

March 18, 1958

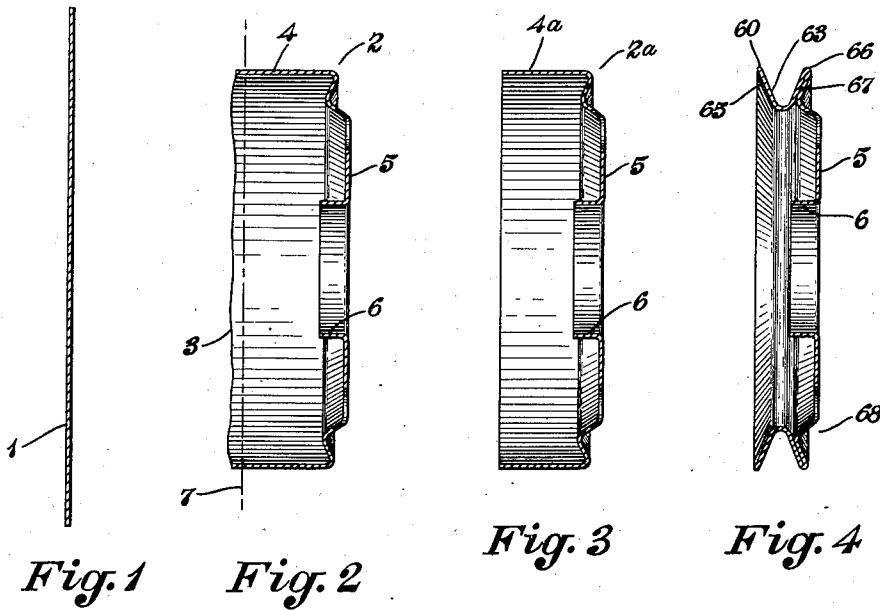
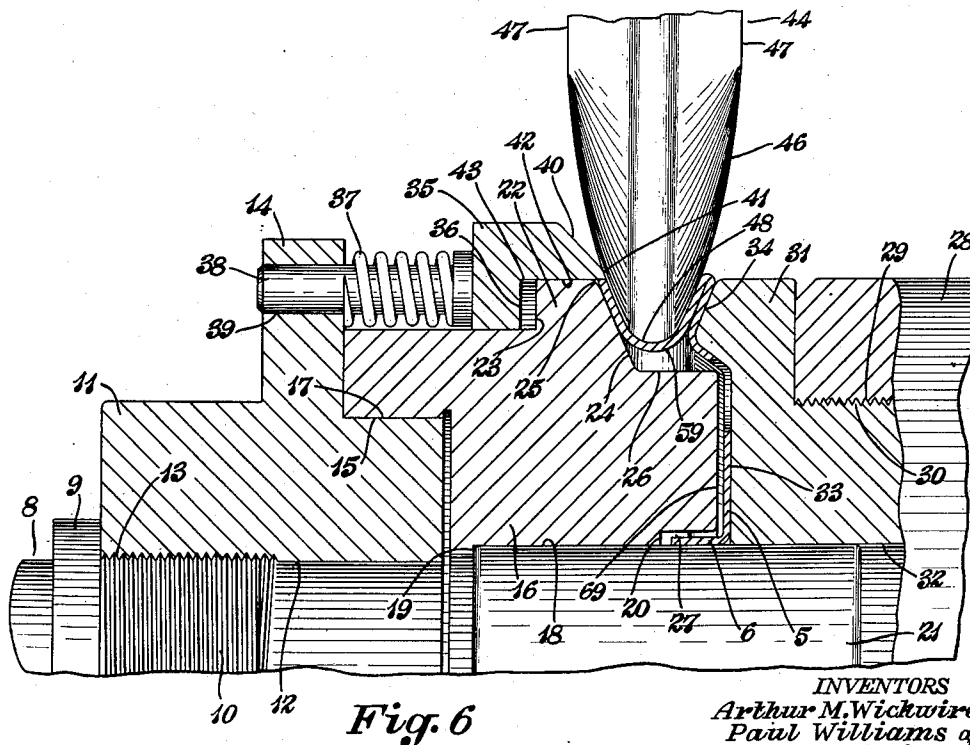
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2,826,804

SPUN METAL MANUFACTURE

Filed Dec. 29, 1949

4 Sheets-Sheet 1



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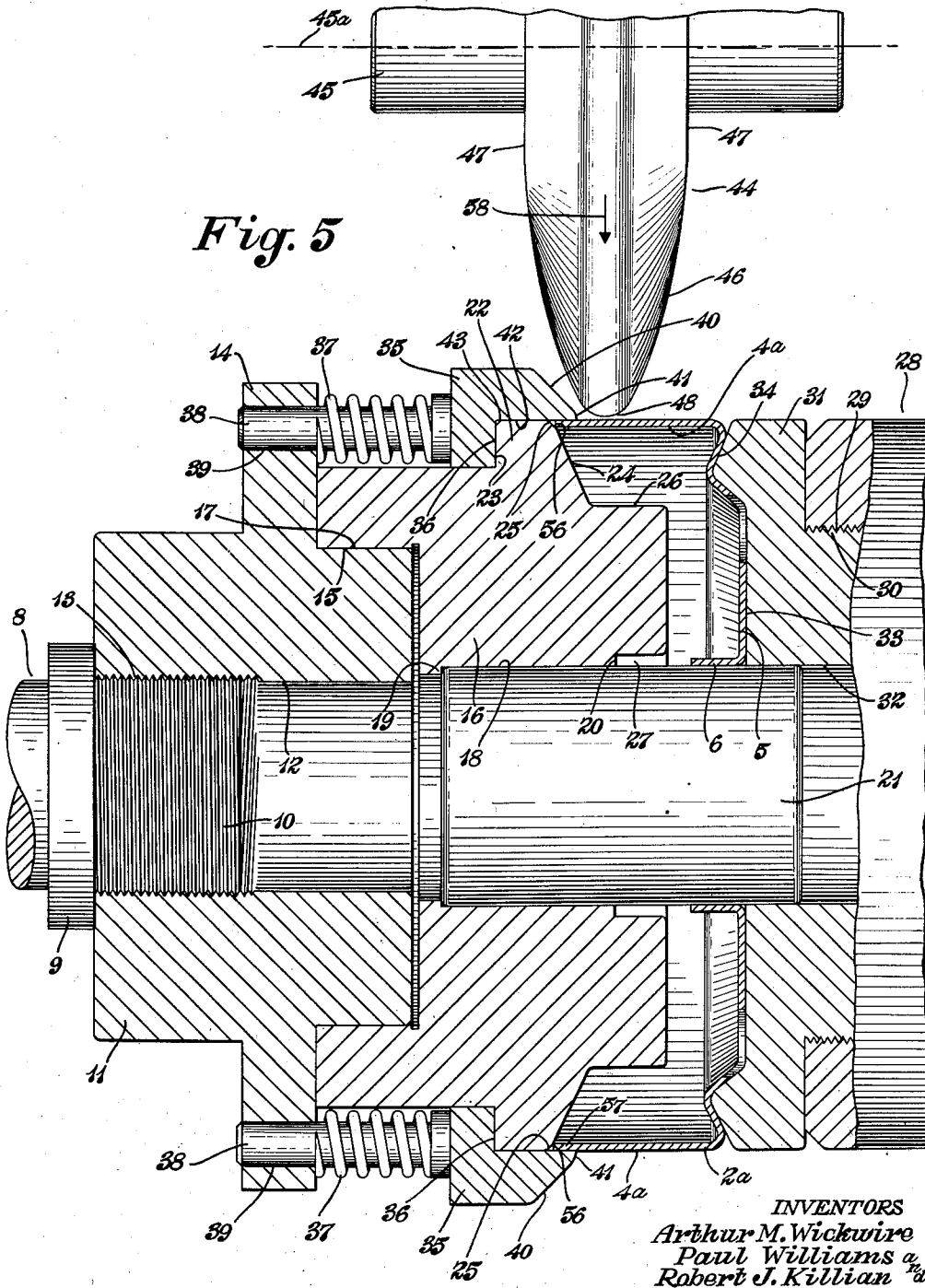
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4 Sheets-Sheet 2

Fig. 5



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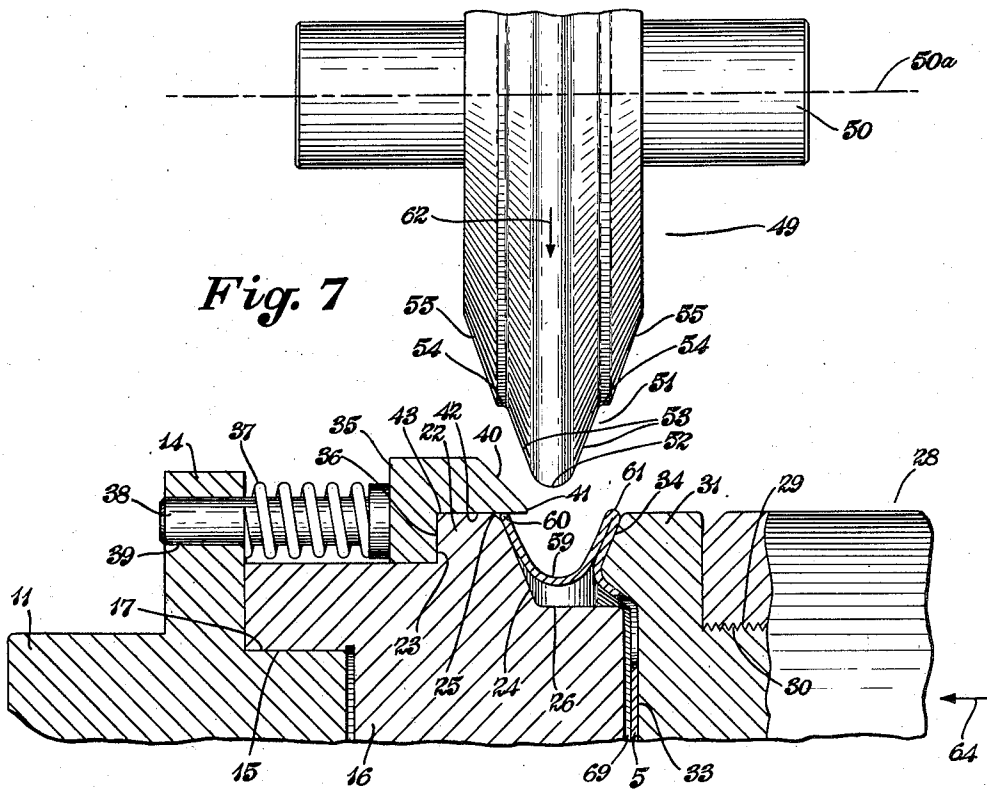
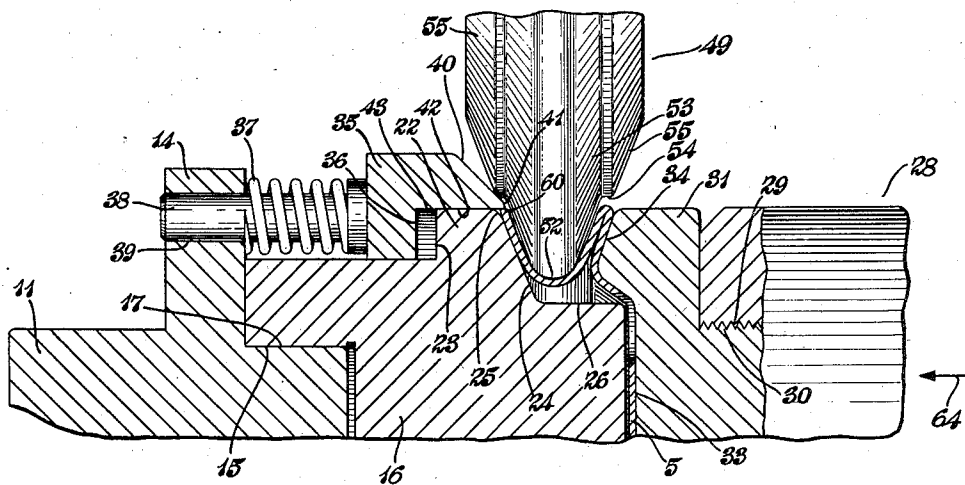


Fig. 8

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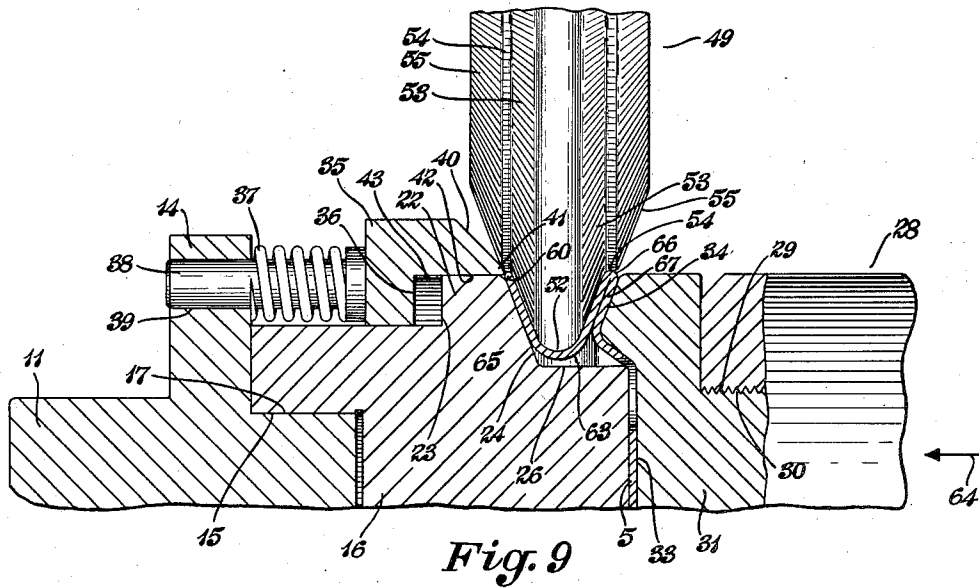
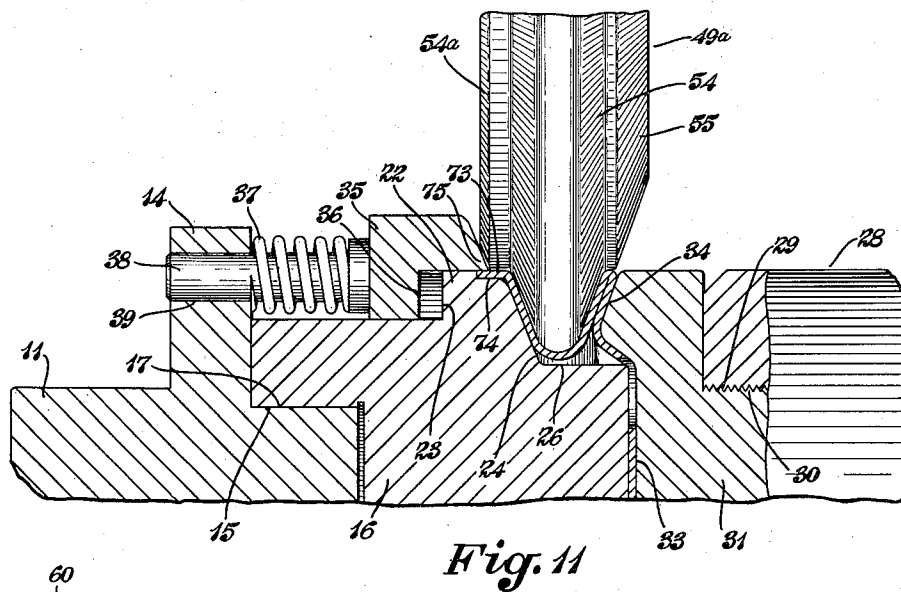
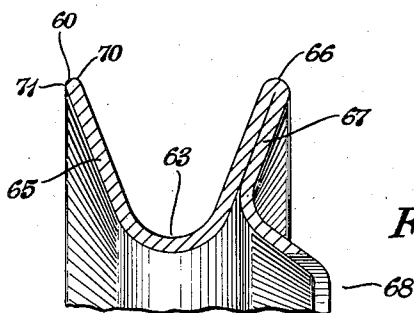
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SPUN METAL MANUFACTURE

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2,826,804

SPUN METAL MANUFACTURE

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Application December 29, 1949, Serial No. 135,754

3 Claims. (Cl. 29—159)

The invention relates to the precision manufacture of one-piece spun metal pulleys, such as V-groove pulleys, from ductile material, preferably rolled steel sheets or strips; and relates more particularly to a method of making a one-piece pulley from a single metal blank formed with a relatively narrow and relatively deep V-shaped groove therein with a minimum of scrap loss and in accordance with quantity production procedure without sacrificing uniformity of finished product.

More particularly, the present invention constitutes improvements upon the methods of making spun metal articles set forth in the Nelson Patent No. 1,680,061 and the Harrison Patents Nos. 1,828,464, and 2,062,415.

In the manufacture of pulleys in accordance with the methods set forth in said prior patents, a cup-shaped blank is formed from a sheet metal blank in one of a number of ways, as by spinning or deep drawing; a V-groove is then roller spun by several operations in the annular flange wall of the cup-shaped blank; and excess metal resulting from the cup forming and roller spinning operations at the outer or free edge of the V-groove forming wall (which was the free annular edge of the cup) is trimmed from the roller spun article to provide the finished article.

Roller spun pulleys are recognized to have many distinct advantages, such as static and dynamic balance, true concentricity, lightness of weight, maximum strength and durability, and dense, smooth, work-hardened and truly formed roller spun V-groove surfaces. It is extremely important that these characteristics not only be obtained and maintained in the manufacture of such pulleys in large quantities, but that variations in any one or more of such characteristics be maintained at a minimum because any substantial variation in such characteristics may be cause for rejecting a finished pulley at final inspection.

Certain difficulties have been encountered in using the methods of pulley manufacture set forth in said prior patents.

From a practical standpoint it is not possible in production to draw a flange or annular wall in a cup-shaped blank having a uniform length throughout the extent of the annular flange wall. Accordingly, it is necessary to allow for excess metal in the cup-flange, as drawn, which excess metal is removed when the finished pulley is trimmed. Also, the non-uniformity of cup-flange length, as drawn, may affect to some extent uniformity of wall structure in the V-groove wall adjacent the free or outer edge of the blank or pulley, as spun. This factor must be recognized in allowing for excess metal in the cup-flange and in trimming the finished pulley so that the remaining metal in the pulley walls has uniform characteristics.

During the spinning operation, stretching, thinning and flow of the metal in the cup-flange wall in which the V-groove is formed, can not be avoided entirely; this stretching, thinning or flow of metal in the V-walls for a number of reasons may not occur uniformly. Variations in length of the non-uniform length drawn cup-flange

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may be one of the causes of non-uniform metal flow when the cup-flange is being worked. The natural flow of the metal when the cup is being worked by the spinning rolls, and when stretching and thinning may occur, is outward of the open end of the cup, thereby increasing the amount of excess metal in this particular zone, which excess metal is trimmed from the roller spun article to form the finished article. Thus, the amount of metal which must be trimmed, and which represents a scrap loss, is increased by the spinning operation over that required to be trimmed by reason of the cup forming operation.

The final trimming operation in accordance with prior practice is normally a pinch trimming operation performed in dies in which the excess metal extending from the free side wall of the V-groove, is removed. This trimming operation not only may affect the concentricity of the pulley but, also, may change the angle or width of the V-groove walls, producing variations in the trimmed pulleys which must be corrected.

Furthermore, the trimming operation results in a trimmed raw metal edge which must be burnished or rounded as an extra operation. The trimmed pulleys then must be trued in respect to concentricity and V-groove angle and width in order to provide uniformity in the finished precision product.

The truing and burnishing operations involve handling of the otherwise finished pulley and the cost of truing and burnishing, and handling incident thereto, increase the cost of the finished pulley.

These difficulties have presented a continuing problem in the art, which, prior to the present invention, has remained unsolved. As a consequence the manufacture of one-piece, spun, sheet metal pulleys involves high costs and scrap losses, extra operations and handling, and an undesirably large amount of special work in truing defective or rejected finished pulleys.

Accordingly, it is an object of the present invention generally to improve the art of making roller spun V-groove pulleys.

Also, it is an object of the present invention specifically to improve the method of pulley manufacture set forth in the above enumerated prior art patents so as to eliminate the above described difficulties and disadvantages.

Moreover, it is an object of the present invention to provide an improved method of making roller spun, V-groove, sheet metal pulleys so as to obtain a relatively high degree of uniformity and precision in the finished product.

Furthermore, it is an object of the present invention to eliminate trimming as one of the final operations in the manufacture of a roller spun sheet metal pulley.

Likewise, it is an object of the present invention to eliminate the operation of burnishing or rounding the raw edge of a trimmed roller spun sheet metal pulley, and handling thereof incident to such an operation.

Also, it is an object of the present invention to eliminate factors which may cause a change in the angle, or width, or concentricity of a roller spun V-groove pulley after the V-groove has been precision formed therein.

Moreover, it is an object of the present invention to reduce stretching and thinning of the metal in the V-groove walls of a roller spun sheet metal pulley, and to obtain uniform metal flow in the V-groove walls during the spinning operation.

Furthermore, it is an object of the present invention to reduce the amount of scrap loss involved in the manufacture of roller spun, V-groove, sheet metal pulleys.

Also, it is an object of the present invention to substantially reduce the number of rejected pulleys made in

the production manufacture of roller spun, V-groove, sheet metal pulleys.

Finally, it is an object of the present invention to provide an improved method of manufacturing roller spun, V-groove, sheet metal pulleys which satisfies the foregoing objects, solves problems existing in the art, obtains unexpected results, reduces costs, and which is simple and convenient to use.

These and other objects and advantages apparent to those skilled in the art from the following description and claims may be obtained, the stated results achieved, and the described difficulties overcome, by the methods, steps, procedures, operations, and combinations which comprise the present invention, the nature of which are set forth in the following general statements, a preferred embodiment of which—illustrative of the best mode in which applicants have contemplated applying the principle—is set forth in the following description and shown in the drawings, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improved method of the present invention may be stated in general terms as including drawing a cup-shape from a single sheet metal blank, preferably a sheet or strip steel blank, trimming excess metal from the annular free edge of the flange of the cup-shaped blank to provide a uniform flange length, roller spinning a V-groove in said flange while confining the trimmed flange edge against radial or axial or outward movement thereby preventing outward flow of the metal in the flange and reducing stretching and thinning of the metal in the V-groove during spinning, and rolling the outer confined trimmed edge of the blank during roller spinning.

By way of example, a preferred embodiment of the method steps of the present invention are illustrated in the accompanying drawings forming part hereof, wherein:

Figure 1 is a diagrammatic sectional view of a flat sheet metal blank from which a pulley may be fabricated in accordance with the invention;

Fig. 2 is a diagrammatic sectional view of a cup-shaped pulley blank drawn from the flat sheet metal blank of Fig. 1;

Fig. 3 is a similar view of the cup-shaped blank of Fig. 2 after the cup has been trimmed to provide a predetermined uniform length of annular flange;

Fig. 4 is a view similar to Fig. 3 illustrating a V-groove roller spun in the flange of the cup-shaped blank of Fig. 3;

Fig. 5 is a fragmentary, diagrammatic, sectional view illustrating the dies for roller spinning a V-groove in the flange of the trimmed blank of Fig. 3 at the beginning of the rough spinning operation;

Fig. 6 is a view similar to Fig. 5 illustrating the spinning dies at the conclusion of the rough spinning operation;

Fig. 7 is a view similar to Fig. 5 showing the roller spinning dies at the beginning of the finish spinning operation;

Fig. 8 is a view similar to Fig. 7 showing the parts in one stage during the finish spinning operation;

Fig. 9 is a view similar to Figs. 7 and 8 showing the parts at the conclusion of the finish spinning operation;

Fig. 10 is an enlarged view of a portion of the finished pulley shown in Figs. 4 and 9; and

Fig. 11 is a view similar to Fig. 9 showing a slightly modified form of pulley shape and spinning dies therefor.

Similar numerals refer to similar parts throughout the various figures of the drawings.

Roller spun V-groove pulleys conventionally are made of sheet or strip metal of say sixteen gauge metal (.065" in thickness) although heavier or lighter gauge metal obviously may be used. Likewise, such pulleys con-

ventionally are made of steel, but obviously may be made of other types of sheet metal. Accordingly, it is understood that the invention is not limited to the particular gauge or type of metal used.

Although a V-groove pulley may be made from a flat sheet metal blank solely by spinning operations, as indicated in the Nelson Patent No. 1,680,061; nevertheless, in the volume production of pulleys, it is preferred to draw, by deep drawing or press operations, a cup-shaped blank or work piece with a cylindrical flange wall in which the V-groove is later formed, and then to spin the V-groove in the flange wall of the cup-shaped work piece by spinning operations.

A flat sheet metal blank is indicated at 1 in Fig. 1 from which the cup-shaped blank generally indicated at 2 in Fig. 2 is drawn in a press. The cup-shaped blank 2 has the usual characteristic scalloped or wavy edge 3 of a drawn piece at the open or free end or edge of the cylindrical or annular flange 4 of the blank 2. The cup-shaped blank 2 also includes a wheel disc portion 5 and may have an annular hub flange 6, the disc portion 5 and hub flange 6 being formed when the cup-shaped blank 2 is drawn. The annular cup-flange 4 is the portion of the blank 2 in which the V-groove of the pulley is to be formed by spinning. In accordance with the present invention, the axial length of the annular cup-flange 4 must be absolutely uniform throughout its entire periphery, and must be of predetermined length; so that the exact amount of metal required for the V-groove walls of the finished pulley is contained therein. Accordingly, the cup-shaped blank 2, of Fig. 2, as drawn, must be trimmed as on the dot-dash line 7 in Fig. 2 to provide a trimmed cup-shaped blank generally indicated at 2a in Fig. 3 having a flange 4a of predetermined uniform length.

The blank 2 may be trimmed to provide the trimmed blank 2a by a trimming operation carried out on a machine known as a rotary stamping trimmer and in which extremely close tolerances are maintained in the trimmed length of successive work pieces being trimmed. A rotary stamping trimmer in which this trimming operation may be carried out is disclosed in the copending application of Arthur M. Wickwire and Robert J. Killian, filed April 15, 1949, Serial No. 87,612, now Patent No. 2,702,597.

The trimmed blank 2a is now ready to have a V-groove spun in the annular flange 4a thereof, and this spinning operation may be carried out on a lathe type machine having a driven rotatable headstock, a cooperating tailstock, and one or more spinning rolls movable radially toward and away from the common axis of the head and tailstocks. Such a spinning machine is illustrated generally in the Harrison Patent No. 2,062,415 except that in accordance with the present invention the head and tailstock spinning dies and cooperating spinning rolls must be modified in construction, operation and shape from the construction, operation and shape of these elements disclosed in said Harrison patent.

The headstock spindle of such a spinning machine is indicated generally at 8, and in accordance with the present invention (Fig. 5) is provided with a flange 9 terminating in a threaded stub shaft 10. An adapter member 11 having an axial opening 12 threaded at 13 is rigidly mounted on the threaded stub shaft 10.

The member 11 is provided with a flange 14 intermediate its ends and is further provided with a reduced portion 15 on which the headstock spinning die 16 is fixed. The member 16 is provided with an axial recess 17 telescoped over the portion 15 of adapter member 11, and an axial opening 18, shouldered at 19 and 20, is formed in the member 16 extending from the recess 17. A pilot pin or shaft 21 is mounted by a press fit in the opening 18 for a purpose to be later described.

An annular collar-like flange 22 extends outwardly

from the periphery of the headstock die 16 providing a shoulder 23 on the headstock side of the flange 22; and the opposite side of the flange 22 is formed with a tapered or conical annular surface 24, preferably terminating outwardly in a slightly chamfered corner 25 and terminating inwardly in a cylindrical portion 26. The annular surface 24 is angled at the exact angle to be formed in one of the V-groove walls of the finished pulley.

As illustrated, an annular recess 27 is formed by the shoulder 20 opening toward the outer or tailstock end of the headstock die 16 and surrounding the pilot pin 21 carried thereby for a purpose to be later described.

The tailstock spindle of the spinning machine is indicated generally at 28 and is provided with an internally threaded portion 29 in which the threaded portion 30 of the tailstock spinning die 31 is received for mounting die 31 on the tailstock spindle 28. The tailstock die 31 has a central opening 32 of the same diameter as the diameter of the pilot pin or shaft 21 for receiving the pilot pin 21 as the tailstock spindle 28 moves toward the headstock spindle 8, thereby centering the tailstock die 31 accurately with respect to the headstock die 16 and centering the blank 2a with respect to the dies 16 and 31. Alternately, pilot pin 21 may be mounted by a press fit in the tailstock opening 32 and received in headstock opening 18. The surface of the tailstock die 31 facing the headstock die 16 is provided with a shape or configuration 33 matching in a complementary manner the shape of the outer surface of the wheel disc portion 5 of the cup-shaped blank 2a; and the tailstock surface 33 is formed at 34 near its outer edge to have an angled or conical annular contour on the same angle as the angle to be formed in the other V-groove wall of the finished pulley.

A ring 35 is slidably mounted on the headstock die 16 having a shoulder 36 adapted to abut the headstock die shoulder 23. The ring 35 normally is held in the position shown in Fig. 5 by springs 37 reacting between the ring 35 and flange 14; and the springs 37 surround pins 38 which are slidably mounted in apertures 39 in the flange 14 of adapter member 11. Thus, the ring 35 is yieldingly held in the position shown in Fig. 5, but may move against the pressure of springs 37 axially away from the working surface of headstock die 16. The ring 35 has a tapered annular surface 40 above the angled annular surface 24 of the headstock die 16 which terminates inwardly in a more sharply angled annular surface 41; and then the ring 35 is in the position shown in Fig. 5, the annular end 41 of the ring 35 circumferentially overhangs the angled annular surface 24 of the headstock die 16. The outer annular surface 42 of the headstock die flange 22 is cylindrical and of the same diameter as the cylindrical inner annular surface 43 of the ring 35 which slides thereon when the ring 35 is pushed against springs 37; and the diameters of the surfaces 42 and 43 are the same as the finished outside diameter of the pulley to be formed.

Associated with the headstock die 16 and tailstock die 31 are several spinning rolls, a rough spinning roll being indicated generally at 44 in Figs. 5 and 6. The spinning roll 44 is rotatable on a spindle 45; and the axis 45a of spindle 45 is parallel to and may be moved toward and away from the common axis of the head and tailstock spindles 8 and 28. The spinning roll 44 has a rounded annular working surface 46 shaped in cross-section to be generally like the shape or configuration of the V-groove to be formed in the pulley. However, the working surface 46 is preferably formed to have a contour sweeping first gradually and then more sharply in a curved manner from the sides 47 of the roll to the curved nose 48 thereof.

Also associated with the headstock die 16 and tailstock die 31 is a finished spinning roll generally indicated at 49 in Figs. 7, 8, and 9. The spinning roll 49 is rotatable on a spindle 50; and the axle 50a of the

spindle 50 is parallel to and may be moved toward and away from the common axis of the head and tailstock spindles 8 and 28. The spinning roll 49 has a working surface generally indicated at 51 shaped in cross-section to have substantially the contour of the V-groove to be formed in the pulley. The working surface 51 comprises an annular rounded nose 52, angled, annular side surfaces 53 angled at angles complementary to the angles of the annular surfaces 24 and 34 on the head and tailstock spinning dies 16 and 31, and annular shoulders 54. The spinning roll 49 also may have tapered annular surfaces 55 extending from the annular shoulders 54.

The spinning machine of the Harrison Patent No. 2,062,415 on which the improved spinning dies 16 and 31 and spinning rolls 44 and 49 may be mounted for carrying out the improved method of the present invention is constructed so that the headstock spindle 8 may be rotated; so that the tailstock spindle 28 may be moved axially toward the headstock and axial pressure applied between the head and tailstock dies 16 and 31, the working pressure being effected through air cylinder or hydraulic cylinder means; and so that the rough and finish spinning rolls 44 and 49 may be moved selectively, toward and away from the cooperating spinning dies 16 and 31, by mechanical or hydraulic means.

In accordance with the present invention, the headstock and tailstock spindles 8 and 28 are both driven at the same speed for rotating the same, a usual drive from a common shaft or source of power being provided.

In carrying out the spinning procedure of the present invention, a trimmed blank 2a is telescoped over the pilot pin 21 with its hub flange 6 closely fitting the outer surface of the pilot pin 21. The headstock and tailstock spindles 8 and 28 are then rotated and the tailstock spindle 28 is moved toward the headstock spindle, the free end of the pilot pin 21 entering the opening 32 in the tailstock die 31. The blank 2a is thus clamped between the driven head and tailstock dies 16 and 31 and rotated therewith, as shown in Fig. 5.

In this clamped position, the outer end edge 56 of the annular flange 4a of the cup-shaped blank 2a abuts against the chamfered corner 25 of the headstock die 16 and an annular band at the outer end of the flange 4a of the blank 2a, indicated at 57 in Fig. 5, is confined within and by the overhanging edge 41 of the ring 35. Thus the ring 35 confines and holds the open end of the formed cup 2a against radial or outward expansion.

With the trimmed cup-shaped blank 2a thus clamped, confined, held and rotated by driven dies 16 and 31 and ring 35, the axis of the rough spinning roll 44 is moved toward the common axis of the head and tailstock spindles, as indicated by the arrow 58, until the nose 48 of roll 44 engages an intermediate surface of the cup-flange 4a. Continued movement of the spinning roll 44 toward the axis of the head and tailstock spindles applies a roller spinning pressure to the flange 4a, thus forming a groove inwardly therein until the spinning roll 44 reaches the limit of its inward movement as illustrated in Fig. 6.

Meanwhile the overhanging edge 41 of the ring 35 has continued to confine and hold the open end 56 of the cup-flange 4a against any radial or outward movement. As the spinning roll 44 moves from the position shown in Fig. 5 to the position shown in Fig. 6, its working surface 46 first engages the angled surface 40 and finally the angled surface 41 of the ring 35 to push the ring axially against the pressure of the springs 37 to the position shown in Fig. 6.

By confining the end 56 of the cup-shaped blank 2a as the semi-finished groove 59 is being formed in flange 4a by the rough spinning roll 44, the natural flow of metal outward of the open end of the cup, as the metal in the flange 4a is being worked by the spinning roll 44, is re-

stricted; and a more uniform and less thinned metal structure in the groove section 59 is obtained.

While the rough spinning roll 44 is moving to the limit of its inward movement shown in Fig. 6, the tailstock die 31 moves to the left from the position shown in Fig. 5 to the position shown in Fig. 6. During such movements, the annular flange 6 of the blank 2a slides along pilot pin 21 and into recess 27 which is provided for receiving the hub flange 6. At the completion of the rough spinning operation, illustrated in Fig. 6, the wheel disc portion 5 of the cup-shaped blank 2a, although pushed to the left by tailstock die 31, is still spaced from the right-hand end face of the headstock die 16, as indicated at 69 in Figs. 6 and 7. This condition must exist at the end of the rough spinning operation so that further movement of the disc portion 5 of the blank to the left may take place during the finish spinning operation when the V-groove being formed is deepened and narrowed.

In performing the rough spinning operation illustrated in Figs. 5 and 6, annular flange 4a of blank 2a collapses inward, so to speak, by the inward pressure of the rough spinning roll 44 and the axial pressure of tailstock die 31. Due to the character and shape of the rounded working surfaces 46 and 48 of the roll 44, the metal in the flange wall 4a flows evenly and uniformly during the reshaping without any localized pressure which would cause thinning of the metal in the walls of the groove 59 being formed. In fact, because the outer edge 56 of the flange 4a is confined by the ring 35, preventing normal or natural flow of metal outward in the left-hand wall of the groove being formed, the tendency may be to thicken rather than to thin the metal in the groove wall because of the reduction in diameter thereof.

Referring to Fig. 5, the overhang of edge 41 of ring 35 is substantial so that it is impossible for any portion of the free edge 56 of the cup-shaped blank to slip out of the confining pocket formed by the overhanging edge 41 of ring 35. If the end 56 of the cup-shaped blank were to slip out of a confined position during the rough spinning operation, the benefits of the present invention would be lost because there then would be an outward flow of metal in the outer groove wall, which excess metal would have to be trimmed as a final operation, and the metal in the groove walls would not be uniformly worked.

Of equal importance in this connection is the fact that the trimmed blank 2a has a flange 4a of absolutely uniform predetermined length. If there are any variations in the length of the flange 4a, the confining pressure on the flange during the rough spinning operation will be localized at the zone of greatest flange length, thus causing non-uniform working and flow of the metal during the groove formation and creating the possibility of the open end 56 of the flange slipping out of confinement by the overhanging edge 41 of ring 35.

Finally, during the rough spinning operation, the metal in the annular inner and outer corners of the end 56 of the flange 4a is slightly rounded or deburred as this edge 56 and the wall zone 57 moves or is reshaped from the position or shape shown in Fig. 5 to the position or shape shown in Figs. 6 and 7. This occurs because of the pressure of the tailstock die 31 and rough spinning roll 44 resisted by tapered headstock die wall 24, chamfered corner 25, and the inner cylindrical surface 42 of the ring 35. Thus these inner and outer corners of the metal edge wall 56, in turning or rotating on such die surfaces under pressure, become slightly rounded.

The spinning roll 44 is then moved away from the head and tailstock spindles 8 and 28 at which time the ring 35, by the pressure of springs 37, may move back to a position in which its shoulder 36 abuts the shoulder 23 of the headstock die 16, and the end 41 of the ring 35 overhangs the open end edge 60 of the semi-finished pulley 61 to a maximum extent, as shown in Fig. 7. The finish spinning roll 49 (Fig. 7) is then moved toward the rotat-

ing semi-finished pulley 61 in the direction of the arrow 62 shown in Fig. 7, and rolls the V-groove 63 from the semi-finished shape illustrated at 59 in Fig. 7 to the final finished shape illustrated at 63 in Figs. 4, 9 and 10.

As the roll 49 moves toward the rotating spinning dies 16 and 31, the nose 52 of the roll working surface 51 works the metal in the base of the groove 63. Meanwhile the continued pressure of the tailstock die 31 in the direction of the arrow 64 in Figs. 7, 8, and 9 further collapses and narrows the width of the V-groove, and the roll surfaces 53 iron the metal in the side walls of the V.

As the roll 49 moves inward, the tapered surface 55 on the left side thereof engages the angled surfaces 40 and 41 of the ring 35, and pushes the ring 35 to the left as illustrated in Fig. 8. Just before roll 49 reaches its final metal working position (Fig. 8), the overhanging end 41 of the ring 35 slips over the end 60 of the semi-finished pulley 61 thereby momentarily releasing confinement or restriction thereof. However, the roll 49 immediately moves further inward in semi-finished groove 59 (Fig. 9) to the final predetermined depth of the groove, and in so doing, the annular shoulders 54 on the roll 49 engage and work the open end 60 of one V-wall 65 and the outer edge 66 of the other double thickness metal V-wall 67, as illustrated in Fig. 9.

As the spinning roll 49 reaches its limit of inward movement (Fig. 9) it exerts final working pressure on the pulley blank between its working surface 51 and the angled working surfaces 24 and 34 of the spinning dies 16 and 31, and the tailstock die 31 moves to the limit of its movement to the left, thereby uniformly and finely ironing and working the metal surfaces of the finally formed V-groove 63 of the finished pulley 68. During this final working operation of the metal in the V-groove of the pulley, the shoulders 54 of the roll 49 roller work the edges 60 and 66 of the metal at the outer end of the V-shape, thereby rounding these edges in such manner that no separate final burnishing operation is required.

Although it is indicated above that the internal diameter 43 of the overhanging edge of ring 35 is of the same diameter as the outer diameter of the finished pulley 68, as a practical matter and because of the momentary release of the outer edge 60 of the pulley when ring 35 gives way to the finish spinning roll 49 just before the finish spinning roll reaches its limit of inward movement, this internal diameter 43 is made slightly under the size of the finished diameter of the pulley 68, so that when the open edge 60 of the pulley momentarily tends to grow or flow or expand outward before the roll 49 reaches its limit of inward movement, the shoulders 54 will roller work the V-groove wall edges 60 and 66 and finally size the pulley.

During the working movement of the finish spinning roll 49, as illustrated in Figs. 7, 8 and 9, the tailstock die 31 moves further to the left from the position shown in Fig. 7 to the position shown in Fig. 9, and the gap 69 decreases in width as the final position of Fig. 9 is reached.

During the final spinning operation, the side walls of the V-groove are further shaped from the shape illustrated in Fig. 7 to that illustrated in Figs. 4, 9 and 10 so as to have the desired V-groove angle and width. At the same time, the metal in the base of the groove is further worked inward by the nose 52 of roll 49, from the position 59 shown in Fig. 7 to the positions 63 shown in Fig. 9.

Meanwhile, the overhanging edge 41 of ring 35 continues, until the momentary release previously described, to confine the outer edge 60 of the semi-finished pulley 61 to prevent outward flow of the metal in the outer groove wall and to prevent any appreciable or substantial thinning of the metal in the groove wall. Also, this confinement of the edge 60 of the semi-finished pulley 61 during the finish spinning operation continues to prevent the metal walls being worked from slipping out

of the desired confined position with respect to the dies and spinning roll.

The final ironing of the metal surfaces of the formed V-groove 63, just as the roll 49 reaches its limit of inward movement in Fig. 9, uniformly works and sizes the shape of the V-groove and the thickness of the groove-forming metal walls, thus providing a finished pulley having static and dynamic balance and true concentricity and having dense, smooth, work-hardened and truly formed roller spun V-grooves surfaces.

Furthermore, as previously indicated, the final ironing operation also works and rounds the edges 60 and 66 of the V-groove walls by the rolling pressure of the roll shoulders 54. The rounding or deburring of the edge 60 which was commenced in the rough spinning operation and thus completed in the final spinning operation, produces the edge shape illustrated in Fig. 10 wherein the corners 70 and 71 of edge 60 are truly rounded.

A slightly modified form of pulley shape is indicated at the outer or free edge of the V-groove walls. This pulley shape may be formed in accordance with the present invention by slightly modifying the headstock die 16 to have a recess 74 for receiving the pulley flange 73 beneath the overhanging edge 75 of confining ring 35 and by modifying the shape of the finish spinning roll 49a to have a wider shoulder 54a at its left-hand side. The modified dies and finish spinning roll illustrated in Fig. 11 operate in the same manner as described in connection with Figs. 7, 8 and 9 except that the ring 35 always confines the free end of the pulley blank without the momentary release just before the finish spinning roll reaches its limit of inward movement described in connection with Figs. 8 and 9.

In commercial operations involving the use of the improved apparatus and procedure of the present invention to make the improved product described, the novel procedure is commonly referred to as "spinning in the ring." This term is used because the open end of the formed cup, which is to be spun, is confined within the movable ring 35, located and sliding on the headstock die 16 of the spinning apparatus. The tapered surfaces 40 and 41 of the movable ring facilitate movement of the ring by the spinning rolls 44 and 49 as these spinning rolls are working the metal in the pulley blank. The sharper angle of the surface 41, with respect to the angled surface 40 of the movable ring 35, reduces to the last possible split second the time elapsing between the moment that the movable ring releases confinement of the blank edge 60 and the moment when the finish spinning roll 49 reaches its limit of inward movement as shown in Fig. 9.

The improved apparatus and procedures of the present invention accomplish many new results and advantages.

First, since the metal in the pulley blank is confined by the movable ring during the spinning operations, a more uniform and less thinned groove section is obtained.

Second, trimming of excess steel which is present in pulleys not spun in the ring is eliminated. By the elimination of this trimming operation, steel is saved as well as the handling of the spun pulleys in connection with a final trimming operation. Moreover, the elimination of the final trimming operation also eliminates the possibility of distortion of the spun pulley and a change in the belt groove angle or width which may occur when a spun pulley is thereafter trimmed. The elimination of these operations in turn reduce scrap loss, save steel, and eliminate to a large extent the necessity for any standard truing-up operation following spinning. Of course, a final inspection is always used but when pulleys are made in accordance with the present invention, there are only a minimum number of pulleys

rejected at the final inspection which must be trued-up to provide a uniform groove angle or width.

Third, in view of the fact that the outer edge of the confined pulley blank flange is rounded and rolled, as indicated at 70 and 71 in Fig. 10, a final burnishing operation is eliminated together with handling of the spun pulley and likelihood of a change of the groove angle or width incident to such burnishing operation.

Fourth, the relative concentricity of pulleys made in production runs in accordance with the present invention is better than in any prior known pulley manufacturing procedure.

Accordingly, the present invention provides general improvements in the art of making roller spun V-groove pulleys; satisfies each and all of the objects set forth in the preamble of the specification; enables the advantages of roller spun pulleys to be obtained in a spun pulley product while eliminating disadvantages and defects heretofore encountered in the manufacture of pulleys by spinning procedures; enables the elimination of final steps of trimming, burnishing, and handling incident thereto; provides for the manufacture of roller spun V-groove sheet metal pulleys with a high degree of concentricity, uniformity, and precision in the finished product and with a minimum of scrap loss and rejected pulleys produced; and solves problems and satisfies demands existing in the art, and obtains the new enumerated unexpected results.

In the foregoing description, certain terms have been used for brevity, clearness and understanding, but no unnecessary limitation are to be implied therefrom beyond the requirements of the prior art; because such words are used for descriptive purposes and not for the purpose of limitation and are intended to be broadly construed.

Moreover, the invention is not limited to the exact spinning die and spinning roll structures shown, nor to the exact pulley shape illustrated, because the particular shapes of the dies, rolls and pulleys may be varied to provide other structural embodiments without departing from the scope of the present invention.

Having now described the features of the invention, the construction and operation of preferred embodiments of improved roller spinning apparatus, the details of the steps of the improved method, the new spun metal products provided, and the advantageous, new and useful results obtained thereby; the new and useful inventions, constructions, devices, parts, elements, arrangements, combinations, sub-combinations, methods, steps, procedures, operations, discoveries, principles, products, and reasonable mechanical equivalents thereof, obvious to those skilled in the art, are set forth in the appended claims.

We claim:

1. In a method of making a spun, grooved, sheet metal pulley, the steps of forming a cup-shaped metal blank having an annular flange wall in which the groove is to be formed, then trimming excess metal from the open free end of the formed flange wall to provide a predetermined axial flange length uniform throughout the periphery of the flange wall, then roller spinning a groove in said trimmed flange wall, and confining the trimmed end of said flange wall against radial outward movement throughout the groove spinning operation.

2. In a method of making a one piece, spun, V-grooved, sheet metal pulley, the steps of drawing a cup-shaped metal blank having a cylindrical flange wall in which the V-groove is to be formed, then rotary trimming excess metal from the open free end of the formed flange wall to provide a predetermined axial flange length uniform throughout the periphery of the flange wall, then roller spinning a V-groove in said trimmed flange wall, and confining the trimmed end of said flange wall against

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expanding outward movement throughout the groove spinning operation.

3. In a method of making a spun, V-grooved, sheet metal pulley, the steps of forming a cup-shaped metal blank having an annular flange wall in which the V-groove is to be formed, then trimming excess metal from the open free end of the formed flange wall to provide a predetermined axial flange length uniform throughout the periphery of the flange wall, then roller spinning a V-groove in said trimmed flange wall, and confining the trimmed end of said flange wall against radial outward movement throughout the groove spinning operation thereby preventing expanding outward flow and limiting, stretching and thinning of the metal in the V-groove walls throughout spinning.

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