

[54] **METHOD AND APPARATUS FOR MAKING GROOVED WHEELS**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 854,957, Nov. 23, 1959, Pat. No. 3,087,531, and a continuation of Ser. No. 266,451, March 19, 1963, abandoned.

[52] U.S. Cl. **29/159 R, 72/83**

[51] Int. Cl. **B21d 53/26, B21k 1/42, B21d 22/14**

[58] Field of Search **29/159, 64; 72/83, 84; 77/32.8; 82/101**

[56]

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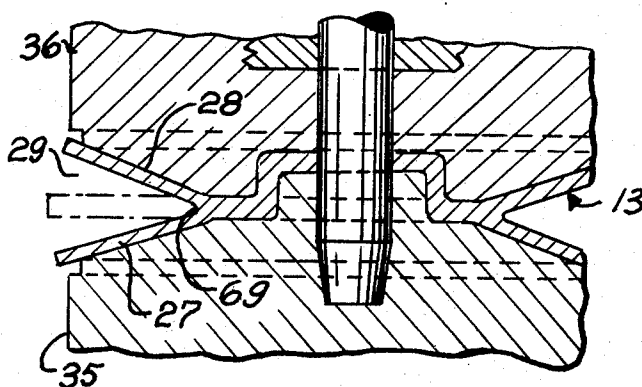
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[57]

ABSTRACT

This invention relates to the manufacture of peripherally grooved members, such as peripherally grooved wheels, pulleys, sheaves and other wheel-like members, and provides a novel method and novel apparatus for producing such grooved members by a blank-splitting procedure. The grooved members are hereinafter referred to merely as grooved wheels.

26 Claims, 10 Drawing Figures



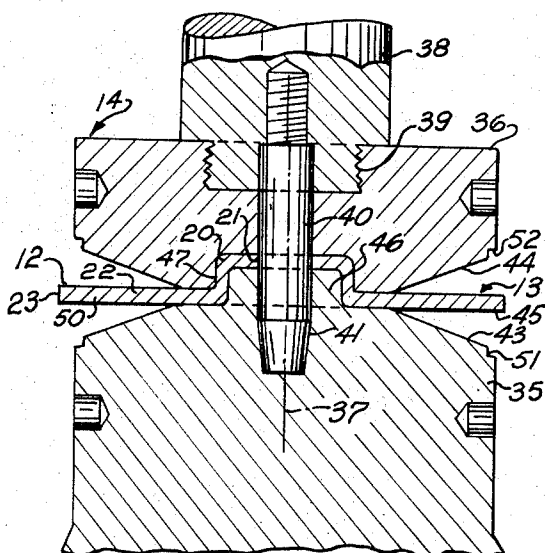


FIG. 1

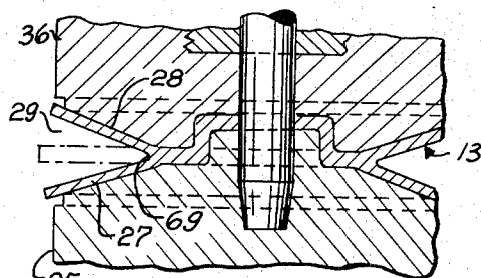


FIG. 2

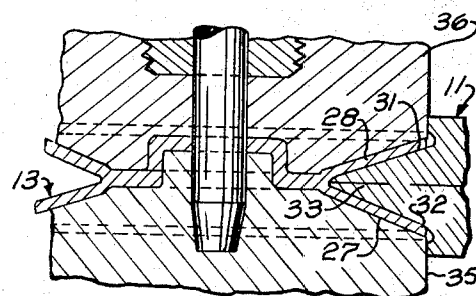


FIG. 3

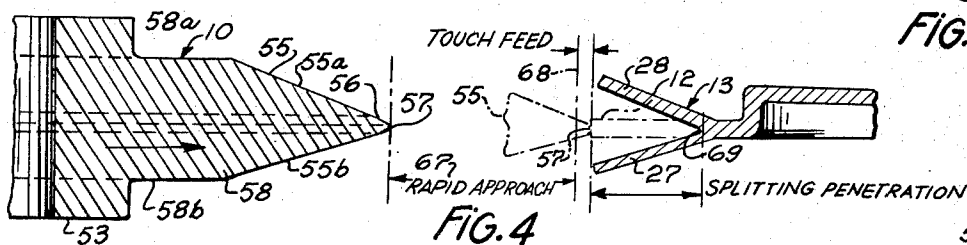


FIG. 4

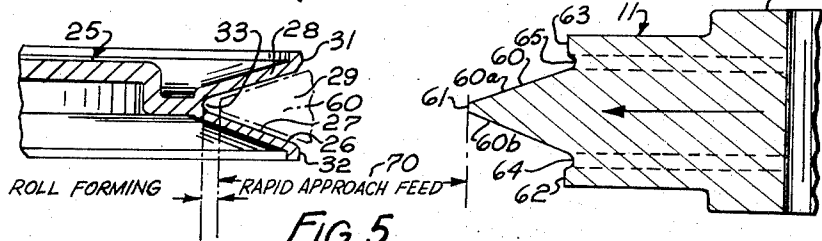


FIG. 5

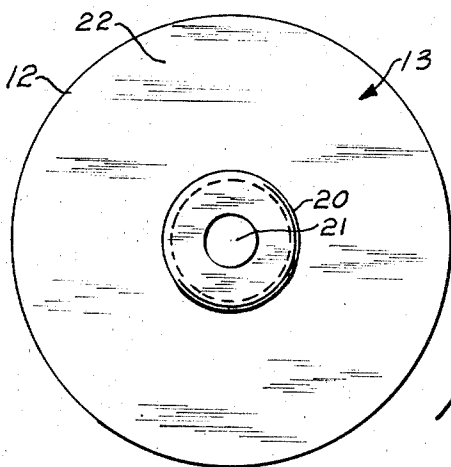


FIG. 6

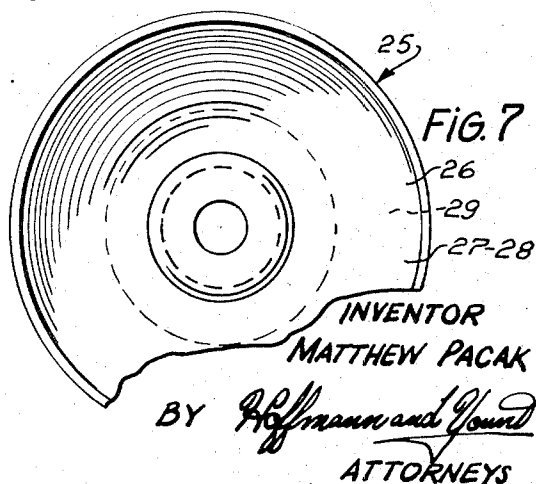


FIG. 7

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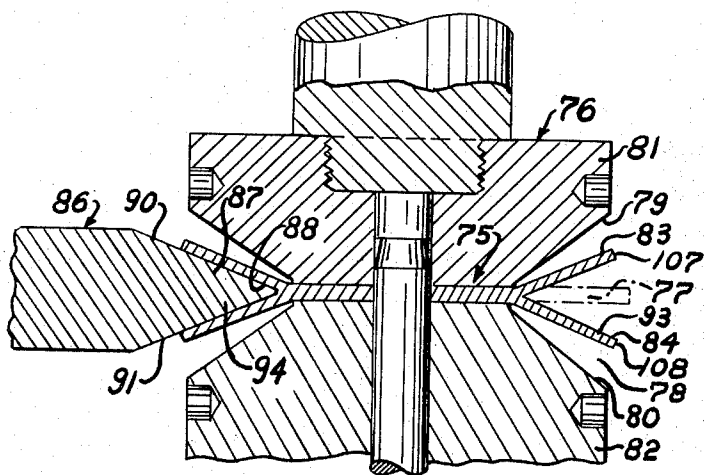


FIG. 8

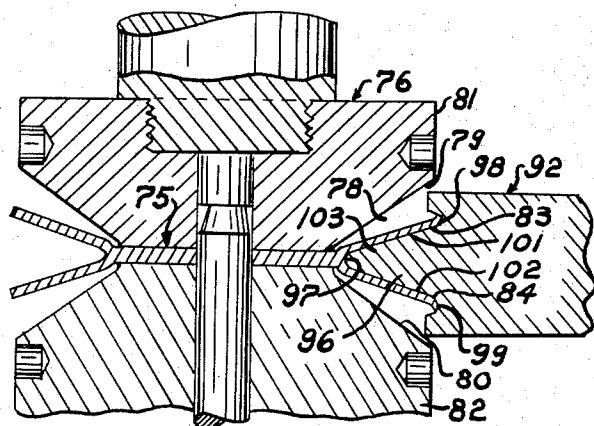


FIG. 10

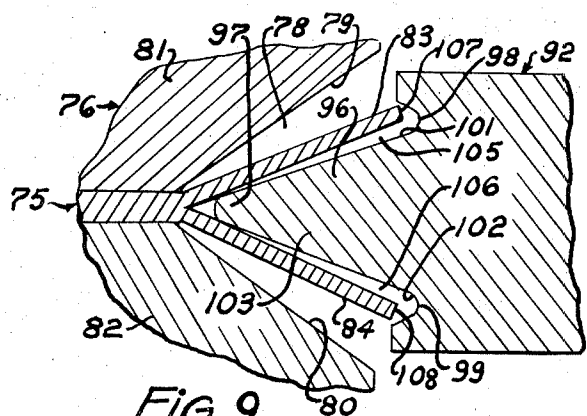


FIG. 9

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METHOD AND APPARATUS FOR MAKING GROOVED WHEELS

This application is a continuation-in-part of original application Ser. No. 854,957, filed Nov. 23, 1959, now U.S. Pat. No. 3,087,531, issued Apr. 30, 1963, and a continuation of my copending application Ser. No. 266,451, filed Mar. 19, 1963 now abandoned.

Various problems are encountered in attempting to produce grooved wheels by such a blank-splitting procedure using a penetrating roller as the splitting tool. One problem has to do with the manner of engaging the splitting tool with the blank so as to avoid damage thereto as by tearing or bending, or by a harmful run-off of the tool from the blank edge engaged thereby. In the method of this invention this problem is successfully met by providing for a slow-feed touch engagement of the tool edge with the blank followed by a more rapid feed for penetrating the tool into the blank.

Another problem concerns the matter of tool life for the splitting tool and the rate of penetration of the splitting tool into the blank. If the splitting tool has an annular edge portion which is relatively thin or sharp by reason of its having a small or very acute included angle, the tool will penetrate rapidly but will have only a short life because of the greater vulnerability to dulling. Rapid dulling of the splitting tool is a serious disadvantage because the need for frequent tool replacement interrupts the production operation of the machine and moreover, a dull condition of the splitting tool of itself slows production output and results in a poor quality of product.

On the other hand, if the edge portion of the splitting tool is relatively thick or blunt by reason of its included angle being less acute, a longer tool life will be achieved but blank penetration and work output will be slower and the tendency for tool run-off will be greater. In the present invention this problem of tool life and rate of blank penetration is successfully met by the use of a splitting tool having an edge characteristic particularly suitable for the character of the operation being performed.

In referring herein to the edge portion of the splitting tool as being either sharp or blunt, it should be understood that these terms are being used to describe or compare the acuteness of the convergent side faces of such edge portion and do not refer to any particular condition of sharpness of the extreme apex or knife-edge located precisely at the junction or intersection of the convergent side face. The sharpness of the knife-edge at the extreme apex concerns the method of this invention only in relation to the acuteness, that is, the thinness or thickness of the edge portion adjacent to but behind the knife-edge. This is true because, even if such a knife-edge of an extremely sharp character is initially provided on the splitting tool, it will necessarily become dulled by rounding or flattening thereof against the workpiece during the very first, or first few, splitting operations carried out whereas the angle of convergence of the side faces of the edge portion of the splitting tool will remain substantially unchanged.

Therefore, it will be recognized that a splitting tool having a relatively sharp edge portion, as contemplated by this invention, is one whose convergent edge portion adjacent the knife-edge is relatively thin or more acute, and a splitting tool having a blunt edge portion is one whose convergent edge portion adjacent the knife-edge

is thicker or relatively less acute. The radial length of the convergently tapered portion or portions supporting the knife-edge can, of course, be varied as desired and will depend largely on the cross-sectional shape and axial thickness of the portion or portions of the splitting tool which connects the convergent portion or portions with the hub of the tool.

Having in mind these and other problems this invention provides, as one of its objects, a novel method and novel apparatus by which grooved wheels can be produced rapidly and economically by a splitting procedure and with a desired quality and uniformity in the articles produced.

Another object is to provide a novel method and novel apparatus for producing grooved wheels and involving the use of sharp-edged and blunt-edged tools, preferably rollers, and the application of such tools in succession to the edge portion of a blank for splitting the edge portion and then forming the blank by shaping the split portion thereof into a rim.

A further object is to provide a novel grooved wheel making method and novel apparatus, of the character referred to above, wherein the workholder means comprises cooperating holder members having bevel portions defining a groove into which the edge portion of the blank projects, and wherein the tools cooperate with the blank for splitting and shaping such edge portion into a wheel rim of the desired form.

Still another object is to provide a novel method and novel apparatus for producing grooved wheels by splitting and shaping the edge portion of a blank and wherein flanges forming the sides of the split portion are deflected, during the splitting, to a given divergence angle therebetween and are subsequently deflected back to a lesser included divergence angle.

Yet another object is to provide such a novel method and novel apparatus for making grooved wheels wherein the extent to which the flanges of the split portion are opened or spread apart is less than the width of the groove of the workholder means during both the splitting step and the subsequent forming step, so that the flanges always remain in a spaced relation to the sides of the workholder groove.

Additionally, this invention provides such a novel method and apparatus for making grooved wheels in which the forming of the split portion to final wheel rim shape includes beading of the peripheral edges of the flanges and deflecting or closing the flanges to a smaller included angle than that to which they were previously opened during the splitting step.

Other objects, novel characteristics and advantages of this invention will be apparent in the following detailed description and in the accompanying drawings forming a part of this specification and in which,

FIG. 1 is a partial vertical axial section taken through a rotatable workholder means having a blank therein to be split, and showing the blank prior to the splitting thereof;

FIG. 2 is another such partial vertical axial section taken through the workholder means and showing the blank after the splitting thereof;

FIG. 3 is a similar partial vertical axial section but showing the split blank after the forming operation thereon, and also showing the cooperation of bead-forming shoulders of an associated forming roller with the workholder means;

FIG. 4 is a vertical axial section of a somewhat diagrammatic form showing the shape of the splitting tool and illustrating the procedure sequence in accomplishing the splitting of the blank;

FIG. 5 is another vertical axial section of a diagrammatic form showing the shape of the forming roller and further illustrating the shaping of the split blank to wheel rim form;

FIG. 6 is a plan view of the blank before being placed in the workholder means;

FIG. 7 is a partial plan view of the completed article;

FIG. 8 is a vertical axial section similar to that of FIG. 2 but showing a modification of the invention;

FIG. 9 is a fragmentary axial section on a larger scale showing the start of the forming step of such modification; and

FIG. 10 is an axial section similar to that of FIG. 3 and showing the condition of the blank upon completion of the forming step.

The method and apparatus of this invention are intended for the rapid and economical production of grooved wheels of good quality and uniformity, such as pulleys, sheaves and the like, by splitting and shaping of a sheet metal blank. The invention involves the use of splitting and forming tool means and the engagement thereof in a particular manner with the edge portion of the metal blank so as to split and form such edge portion into a grooved rim.

The tool means is here shown as comprising rollers 10 and 11, which are successively brought into operative engagement with the edge portion or periphery 12 of a disk-shaped metal blank 13 for splitting such edge portion and shaping the same into a grooved rim, while the blank is being held and rotated by a workholder means 14.

The splitting and forming rollers 10 and 11 and the workholder means 14 ordinarily comprise components of a wheel making apparatus, such as the machine shown and described in the original application identified above. In that machine the workholder means 14 is located between a pair of tool carrying heads which support the splitting and forming rollers 10 and 11 so that these rollers are movable into engagement with the edge portion 12 of the blank 13 from opposite sides of the rotation axis of the workholder means.

The blank 13 is shown, by way of example, as being a disk-like sheet metal stamping (see FIGS. 1 and 6) having a cup-shaped central hub 20 provided with an opening 21 and a flat circular plate portion 22 connected with the hub in a radially projecting relation thereto and terminating in the flat annular edge portion 12. The edge portion 12 presents a radially outwardly facing circular edge wall 23 of an axial dimension corresponding with the thickness of this portion of the blank.

The blank 13 can be of any sheet stock suitable for the splitting procedure disclosed herein and is of a thickness having a suitable relation to the diameter of the blank. The sheet stock is preferably one which will have a desired uniformity as to the hardness and grain structure of the edge portion 12, so as to facilitate the splitting procedure and the accuracy thereof. If the blank 13, or the sheet stock from which it is obtained, does not initially have the hardness and grain structure characteristics needed for a good splitting action, it can

be suitably treated as by annealing, heat-treating or other such steps to acquire the needed characteristics.

Although the blank 13 is shown as being a one-piece stamping it may, if desired, be a well-known form of wheel structure comprising a hub member and a disk member suitably connected to such hub member.

FIG. 7 shows a completed article 25, in this case a grooved wheel having the form of a pulley, which has been produced from the blank 13 in accordance with this invention and which is of a circular shape having an annular rim portion 26 defined by a pair of divergent walls or flanges 27 and 28 (see FIG. 5) separated by an intervening V-shaped annular groove 29 for receiving a belt or the like. The rim portion 26 is formed by splitting and shaping the annular rim portion 12 of the blank 13, as will be fully developed hereinafter. The outer peripheral or free edges of the divergent flanges 27 and 28 extend in an axially oppositely deflected relation as annular beads 31 and 32 formed on these walls. The bottom of the V-shaped annular groove 29 preferably has the form of a transversely concave annular fillet portion 33 which merges with, and smoothly joins, the adjacent surfaces of the divergent flanges 27 and 28.

The workholder means 14 is shown in FIG. 1 as comprising cooperating workholder members 35 and 36 which are rotatable about a common axis 37 and of which the lower workholder member 35 is an anvil member and the upper workholder member 36 is a clamping member for clamping the blank 13 against the anvil member. The clamping member 36 is movable toward and away from the anvil member 35 for clamping or releasing the blank 13, as by means of a reciprocally movable actuating rod 38 to which the clamping member is attached by a threaded connection 39. The workholder means 14 also includes a pilot pin 40 extending through, and projecting from, the clamping member 36 and which is movable into a socket 41 of the anvil member 35 by passage through the opening 21 of the blank.

The workholder members 35 and 36 are provided with annular bevel surfaces 43 and 44 on their adjacent ends which co-operate to define an inwardly converging annular work groove 45 having an included angle, which in the form of the invention disclosed in FIGS. 1 to 5, corresponds substantially with the angle of divergence of the pulley rim flanges 27 and 28. The anvil member 35 is here shown as having a central axial stem portion or boss 46 which enters the recess of the cup-shaped hub portion 20 of the blank 13 and the clamping member 36 is provided with a cup-shaped mating central axis recess 47 for receiving the hub of the blank, so that the cooperation of these portions of the workholder members with the blank will result in the blank being securely held therebetween with the flat annular edge portion 12 projecting radially into or through the work groove 45.

When the blank 13 has been clamped in the workholder means 14 in the relation just described above the mid-plane 50 of the flat plate portion 22 of the blank will be substantially coincident with the transverse mid-plane of the annular work groove 45 which is also the parting plane between the workholder members 35 and 36. The workholder members 35 and 36 are also provided at the outer edges of the bevel sur-

faces 43 and 44 with annular recesses or notches 51 and 52 to which further reference will be made in connection with the description of the formation of the beads 31 and 32 on the rim portion 26 of the wheel 25 being produced.

The splitting roller 10 is of an appropriate size in relation to the dimensions of the blank 13 on which it is to operate and is shown as having a hub portion 53 by which this tool can be rotatably mounted on a suitable shaft or arbor (not shown). The splitting roller 10 is also shown as having outwardly convergent annular portions comprising a ridge-shaped portion 55 and an edge portion 56, the latter of which terminates in and supports an annular apex or knife-edge 57.

The portion of the roller 10 which connects the annular ridge portion 55 with the hub 53 is here shown as being an annular radial portion 58 having parallel annular sides 58^a and 58^b. The included angle between the convergent side faces 55^a and 55^b of the ridge portion 55 is of a suitable value corresponding substantially with the included angle of the V-shaped groove 29 of the wheel 25 to be produced. The groove 29 of the wheel 25 is here shown as having an included angle of 37° but the included angle of this groove could be of any desired value between, say, 30° and 90°. The splitting roller 10 is made of suitable material such as hardened tool steel.

It has already been indicated above in a general way that the included angle of the convergent annular edge portion 56 which is adjacent the knife-edge 57 of the splitting roller 10 is an important characteristic because, if this edge portion is relatively thin, that is, defined by a very small included angle, it will be subject to rapid dulling, and consequently, the tool will have a short life and will need frequent replacement which will mean frequent interruptions in the production operation of the machine 16. On the other hand, if the convergent annular edge portion 56 is less sharp by reason of its being thicker, that is, having an included angle of a relatively large value, the tool will have a greater useful life but will penetrate the blank more slowly and will also be subject to a greater tendency for run-off of the tool from the edge portion of the blank.

The present invention contemplates the use of a sharp annular splitting edge portion 56 on the roller 10, that is, a convergent or V-shaped annular edge portion immediately adjacent the knife-edge 57 and which is defined by an included angle not materially greater than, say, 75°. A splitting edge of this sharpness, that is, a convergent or V-shaped annular edge portion having an included angle of a value from 30° to 75°, will provide a relatively rapid penetration rate with a good tool life and will also operate satisfactorily in contacting or marking the edge of the blank during feeding engagement therewith with very little tendency to tear or deflect the blank or to have any marked run-off tendency. The ridge portion 55 and the sharp annular edge portion 56 of the splitting roller 10 are symmetrical in cross-sectional shape, as shown in FIG. 4, with the knife-edge 57 lying in the radial mid-plane of the roller.

The forming tool 11 is shown in FIG. 5 as having a hub portion 59, by which this roller can be rotatably mounted on a suitable shaft or arbor (not shown), and carries an outwardly convergent annular ridge portion 60 terminating in a blunt or transversely convex

peripheral edge 61. The annular ridge portion 60 is substantially V-shaped and constructed so that the included angle between the side faces 60^a and 60^b thereof will correspond substantially with the included angle of the annular groove 29 desired in the completed wheel 25 and which, in this case, is an included angle of approximately 37° as mentioned above. The transverse curvature of the apex of the blunt or convex peripheral edge 61 is substantially the same as the transverse shape of the filleted portion 33 of the completed wheel 25.

The forming roller 11 is provided with radially facing annular shoulders 62 and 63 on opposite sides of the ridge portion 60 and with annular bead forming grooves 64 and 65 recessed into these shoulders and merging smoothly with the side faces 60^a and 60^b of the ridge portion adjacent the base of the latter. The roller 11 is made of a suitable material such as hardened tool steel.

In the performance of the splitting procedure of this invention the blank 13 is clamped in the workholder means 14 in the relation shown in FIG. 1 and described above, and the splitting roller 10 is advanced toward the peripheral edge face 23 of the blank with the sharp annular edge portion 56 of the roller lying in or centered on the mid plane 50 of the blank. The feeding movement of the roller 10 toward the blank 13 is carried out with an initial rapid approach movement, represented for example by the dimensional distance 67 indicated in FIG. 4, and brings the splitting edge 56 to the position represented by the line 68, that is, at or about a distance comprising a fraction of an inch, say, approximately one-eighth of an inch, from the edge face 23 of the blank.

The rapid approach feeding movement of the splitting roller 10 can be at any suitable fast rate, but the movement of the tool to advance the splitting edge 56 from the position represented by the line 68 into a touch engagement or marking contact with the edge face 23 of the blank should be at a relatively slow rate of feed. The rate of feed for this touch engagement can be reasonably varied and will depend to an appreciable extent upon the dimensions and characteristics of the blank 13 and of the splitting tool 10. For some blank materials and dimensions touch feed movements of from 3 to 10 inches per minute are appropriate and have been used in the method hereof. Such an appropriate slow touch feed movement of the splitting edge 56 into engagement with the blank 13 will cause the edge face 23 of the blank to be marked therearound on the midplane 50 with little or no run-off tendency of the tool and with little or no likelihood of the blank being torn or deflected.

As soon as the splitting edge 56 has been brought into such a marking engagement with the edge face 23 of the blank 13 by the slow touch feed movement just described above, the splitting roller can then be advanced at a more rapid feeding rate for penetrating the tool into the edge portion 12 of the blank to split the same. The feeding rate for the roller 10 during this splitting penetration can be at a rate considerably faster than the touch feed movement. Again, the penetrating feed movement can be reasonably varied and will depend to an appreciable extent upon the dimensions and characteristics of the blank and splitting tool, as well as

on the value of the pressure being applied. For certain blanks a penetrating feed of approximately 35 inches per minute has been found satisfactory. The pressure for causing the roller 10 to penetrate the blank is applied through the shaft or arbor 54^a thereof and is of a value suitable for the blank and for the rate of penetration desired.

During the splitting and forming operations performed on the blank 13, the workholder means 14 is driven and rotates the blank at a suitable speed which can be varied depending upon the size of the blank, characteristics of the metal thereof, the characteristics of the tools 10 and 11, and various other factors. The splitting roller 10 can be rotatably driven by appropriate power means, provided that it is not rotated at a faster speed than the blank 13. In the machine disclosed in said original application, however, the splitting roller 10 is rotated merely as the result of its engagement with the rotatably driven blank 13.

The relatively slow touch feed movement for the splitting roller 10 is needed when this roller is not separately driven because, in addition to the start of the penetration of the splitting edge portion 56 into the blank 13, the splitting roller must be accelerated during the touch engagement from a zero speed to the rotative speed at which the blank is being driven by the workholder means 14. This acceleration of the splitting tool 10 represents a drag applied thereby to the annular edge portion 12 of the blank and, if the drag effect is too severe, there is a possibility that tearing or other damage may be inflicted on the blank. The sequence described above for the different speeds of feeding movement is not essential and any desired rates and sequence of feeding movements can be employed, so long as they provide for a slow-feed touch engagement of the splitting roller with the edge portion of the blank which will permit acceleration of the splitting roller without damaging the blank.

The penetration of the edge portion 56 of the roller 10 into the blank 13 splits the edge portion 12 of the latter peripherally therearound by dividing such edge portion into the two spaced or divergent flanges 27 and 28, as shown in FIG. 2. When the splitting roller 10 has been advanced toward the workholder means 14 for a feeding distance sufficient to cause the edge portion 56 to penetrate and split the blank for the desired depth, the flanges 27 and 28 will be opened or spread by deflection thereof toward the bevel faces 43 and 44 of the workholder members 35 and 36 and will, in the form of the invention disclosed in FIGS. 1 to 5, be pressed against these faces by the action of the inclined side walls 55^a and 55^b of the ridge portion 55.

The splitting of the edge portion 12 of the blank 13 and the spreading apart or opening of the flanges 27 and 28 results in the formation of the annular groove 29 which will have an included angle of approximately the same value as that desired in the completed wheel 25, namely the 37° included angle referred to above, but the bottom portion 69 of this groove will still have a sharp-V shape as shown in FIGS. 2 and 4 and corresponding with the sharp-V shape of the annular splitting edge 56 of the roller 10. At the completion of the splitting step performed by the roller 10, the outer or free annular edges of the divergent flanges 27 and 28 will project beyond the inner edges of the annular

notches 51 and 52 of the workholder members 35 and 36, as shown in FIG. 2.

In shaping the split portion of the blank 13 to wheel-rim form, the forming roller 11 is advanced into operative engagement with such split portion as represented in FIG. 5 and results in a shaping, or reshaping, of the split portion to the condition illustrated in FIG. 3 and corresponding with the shape desired for the rim portion of the completed wheel 25.

As indicated in FIG. 5, the advance feeding movement of the forming roller 11 is preferably carried out with a rapid approach feed represented by the dimensional distance 70 and is then advanced into engagement with the split portion with a slower feeding rate to accomplish the forming operation on the blank.

For the purpose of the forming operation by the roller 11, the split blank 13 is rotated by the workholder means 14. The roller 11 can if desired be individually driven but, in the machine of which the workholder 14 usually forms a part, is driven only by its engagement with the blank 13.

During the feeding movement of the forming roller 11, the ridge-shaped portion 60 thereof enters the groove 29 of the blank to thereby bring the side faces 60^a and 60^b of the ridge portion into a smoothing and flattening engagement with the divergent flanges 27 and 28. More important, however, is the cooperative engagement of the blunt edge 61 of the forming roller with and in the sharp-V bottom portion 69 of the groove which causes a widening and reshaping of this bottom portion into the transversely concave smoothly-filleted annular bottom portion 33 shown in FIGS. 3 and 5 and which is the desired finished shape and contour for the bottom of this groove in the completed wheel 25.

The feeding movement of the forming roller 11 also brings the bead-forming grooves 64 and 65 thereof into deflecting engagement with the free annular edges of the divergent flanges 27 and 28 to form those edge portion into the smooth annular beads 31 and 32 on the rim of the completed wheel 25.

The engagement of the forming roller 11 with the blank as described above is carried out by the use of a pressure of a suitable value applied to the forming roller through the support shaft or arbor 59 thereof to accomplish the forming or shaping of the split portion of the blank to the desired final wheel-rim form.

FIGS. 8, 9 and 10 of the drawings show a modification of this invention in which a blank 75 similar to the blank 13 is split around the peripheral edge thereof, and the split portion subsequently formed to a desired wheel-rim shape. The blank 75 is held in rotatable workholder means 76 which is similar to the workholder means 14, and an annular edge portion 77 of the blank projects into an annular work groove 78 of the workholder means. The work groove 78 is defined by divergently disposed annular walls 79 and 80 of a pair of cooperating workholder members 81 and 82.

The peripheral edge portion 77 of the blank 75 is split into two flanges 83 and 84 by penetration of a splitting roller 86 into such edge portion. The splitting roller 86 is similar to the splitting roller 10 described above in that it has a ridge-shaped portion 87 carrying a relatively sharp annular edge portion 88. The ridge-shaped portion 87 and the edge portion 88 are defined

by convergent side faces 90 and 91 on opposite sides of the roller. The inclination of the side faces 90 and 91 is selected so that satisfactory splitting of the edge portion 77 will be obtained by penetrating the splitting roller thereto, as well as a spreading of the flanges 83 and 84 to the extent needed to provide a split portion 93 on the blank which can be readily further shaped to the desired final wheel-rim form by a forming roller 92 of a shape similar to that of the forming roller 11. The splitting roller 86 is here shown as having an included angle 94 between its inclined side faces of approximately 42°, but this angle can be varied to suit different materials and circumstances.

The workholder means 76 is constructed so that, when the blank 75 is being held between the workholder members 81 and 82, the work groove 78 will be of a size and cross-sectional shape to readily accommodate the split portion 93 of the workpiece. The inclination and positioning of the divergent annular walls 79 and 80 are such that, when the blank has been split and the flanges 83 and 84 spread apart by penetration of the splitting roller 86 to the desired distance into the blank, the flanges will lie adjacent to, but will be spaced from, the divergent walls 79 and 80 as shown in FIG. 8.

For various reasons it is desirable to carry out the splitting of the edge portion 77 while the latter is disposed in the work groove 78. One of the reasons is that the portion of the blank being subjected to the splitting operation will then be in a partially housed condition and, in the event that pieces or slivers of metal are dislodged from the blank by the splitting roller, they will be somewhat confined and less likely to fly about in a loose condition. The work groove 78 will accomplish this confining action also with respect to pieces which may be severed from the blank by the splitting roller 86 in the event of run-off of the latter from the edge portion 77.

Although it is desirable to carry out the splitting of the blank with the edge portion 77 housed in the work groove 78 as just above explained, it is also important that the flanges 83 and 84 remain spaced from the walls 79 and 80 of the work groove as previously mentioned. One important advantage for having the flanges 83 and 84 spaced from the walls 79 and 80 is that any surface imperfections on the outer wall surfaces of flanges 83 and 84 will not be transferred to the belt-contacting inner faces of the flanges in the completed pulley.

Another advantage realized in having the work groove 78 of a size and shape such that the flanges 83 and 84 are always spaced from the walls 79 and 80 is that the splitting operation can be carried out more readily and without hindrance. This result is achieved because the intervening space between the flanges 83, 84 and the walls 79, 80 accommodates slight variations in the positioning of the flanges whereas, if either of the flanges should be pushed into abutting engagement with its associated workholder wall, further penetrating movement of the splitting roller 86 into the blank would be hindered.

FIGS. 9 and 10 of the drawings show the forming roller 92 as being similar to the forming roller 11 and as being used in a similar manner for shaping the split portion 93 of the blank 75 to the wheel-rim form desired in the completed article. The forming roller 92 has a

ridge-shaped portion 96 carrying an annular edge portion 97 which is relatively blunt as compared with the edge portion 88 of the splitting roller 86. The edge portion 97 is convexly curved transversely thereof and performs the same function as the blunt edge portion 61 of the forming roller 11 in reshaping the bottom of the groove of the split portion 93 of the blank. The forming roller 92 is also provided with bead-forming grooves 98 and 99 in the same location and for the same purpose as the bead-forming grooves 64 and 65 of the forming roller 11.

The ridge-shaped portion 96 has inclined side faces 101 and 102 and is of a size and cross-sectional shape, in relation to the size and cross-sectional shape of the work groove 78, such that the forming roller 92 will perform its intended function of shaping the split portion 93 of the blank to the desired final wheel rim shape while the flanges 83 and 84 remain in an adjacently spaced relation to the divergent walls 79 and 80 of the workholder means 76. This adjacently spaced relation for the flanges 83, 84 relative to the divergent walls 79, 80 of the work groove is desirable because it results in the same advantages during the operation of the forming roller 92 as result during the operation of the splitting roller 86 and which advantages were explained above.

In FIG. 9 of the drawings the forming roller 92 is shown in the position where it has entered the groove of the split portion 93 of the blank 75 to the point of just starting the reshaping of the bottom portion of such groove. The ridge-shaped portion 96 of the forming roller 92 is constructed with an included angle 103 of a suitable value between the inclined sides 101 and 102 to provide the cross-sectional shape relationship referred to above between the forming roller and the work groove 78. In this case, the ridge-shaped portion 96 of the forming roller 92 is shown as having an included angle of approximately 36° which is a smaller included angle than that of the splitting roller 86.

When the forming roller 92 has been advanced into the split portion 93 of the blank to the point where the forming operation is just starting as shown in FIG. 9 it will be noted that, since the included angle of the forming roller is smaller than the included angle of the splitting roller 86, there will be crevice spaces 105 and 106 remaining between the flanges 83, 84 and the sides 101, 102 of the forming roller. As the forming roller 92 is moved farther into the split portion 93 of the blank, the blunt edge portion 97 will reshape the bottom of the groove of the blank to a transversely concave cross-section and, while this is taking place, the flanges 83 and 84 will have a resulting inherent tendency to move or swing in a closing direction.

This closing movement of the flanges 83 and 84 causes them to come into engagement with the sides 101 and 102 of the forming roller 92 whereby the flanges assume positions to provide the grooved rim of the article with the desired final shape. As the flanges 83 and 84 close against the sides of the forming roller 92, the peripheral edge portions 107 and 108 of the flanges are received in the beading grooves 98 and 99. The continued inward movement of the forming roller 92 by which the blunt edge portion 97 completes the reshaping of the bottom portion of the groove to the desired concave form, the beading grooves 98 and 99

act on the peripheral edge portions of the flanges to form or upset the same into beads of the shape shown in FIG. 10.

From the accompanying drawings and the foregoing detailed description it will now be readily understood that this invention provides a novel method and apparatus for rapidly and economically producing annularly grooved wheels by a blank splitting and forming procedure involving the pressure application of tool means to the annular edge of a blank being rotatably driven. It will also be seen that the tool means is applied to the blank in a particular manner and comprises a sharp-edged splitting roller and a blunt-edged forming roller, such rollers being operatively engaged with the blank in succession while the blank is being held and rotated by the workholder means. The use of the sharp-edged splitting tool and the application thereof to the blank in the manner hereinabove described, makes possible a rapid splitting of the edge portion of the blank, and the use of the blunt-edged forming tool applied to the work in the manner described makes possible a rapid forming or reshaping of the split portion of the blank to the shape desired for the rim portion of the completed wheel.

It will now also be understood that this invention provides such a novel method and apparatus for producing grooved wheels wherein the splitting of the blank and the forming of the split portion to grooved-rim shape are carried out to further advantage with the flanges of the split portion relatively unsupported by the workholder means during both the splitting procedure and the subsequent forming procedure.

Although the wheel making method of this invention has been illustrated and described herein to a somewhat detailed extent, it will be understood, of course, that the invention is not to be regarded as being correspondingly limited in scope but includes all changes and modifications coming within the terms of the claims hereof.

Having described my invention, I claim:

1. In a method of forming sheaves, pulleys and similar articles having a peripheral V-groove defined by a pair of substantially straight flanges: the steps comprising forming a sheet metal disc-shaped blank, rotating said blank, initially slitting said blank at its peripheral edge to form a peripheral groove and two angularly extending flanges by movement of a slitting tool radially of the rotating blank, progressively pressing said flanges laterally, expanding said groove while progressively slitting the blank by continuing the radial movement of the slitting tool, and forming straight flanges by the continuing movement of the slitting tool.

2. The method of making grooved wheels which comprises; rotating a metal blank having an annular peripheral portion; providing tool means having a relatively sharp edge portion; engaging said edge portion with said peripheral portion; and splitting said peripheral portion annularly therearound into a grooved wheel rim; the movement of said tool means relative to said peripheral portion comprising an initial rapid-feed approach movement, followed by a slow-feed touch engagement of said edge portion with said peripheral portion, and a subsequent rapid-feed movement and pressure penetration of said edge portion into said peripheral portion for splitting the same.

3. The method of making grooved wheels according to claim 2 wherein said tool means comprises a roller having said relatively sharp edge portion extending therearound as a continuous annular edge portion; and bringing said annular edge portion into contact with said peripheral portion by said slow-feed touch engagement.

4. The method of making grooved wheels according to claim 2 wherein said tool means comprises roller means; and wherein said roller means is rotated and accelerated by said touch engagement to substantially the speed of rotation of said blank.

5. The method of making grooved wheels which comprises; rotating a metal blank having an annular peripheral portion; splitting said peripheral portion annularly therearound by pressing thereinto a first roller having a relatively sharp annular edge portion so as to form on the blank an annular split portion having divergent flanges which include free annular edges, and an intervening annular groove between said flanges and whose bottom portion corresponds substantially in cross-sectional shape with said edge portion; applying to said split portion a second roller having a convergent annular ridge portion terminating in a blunt peripheral edge and also having lateral annular shoulders on opposite sides of said ridge portion; shaping said split portion into a rim by advancing said ridge portion therein to in spreading engagement with said flanges; deflecting the free annular edges of said flanges in axially opposite directions to shape said free annular edges into annular beads extending in opposite axial directions from their associated flanges by pressing said annular shoulders against said free edges; and widening said bottom portion of the groove by pressing said blunt peripheral edge thereinto.

6. The method of making grooved wheels which comprises; rotating a metal blank having an annular peripheral portion; providing tool means comprising splitting and forming rollers of which said splitting roller has a relatively sharp tapered annular edge portion, and said forming roller has a relatively blunt tapered annular edge portion; engaging said sharp edge portion of said splitting roller with said peripheral portion by movement of the splitting roller comprising an initial rapid-approach feeding movement followed by a slow-feed touch engagement with said peripheral portion; rotating and accelerating said splitting roller by said slow-feed touch engagement; splitting said peripheral portion therearound into an annularly grooved portion by penetrating said sharp edge portion thereinto with a rapid-rate penetrating feed movement following said touch engagement and acceleration of said splitting roller; and thereafter shaping said split portion by advancing said forming roller into the groove of said split portion and engaging said blunt edge portion with the bottom portion of said groove for widening the latter and reshaping said bottom portion to a concavely curved form.

7. The method of making grooved wheels according to claim 6 and comprising the step of marking the edge surface of said peripheral portion therearound substantially on the midplane of said peripheral portion by said touch engagement of said sharp edge portion therewith as the starting point for the subsequent rapid-feed penetration of said sharp edge portion into the blank.

8. The method of making groove wheels which comprises the steps of providing tool means comprising a splitting roller and a forming roller, of which said splitting roller has a relatively sharp ridge-shaped annular edge portion and said forming roller has a relatively blunt ridge-shaped annular edge portion; providing a metal blank having a plate portion terminating in an annular peripheral portion; mounting the blank on a rotatably driven workholder and rotating the blank on a central axis perpendicular to the plane of said plate portion; moving said splitting roller edgewise thereof toward said peripheral portion through an approach distance at a relatively rapid approach feed rate; discontinuing the rapid approach feed movement upon arrival of said sharp edge portion at a point adjacent to but spaced from said peripheral portion; then further moving said splitting roller edgewise thereof toward said peripheral portion at a relatively slow touch feed rate; engaging said sharp edge portion with said peripheral portion by such slow touch feed movement; marking said peripheral portion therearound by the slow touch feed engagement of said sharp edge portion therewith and meanwhile rotating and accelerating said splitting roller by such marking engagement thereof with the blank; imparting a penetrating feed movement to said splitting roller at a feed rate faster than said touch feed rate; penetrating said sharp edge portion into said peripheral portion at said faster feed rate and splitting said peripheral portion therearound into an annularly grooved portion; and thereafter engaging the blunt edge portion of said forming roller in said grooved portion and shaping the latter to pulley-rim form.

9. The method of making grooved wheels which comprises rotating a blank having a flat annular edge portion; splitting said edge portion into divergent annular flanges and spreading said flanges to an included angle of a given value; and shaping the split portion to desired grooved-rim form including closing said flanges to a final included angle of smaller value than said given value.

10. The method of making grooved wheels which comprises rotating a blank having a flat annular edge portion; splitting said edge portion into divergent annular flanges; opening said flanges to an included angle of a given value; shaping the split portion to desired final grooved-rim form including closing said flanges to an included angle of smaller value than said given value; and forming peripheral beads on said flanges during such final shaping of said split portion.

11. The method of making grooved wheels which comprises providing a rotatable workholder comprising co-operable holder members having annular bevel walls for defining a work groove; rotating a circular workpiece having a flat annular edge portion in said workholder with said edge portion projecting into said work groove; splitting said edge portion into divergent annular flanges by pressing a relatively sharp-edged roller into said edge portion; spreading said flanges to a given included-angle first position adjacent to but spaced from said bevel walls; and thereafter shaping the split portion to desired grooved-rim form by engaging a relatively blunt-edged second roller therewith including closing said flanges to a final position at an included angle smaller than the included angle of said first position.

12. The method of making grooved wheels according to claim 11 wherein said second roller has bead-forming grooves thereon; engaging said bead-forming grooves with the peripheral edges of said flanges; and forming beads on said peripheral edges during said shaping of said split portion.

13. The method of making grooved wheels which comprises the steps of providing tool means comprising a splitting roller and a forming roller, of which said splitting roller has a relatively sharp ridge-shaped annular edge portion and said forming roller has a relatively blunt ridge-shaped annular edge portion; providing a metal blank having a plate portion terminating in an annular peripheral portion; mounting the blank on a rotatably driven workholder and rotating the blank on a central axis perpendicular to the plane of said plate portion; moving said splitting roller edgewise thereof toward said peripheral portion through an approach distance at a relatively rapid approach feed rate; discontinuing the rapid approach feed movement upon arrival of said sharp edge portion at a point adjacent to but spaced from said peripheral portion; then further moving said splitting roller edgewise thereof toward said peripheral portion at a relatively slow touch feed rate; engaging said sharp edge portion with said peripheral portion by such slow touch feed movement; marking said peripheral portion therearound by the slow touch feed engagement of said sharp edge portion therewith and meanwhile rotating and accelerating said splitting roller by such marking engagement thereof with the blank; imparting a penetrating feed movement to said splitting roller at a feed rate faster than said touch feed rate; penetrating said sharp edge portion into said peripheral portion at said faster feed rate and splitting said peripheral portion therearound into an annularly grooved portion having divergent annular flanges; spreading said flanges to a given included-angle first position; thereafter engaging the blunt edge portion of said forming roller in said grooved portion and reshaping the bottom of the latter to a concave transverse curvature; and closing said flanges to a final position at an included angle smaller than the included angle of said first position.

14. The method of making grooved wheels which comprises the steps of providing tool means comprising a splitting roller and a forming roller, of which said splitting roller has a relatively sharp ridge-shaped annular edge portion and said forming roller has a relatively blunt ridge-shaped annular edge portion and bead-forming annular grooves on opposite sides of said blunt ridge-shaped portion; providing a metal blank having a plate portion terminating in an annular peripheral portion; mounting the blank on a rotatably driven workholder and rotating the blank on a central axis perpendicular to the plane of said plate portion; moving said splitting roller edgewise thereof toward said peripheral portion through an approach distance at a relatively rapid approach feed rate; discontinuing the rapid approach feed movement upon arrival of said sharp edge portion at a point adjacent to but spaced from said peripheral portion; then further moving said splitting roller edgewise thereof toward said peripheral portion at a relatively slow touch feed rate; engaging said sharp edge portion with said peripheral portion by such slow touch feed movement; marking said peripheral portion therearound by the slow touch feed engagement of said

sharp edge portion therewith and meanwhile rotating and accelerating said splitting roller by such marking engagement thereof with the blank; imparting a penetrating feed movement to said splitting roller at a feed rate faster than said touch feed rate; penetrating said sharp edge portion into said peripheral portion at said faster feed rate and splitting said peripheral portion therearound into an annularly grooved portion having divergent annular flanges; spreading said flanges to a given included-angle first position; thereafter engaging the blunt edge portion of said forming roller in said grooved portion and reshaping the bottom of the latter to a concave transverse curvature; closing said flanges to a final position at an included angle smaller than the included angle of said first position; and thereby permitting engagement of said bead-forming grooves with the peripheral edges of said flanges for forming beads thereon upon continued inward movement of the forming roller.

15. The method of making a grooved wheel having a final grooved-rim form with annular flanges having a given included angle which comprises the steps of providing a rotatable workholder means having clamping means and divergent walls defining an annular work groove around said clamping means with an included angle greater than said final included angle; providing tool means comprising a splitting roller and a forming roller, of which said splitting roller has a relatively sharp ridge-shaped annular edge portion and said forming roller has a relatively blunt ridge-shaped annular edge portion; providing a metal blank having a plate portion terminating in an annular peripheral portion; mounting said blank in said workholder means with said peripheral portion projecting in said work groove; engaging said peripheral portion by said sharp annular edge portion; splitting said peripheral portion into two annular flanges and spreading the flanges by penetrating said sharp annular edge portion into said peripheral portion; discontinuing the penetrating and spreading when said flanges are adjacent to but still spaced from said divergent walls; and thereafter engaging said blunt ridge-shaped annular edge portion of said forming roller with the split portion and shaping the latter to said final desired grooved-rim form including reshaping the bottom portion of the rim groove to a concave transverse curvature, all while said flanges remain spaced from said divergent walls.

16. In apparatus for producing a grooved wheel having a final grooved-rim form with annular flanges having a given final included angle from a metal blank having a central portion and an outer flat plate portion terminating in an annular peripheral edge portion; a rotatable workholder means adapted to receive said blank and support said central portion; and tool means comprising a splitting roller and a forming roller, said splitting roller having a ridge-shaped portion carrying a relatively sharp annular edge portion and being of a size and cross-sectional shape for splitting said peripheral edge portion into two annular flanges and spreading the flanges apart to positions spaced from said workholder means, in response to penetration of said sharp edge portion into said peripheral edge portion; said forming roller having a ridge-shaped portion carrying a relatively blunt annular edge portion and being of a size and cross-sectional shape for shaping the

split peripheral edge portion to said desired final grooved-rim form while said flanges remain spaced from said workholder means.

17. Apparatus according to claim 16 wherein the included angle of the ridge-shaped portion of said forming roller is smaller than the included angle of the ridge-shaped portion of said splitting roller.

18. Apparatus according to claim 17 wherein said forming roller has annular beading grooves on axially opposite sides of the ridge-shaped portion thereof.

19. Apparatus according to claim 16 wherein said workholder means has divergent annular walls defining a work groove into which said peripheral edge portion projects and is housed during the splitting thereof into flanges by said splitting roller and during said shaping of the split portion by said forming roller; the size and cross-sectional shape of said work groove, in relation to the sizes and cross-sectional shapes of the ridge-shaped portions of said splitting and forming rollers, being such that said flanges remain spaced from said divergent annular walls during the operations performed on the blank by said splitting and forming rollers.

20. The method of making grooved wheels which comprises the steps of providing tool means comprising a splitting roller and a forming roller of which said splitting roller has a relatively sharp ridge-shaped annular edge portion and said forming roller has a relatively blunt ridge-shaped annular edge portion and bead-forming annular grooves on opposite sides of said blunt ridge-shaped portion; providing a metal blank having a plate portion terminating in an annular peripheral portion; mounting the blank on a rotatably driven workholder and rotating the blank on a central axis perpendicular to the plane of said plate portion; moving said splitting roller edgewise thereof toward said peripheral portion; engaging said sharp-edged portion with said peripheral portion; penetrating said sharp-edged portion into said peripheral portion and spreading said peripheral portion therein into an annular groove portion having diverging annular flanges; spreading said flanges to a given included angle first position; thereafter engaging the blunt edge portion of said forming roller into said groove portion and reshaping the bottom of the latter to a concave transverse curvature; closing said flanges to a final position at an included angle smaller than the included angle of said first position and thereby permitting engagement of said bead-forming grooves with the peripheral edges of said flanges for forming beads thereon upon continued inward movement of the forming roller.

21. In an apparatus for producing a grooved wheel having a final grooved-rim form with annular flanges having a given final included angle from a metal blank having a central portion and an outer flat plate portion terminating in an annular peripheral edge portion, a rotatable workholder means adapted to receive the blank and support said central portion and tool means comprising a splitting roller and a forming roller, said splitting roller having a ridge-shaped portion carrying a relatively sharp annular edge portion and being of the size in cross-sectional shape for splitting said peripheral edge portion into two annular flanges spreading the flanges apart to a position having a given included angle in response to penetration of said sharp edge portion into said peripheral edge portion, said forming

roller having a ridge-shaped portion carrying a relatively blunt annular edge portion and engageable with said flanges being of a size and cross-sectional shape to effect movement of said flanges inwardly from their said first position to their final grooved-rim position, said forming roller having annular beading grooves on axially opposite sides of the ridge-shaped portion thereof and effecting beading of the free ends of said flanges while said forming roller is moving inwardly of said groove and simultaneously with the closing of said flanges.

22. The method of making a grooved wheel having a final grooved-rim form with annular flanges having a given included angle which comprises the steps of providing a workholder means having divergent walls defining an annular work groove with an included angle greater than said final included angle; providing tool means comprising a splitting roller having a relatively sharp ridge-shaped annular edge portion; providing a metal blank having an annular peripheral portion; mounting said blank in said workholder means with said peripheral portion projecting in said work groove; engaging said peripheral portion by said sharp annular edge portion; splitting said peripheral portion into two annular flanges and spreading the flanges by penetrating said sharp annular edge portion into said peripheral portion; and discontinuing the penetrating and spread-

ing when said flanges are adjacent to but still spaced from said divergent walls.

23. The method as defined in claim 22 further including the step of engaging a blunt ridge-shaped annular edge portion of a forming roller with the split portion and shaping the split portion to said final desired grooved-rim form including reshaping the bottom portion of the rim groove to a concave transverse curvature, all while said flanges remain spaced from said divergent walls.

24. A method as defined in claim 1 further including the step of shaping the bottom of the groove formed by the slitting and expanding tool by a shaping tool which engages the blank at a point substantially diametrically opposite the point at which the blank is engaged by the slitting and expanding tool.

25. A method as defined in claim 24 wherein said blank is supported in a workholder which defines the outer shape of the V-groove to be formed, and further including the step of pressing said flanges against the workholder by the shaping tool.

26. A method as defined in claim 1 wherein said step of pressing said flanges laterally is performed by a pressing tool which engages the flanges formed by the slitting tool and presses said flanges laterally.

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