obviating the need for a careful cutting of the stock to exact dimensions.

In the first step of my forging procedure the circular plate is heated to a suitable forging temperature, usually between 650 and 950° F. In the case of the aluminum-copper-magnesium-manganese type of alloy it is preferred to preheat the circle to a temperature between 800 and 880° F.

The preheated circular plate is to be transferred immediately to a forging press or hammer and the plate is converted into a disc of predetermined contour between appropriately shaped dies. I prefer to use the hammer type of forging equipment inasmuch as this produces a quick, thorough working of the metal over the entire disc and distributes the stock, filling all of the recesses in the dies.

The shape of the forged disc is of paramount importance in securing a proper distribution of the metal necessary for effecting subsequent drawing operations without undue thickening or reduction in thickness of the drawn product. The forged disc is of varying thickness in the radial direction from the edge to the center. Generally speaking, the edge and adjacent portion of the disc is of substantially lesser thickness than the plate from which the disc was formed. The section thickness increases gradually in the radial direction from the edge to an annular cheek portion which is located approximately midway between the edge and the center of the disc, but the thickness of portion between the edge and cheek is still less than that of the wrought plate. One surface of the disc, which eventually forms the inside of the wheel body, is substantially flat and in one plane over the distance from the edge to a line opposite the inner edge of the cheek section. From that line the surface gradually dips toward the center thus forming a slight depression. On the other side of the disc the surface is flat for a short distance inwardly of the edge and up to the cheek portion. However, the flat portion is not parallel to the surface on the opposite side of the disc but is at a slight angle thereto, the surface rising from the edge toward the cheek and merging therewith. If desired the edge may be rounded into this surface. The annular cheek portion, referred to above, is of a thickness greater than that of the initial circular plate and has a greater cross section than the portions of the disc on either side of it. The cheek section eventually provides metal at the major right angle bend in the wheel between the web or bolt flange and the wheel rim. The enlarged cheek portion appears on but one side of the disc in the form of a gently rounded annular ridge. The width of the ridge or cheek will vary with the depth of the draw and the severity of the bend, but generally this will be between about 20 and 35% of the radius of the disc. The surface of the disc in the central part, i. e. the area circumscribed by the annular cheek, is substantially flat and in a single plane. This area is opposite the depression on the other side of the disc. As a result, the central portion of the disc is of reduced thickness and less metal is wasted in punching the hub hole than would otherwise be the case. Shaping of the disc in the foregoing manner tends to eliminate any directional properties found in the plate and to establish a radial flow of metal.

On completion of the disc forging operation the forged product is reheated to a suitable forging temperature within the range mentioned above and then subjected to the first press forging operation. In this step the forged disc is drawn into a cup shape in a single step to substantially the depth of the final product. The space between the punch and die is such as to provide a cup wall of slightly tapered section from the top to the right angle bend portion, the top being slightly thinner than the lower portion. The thickness of the section in the bend between the bottom and sides of the cup should be of a greater thickness than the portion on either side thereof to provide sufficient metal for subsequent shaping operations. The bottom portion of the drawn product can be of uniform thickness, at least over that portion which will eventually form the web or bolt flange.

The initially formed wheel shape produced by the foregoing operation is allowed to cool to room temperature and the hole for the wheel hub is machined, punched or otherwise cut out. In addition any flash at the edge of the drawn product should be trimmed off.

In preparation for the next and final drawing operation, the trimmed and punched product is reheated to the forging temperature and then subjected to the drawing operation. In this step the upper edge of the cup can be given any desired detailed shape such as one which will provide a flange for retaining the tire on the finished wheel. A further shaping and stretching at the major right angle bend can also be accomplished and thus insure sufficient thickness of metal for subsequent machining operations such as may be necessary to accommodate a tire retaining flange.

The product shaped in the foregoing step is next subjected to a solution heat treatment. This consists of heating the article to a temperature between about 850 and 1000° F., the precise temperature and length of treatment selected being determined by the composition of the alloy. The purpose of the treatment, as suggested by the term "solution," is to dissolve substantially all of the soluble alloying elements. In the case of the aluminum-copper-magnesium-manganese type the treatment should be between 910 and 950° F. The wrought product should be held within the foregoing temperature range for a period of two to six hours but under some conditions a longer or shorter period may be used depending on the heating means. Upon completion of the solution treatment the wheel should be removed from the furnace or other heating medium and quenched, preferably in water, at 140 to 160° F. It is to be understood that other quenching media may be used but water is ordinarily preferred because of its ready availability and the severity of cooling which it provides.

The quenched article may be somewhat distorted by reason of the drastic chill and, in any case, it is necessary to bring the wheel to the precise desired final dimensions. For this purpose the quenched product is cold pressed or drawn with a slight increase in diameter of the wheel. This may mean a reduction in thickness of no more than 1 or 2%. The straightening and stretching introduces some cold work which though small is nevertheless advantageous from the standpoint of increasing the fatigue life of the wheel. The cold working appears to produce stresses which are opposite to those encountered in road service. Furthermore, the cold working, which is not uniform over the entire wheel body, takes place where fatigue is likely to occur.

The final step in the process is that of precipitation hardening the cold worked wheel. Some aluminum base alloys harden sufficiently by standing at room temperature for several days while it is necessary to heat others to a low temperature to achieve the desired increase in hardness and strength. In the latter case, the treat-

ment is usually carried out within a temperature range of 250 to 450° F. over a period of 1 to 30 hours depending upon the alloy. If an aluminum-copper-magnesium-manganese alloy is used of the composition referred to above, the hardening treatment is carried out at 340 to 400° F. for a period of 5 to 15 hours. The hardened wheel is then ready for finish machining operations.

In using some aluminum base alloys it may be possible to effect sufficient solution of the soluble elements during preheating to eliminate the need for a separate solution treatment providing the forged article is quenched from the forging die. When this is done the quenched article is straightened and stretched as described above and finally precipitation hardened.

Referring to the drawings the circular disc **10** shown in Fig. 1 is forged to a shape illustrated in Fig. 2. In Fig. 2 the top flat surface **13** of the disc **12** extends inwardly of the edge over a major portion of the radial distance from the rim to the center. Between the flat portions is a depressed central area **15**. The under side of the disc, which eventually forms the exterior of the wheel, consists of slightly tapered surface **18** which merges into the annular rounded cheek section **14**. The cheek is substantially midway between the edge and the center of the disc and of a thickness greater than that of the plate from which it is made. Opposite the depression **15** and within the annular cheek section is another depression **16** having a flat surface **19**. It is from this portion of the disc that a hole is punched out to receive the axle hub. A flash **20** at the edge of the disc is subsequently trimmed.

The forged disc is drawn to the first shape in a forging press having a punch and a die as seen in Fig. 3. The die body **22** has a cavity therein having a vertical wall **24** with a beveled section **26** and a bottom **28**. The cavity, it should be noted, has a depth of more than half its diameter. The die is mounted in customary manner upon an anvil in a conventional forging press through the keyed section shown at the base of the block. The punch consists of body **30** having a substantially vertical wall **32**, but with enough draft to permit withdrawal of the punch, which blends into an upper beveled surface **34**. The punch is supported from platen **42** attached to the press ram, not shown. The bottom surface **36** of the punch merges into the vertical surface **32** over a gradual curve. Means for knocking out the drawn article when the punch is raised is illustrated by knock out plug **38**, mounted on stem **40** which passes upwardly through the punch body and through the platen **42**. The lower surface of the plug, it will be appreciated, forms a portion of the bottom punch surface during the drawing. The knock out assembly is operated by conventional means, not shown, which form a part of the forging press. A knock out assembly consisting of plug **37** mounted on stem **41** can also be provided in the die. To properly position the forged disc on die body **22** four locating blocks **44** are welded or otherwise attached to the top surface of the die adjacent the edge thereof but removed from the die cavity. To facilitate removal of the drawn article from the punch a conventional stripper may be mounted in the press which cooperates with the punch in known manner.

The relative position of punch and die with respect to the forged disc at the beginning of the pressing operation is to be seen in Fig. 3. At the end of the press stroke the punch, die and pressed product **46** are in the position illustrated in Fig. 4. The product **46** has a depth of more than 50% of the diameter of the cup.

The second drawing operation is performed with a similar punch and die assembly which is more particularly illustrated in Fig. 5. Here a die block **48** is provided with a cavity having vertical wall **50** and contoured walls **52** and **54** which assist in forming the tire flange upon the wheel. The bottom surface **56** of the die cavity provides the desired external contour of the bolt flange section of the wheel. The punch body **58** has nearly vertical surface **60** with enough draft for withdrawal of the punch and surfaces, **62** and **64**, which are complementary to **52** and **54**, respectively, of the die cavity. Surface **66** together with a portion of the bottom surface of plug **38** form the interior of the base portion of the drawn article. The knock out plug **38** and stem **40** together with platen **42** are identical with those elements appearing in Figs. 3 and 4. A knock out plug **37** and stem **41** may also be provided in the die body in a similar manner to that mentioned above in connection with the first punch and die. The product of this operation is the drawn body **68** which has a total depth only slightly greater than that of the preceding product **46**.

The straightening and stretching of the wheel is done at room temperature in apparatus shown in Fig. 6. The die body **78** is provided with a cavity having a vertical surface **80** with contoured sections **82** and **84** to accommodate the tire flange, a base surface **86** and a special corner shape **88**. The punch body **90** has an almost vertical surface **92** extending up to the platen **42**. The surface **92** has a slight draft which aids in withdrawal of the punch. This surface also merges into flat bottom surface **84** over a gradual smooth curve. The same type of knock out means, plug **38** mounted on stem **40**, is employed in the punch with plug **37** on stem **41** functioning in the die, as described hereinabove. The product of this operation, identified as **96**, has total depth substantially the same as that of the drawn article **68**.

As an example of my process, I will now describe the forging of a wheel body from an alloy having a nominal composition of aluminum, 4.4% copper, 0.8% silicon, 0.8% manganese and 0.4% magesium. This alloy in the form of hot rolled plate 1 inch in thickness is heated to a temperature of between 800 and 880° F. whereupon it is removed from the furnace or other heating means and forged under a hammer to the disc shape illustrated in Fig. 2. The section between surfaces **13** and **18** is slightly tapered because of the inclination of surface **18** and is of a thickness varying between about ¾ and ⅞ inch. The maximum cheek thickness, however, is about 1¼ inch. The central portion has a minimum thickness of about ½ inch. The forging is then reheated to the same forging temperature and hot pressed with a punch and die assembly shown in Figs. 3 and 4, the disc **12** being initially positioned on the die **22** between the locating blocks **44**. As the punch **30** descends the disc bends and assumes the shape seen in Fig. 4. It is to be noted that this shape **46** is substantially of the full depth of the wheel and that the depth is more than 50% of the diameter. A flange section is developed between the beveled surfaces **26** and **34** of the die and punch, respectively.

The initial drawn section **46** is allowed to cool to room temperature and hole **76** is punched out to accommodate the axle hub. In addition, the flash **20** on the original disc **12** is trimmed off.

The second and final pressing operation illustrated in Fig. 5 is accomplished by heating the shape **46** to the forging temperature range mentioned above and pressing it between die **48** and punch **58**. In this operation the tire flange is formed by bending the previous bevel flange of the shape shown at **70** and **72** to form a right angle section. At the major bend **74**, between the bolt flange and the tire rim a special shape is given to the wheel to provide enough metal for subsequent machining operations. In this pressing the depth of the cup is only slightly changed, the primary purpose being that of providing a detailed shape.

The hot pressed article **68** produced by the preceding operation is allowed to cool to room temperature and reheated to the solution heat treating temperature or it may be transferred directly from the forging press to the heat treating furnace. In any case, the wheel is heated to a temperature between 920 and 940° F. for 4 hours and quenched in water at 140 to 160° F. The quenched

product which may be slightly warped is placed in die 78 and stretched and straightened by downward movement of punch 90. The diameters of the die cavity and the punch are slightly greater than those of the forging press with the result that the diameter of the wheel is slightly enlarged. This introduces a small amount of cold work which is beneficial to increasing the fatigue life of the wheel. As the final step, the stretched and straightened wheel body is precipitation hardened by heating it to about 375° F. for 11 hours. The forged wheel when removed has the shape illustrated in Fig. 7, the tire rim and flange having a thickness on the order of ½ inch and the bolt flange being about 1 inch in thickness.

Having thus described my invention and an embodiment thereof, I claim:

1. The method of making precipitation hardened deep drawn cup shaped forged disc wheels of heat treatable aluminum base alloys comprising hot forging from flat stock a contoured disc one surface of which consists of a substantially flat portion extending inwardly from the edge and merging into a central depressed area while the other and opposite surface consists of a flat inclined portion adjacent the edge, said inclined portion extending upwardly toward and merging with an annular relatively wide rounded cheek section, and a substantially flat central portion within said annular cheek section, said central flat portion being opposite the depresed area on the other side of the disc, hot pressing said disc into a cup shape of substantially the depth of the final wheel with said flat and depressed area surfaces forming the interior surface of the cup, hot pressing said cup a second time to complete shaping of the wheel body, solution heat treating said wheel body, quenching it, stretching said quenched body whereby the diameter of the wheel is slightly increased and the metal is cold worked and thereafter precipitation hardening said cold worked wheel body.

2. The method of making precipitation hardened deep drawn cup shaped forged disc wheels of heat treatable aluminum base alloys comprising hot forging from flat hot worked plate a contoured disc one surface of which consists of a substantially flat portion extending inwardly from the edge over a major portion of the radial distance between the edge and center and merging with a depressed area occupying the central portion of said disc, the other and opposite surface of said disc consisting of a flat inclined portion adjacent the edge, said inclined portion extending upwardly toward and merging with an annular relatively wide cheek section substantially midway between the edge and the center of the disc, and a flattened portion inwardly of said cheek section occupying the central area of said disc, said flattened portion being opposite said depression on the other side of said disc, hot pressing said disc into a cup shape in a single operation, the depth of said cup being substantially that of the final wheel, said flat and depressed surface forming the interior of said cup, cooling said cup, punching a hub hole in the bottom of said cup, heating and pressing the cup into wheel form, solution heat treating the wheel body at a temperature between 850 and 1000° F., quenching, straightening and stretching said body whereby the diameter is enlarged and the metal is cold worked, and thereafter precipitation hardening said wheel body.

3. The method of making precipitation hardened deep drawn cup shaped forged disc wheels of heat treatable aluminum base alloys comprising heating flat plate stock to the forging temperature between 650 and 950° F., forging a contoured disc from said stock, said contoured disc having a thickened annular section substantially midway between the edge and the center of greater thickness than the original plate, the top surface of said forged disc being substantially flat over the radial distance extending inwardly from the edge to a line substantially opposite the inner edge of said thickened annular section, said flat surface merging into a central depressed area, the bottom surface of said disc consisting of an inclined flat portion inwardly of the disc edge, a raised relatively wide annular ridge and a substantially flat central portion opposite said depressed area on the other side of said disc, press forging said disc at a temperature between 650 and 950° F. into a cup shape so that the top flat surface forms the inner surface of the cup, said disc being drawn to a depth substantially that of the final wheel, cooling said cup, punching a hub hole in the bottom thereof, heating said cup to forging temperature, further press forging said cup to substantially final wheel form, solution heat treating said press forged product at a temperature between 850 and 1000° F., quenching to room temperature, cold working said wheel by slightly enlarging its diameter and thereafter precipitation hardening said wheel.

4. The method of making precipitation hardened deep drawn cup shaped forged disc wheels of heat treatable aluminum base alloys comprising forging at 650 to 950° F. a contoured disc from flat hot worked stock, one surface of said disc consisting of a substantially flat annular portion extending inwardly from the edge and merging into a central depressed area and the other and opposite surface consisting of a flat inclined annular portion adjacent the edge, said inclined portion extending upwardly toward and merging with an annular relatively wide rounded cheek section and a substantially flat central portion within said annular cheek section, said annular cheek section being substantially midway between the edge and the center of the disc and said central flat portion being opposite the depressed area on the other side of the disc, hot pressing said disc at a temperature between 650 and 950° F. into a cup shape of substantially the depth of the final wheel with said flat and depressed area surfaces forming the interior surface of the cup, cooling said cup to room temperature and punching a hub hole in the bottom thereof, heating said cup to a temperature between 650 and 950° F. and further pressing said cup into the shape of a wheel body, solution heat treating said wheel body at a temperature between 850 and 1000° F., quenching said pressed body in water below its boiling point, stretching said quenched body whereby the diameter of the wheel is increased and the metal is cold worked and thereafter precipitation hardening said cold worked wheel body at a temperature between 250 and 450° F.

5. The method of making precipitation hardened deep drawn cup shaped forged disc wheels of an aluminum base alloy composed of 3.9 to 5% copper, 0.5 to 1.2% silicon, 0.4 to 1.2% manganese, 0.2 to 0.8% magnesium and the balance aluminum and impurities comprising forging a contoured disc from plate stock at a temperature of 800 to 880° F., said contoured disc having one surface which consists of a substantially flat annular portion extending inwardly from the edge and merging into a central depressed area and the other and opposite surface consisting of a flat inclined annular portion adjacent the edge, said inclined portion extending upwardly toward and merging with an annular relatively wide rounded cheek section and a substantially flat central portion within said annular cheek section, said annular cheek section being substantially midway between the edge and the center of the disc and said central flat portion opposite the depressed area on the other side of the disc, hot pressing said disc at a temperature between 800 and 880° F. into a cup shape of substantially the depth of the final wheel with said flat and depressed area surfaces forming the interior surface of the cup, cooling said cup to room temperature and punching a hub hole in the bottom thereof, heating said cup to a temperature between 800 and 880° F. and further pressing said cup into the shape of a wheel body, solution heat treating said wheel body at a temperature between 920 and 940° F., quenching said pressed body in water at 140 to 160° F., stretching said quenched body whereby the diameter of the wheel is increased and the metal is cold worked and thereafter

precipitation hardening said cold worked wheel body at a temperature between 340 and 400° F.

6. The method of making precipitation hardened deep drawn cup shaped forged disc wheels of heat treatable aluminum base alloys comprising hot forging from flat stock a contoured disc one surface of which consists of a substantially flat portion extending inwardly from the edge and merging into a central depressed area while the other and opposite surface consists of a flat inclined portion adjacent the edge, said inclined portion extending upwardly toward and merging with an annular relatively wide rounded cheek section, and a substantially flat central portion within said annular cheek section, said central flat portion being opposite the depressed area on the other side of the disc, hot pressing said disc into a cup shape of substantially the depth of the final wheel with said flat and depressed area surfaces forming the interior surface of the cup, hot pressing said cup a second time to complete shaping of the wheel body, quenching said body from the die, stretching said quenched body whereby the diameter of the wheel is slightly increased and the metal is cold worked and thereafter precipitation hardening said cold worked wheel body.

7. The method of making precipitation hardened deep drawn cup shaped forged disc wheels of heat treatable aluminum base alloys comprising heating flat plate stock to the forging temperature between 650 and 950° F.,

forging a contoured disc from said stock, said contoured disc having a thickened annular section substantially midway between the edge and the center of greater thickness than the original plate, the top surface of said forged disc being substantially flat over the radial distance extending inwardly from the edge to a line substantially opposite the inner edge of said thickened annular section, said flat surface merging into a central depressed area, the bottom surface of said disc consisting of an inclined flat portion inwardly of the disc edge, a raised relatively wide annular ridge and a substantially flat central portion opposite said depressed area on the other side of said disc, press forging said disc at a temperature between 650 and 950° F. into a cup shape with said cheek section at the major bend between the vertical and horizontal walls of the cup, the cup being drawn to a depth equal to more than half the diameter of the cup, the top flat surface of said disc also forming the interior of the cup, cooling said cup, punching a hub hole in the bottom thereof, heating said cup to a temperature between 650 and 950° F., further press forging said cup to wheel form by forming a tire retaining right angle flange at the edge thereof, solution heat treating said flanged wheel at a temperature between 850 and 1000° F., quenching, cold working said wheel by enlarging its diameter and thereafter precipitation hardening said cold worked wheel.

No references cited.