

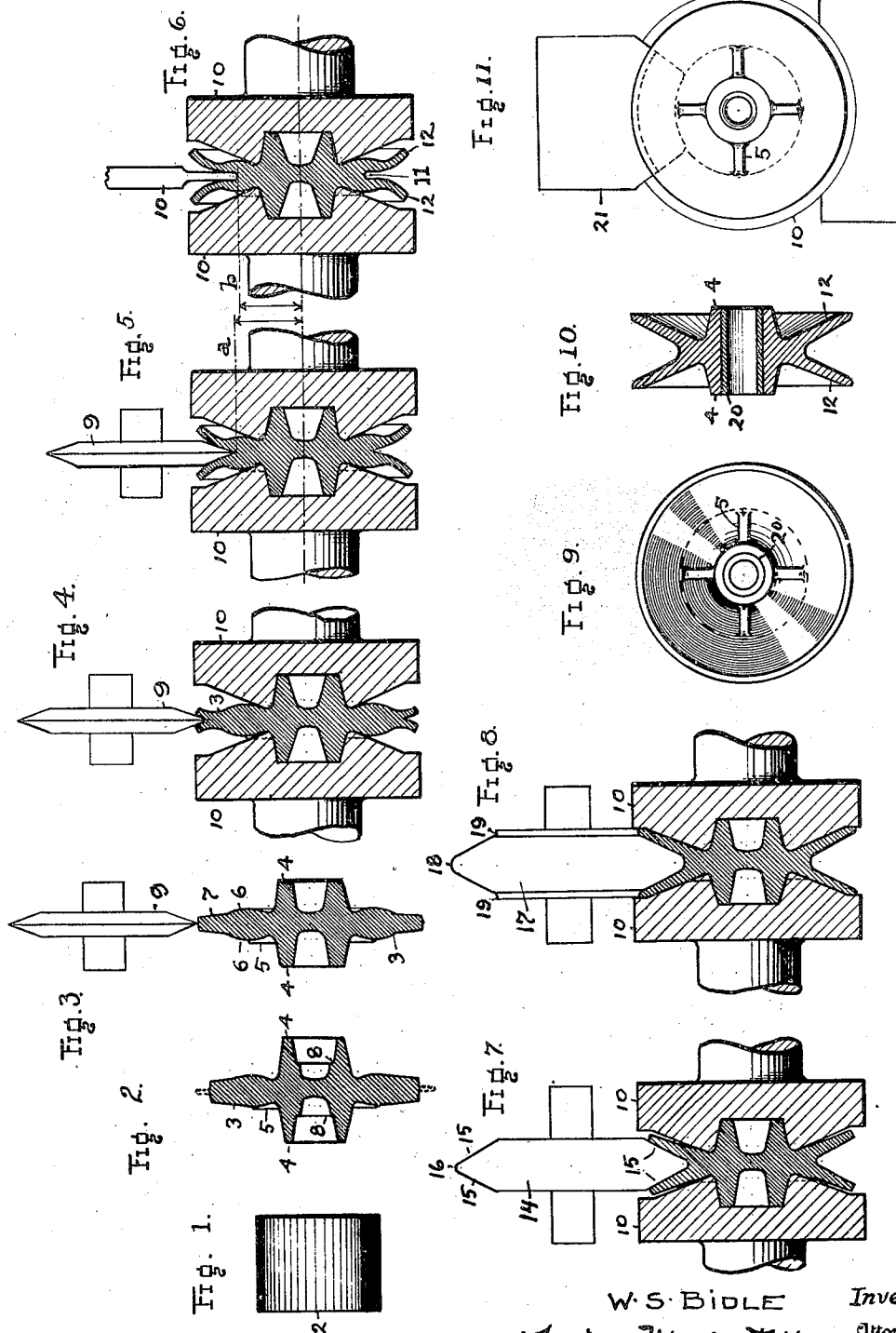
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METHOD OF PRODUCING COPPER TROLLEY WHEELS

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## UNITED STATES PATENT OFFICE.

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## METHOD OF PRODUCING COPPER TROLLEY WHEELS.

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*To all whom it may concern:*

Be it known that I, WILLIAM S. BIDLE, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in a Method of Producing Copper Trolley Wheels, of which the following is a specification.

This invention pertains to a method of making trolley wheels of high electrical conductivity and of the requisite hardness to withstand persistent wear and usage, and the steps taken make it possible to produce trolley wheels of pure or unalloyed copper having relatively hard wearing surfaces capable of giving long service and the maximum electrical conductivity.

The trolley wheels in general use are made of brass, an alloy consisting essentially of copper and zinc. The addition of zinc to copper very materially lowers the electrical conductivity, and as commonly practiced, the making of a trolley wheel of brass of the requisite hardness and composition involves both casting and machining operations. The cost of casting is materially increased because the groove in the wheel requires cores to be used in the molding operation; such castings frequently have imperfections and blow holes; and in machining the groove such imperfections and holes are liable to appear in the final surface and require the imperfect product to be discarded at a considerable loss. The presence of blow holes or imperfections below the final machined surface is also objectionable in that these imperfections cause trouble as soon as the surface wears down to that point, and the presence of metals of lower conductivity than copper is objectionable in a trolley wheel because such metals cause arcing and pitting in the wheel.

My general object is to forge and cold roll or cold work a cast piece or hot rolled or extruded bar of unalloyed copper to produce a trolley wheel without blow-holes or imperfections and with hardened surfaces especially at the wearing places in the wheel. In speaking of hardening the copper surfaces, I mean such hardening as takes place in cold working operations as exemplified in cold drawn wire and cold rolled sheets of copper, and the hardness of the grooved surface of a copper wheel as produced by my method is preferably approximately the

same or slightly below the hardness of the copper trolley wires in general use to prevent undue wear on such wires.

More specifically stated my object is to produce a trolley wheel having the following advantages over a cast and machined brass wheel, to wit: an increased electrical conductivity; absence of blow holes in or beneath the surface of the trolley wire groove; an increased life due to less arcing and pitting of the wheel; an increased salvage value; and a more homogeneous and uniformly hardened wearing surface.

Now referring to the annexed drawing, Figs. 1 to 8, inclusive, are diagrams illustrating the various steps taken in producing a trolley wheel according to my invention. Figs. 9 and 10 are side and sectional views of a finished trolley wheel, and Fig. 11 is a side view of a wheel and swaging die to illustrate a swaging operation.

In practicing the invention, a short round cylinder or other shaped piece 2 of metal (see Fig. 1) is either cast in this form or cut to a given length from a long bar which may in its making be either cast, extruded, hot rolled or cold drawn. Preferably this stock is pure or unalloyed copper, but the method need not be confined to the working of copper but may be practiced with other metals capable of being worked hot and cold in substantially the same way. In this connection it should be understood that only a narrow range of brass compositions can be hot worked under the action of pressure, but such compositions produce inferior trolley wheels; and where brass or any similar composition is used and cold worked it is generally necessary to anneal the worked stock frequently, which again changes the properties sought for in the final product. Therefore pure or unalloyed copper is preferred, and assuming the blank 2 to be of such unalloyed copper, it is placed between a pair of dies adapted to produce a disk-shaped body 3 having hollow hubs or enlargements 4—4 on opposite sides thereof and a series of radial ribs 5 on one or both sides, see Fig. 2. These ribs 5 are shown plainly in the finished wheel, Fig. 9, and their main function is to interlock with the rotary driving holder or die during grooving and rolling operations as hereinafter described.

Now, returning to Fig. 2, the die-pressing

operation leaves a parting flash at the periphery of body 3 which is trimmed off; and body 3 is relatively thicker near the hub than at the periphery, being given a substantially tapering form in cross section. The pressing operation is also performed on a blank 2 heated to a cherry red to avoid brittleness in the pressed stock and subsequent annealing and to relieve the pressure on the dies.

The next step in operations consists in placing the pressed body 3 between another pair of dies constructed to permit the disk to be distended to a larger diameter while tapering and reducing it in thickness in its outer circumferential portion and rounding it convexly on opposite sides to produce a round annular swell or enlargement 6 at the base of the tapering portion 7, see Fig. 3. Both hubs, 4—4, are also compressed to a shorter length in this operation, which is a cold pressing step to impart a definite hardness to the copper by flowing the metal upon itself, especially at the ends of hubs 4 where exposed to wear when in use in a trolley harp having frictional or spring-engaging contacts for conducting the electric current from the wheel to the harp and pole. In connection with Figs. 2 and 3, it should be noted that the outer ends of the hubs in Fig. 2 are relatively thin and tapered and that there is an offset 8 internally to confine the area of movement of the metal under cold working to the outer end portion of the hubs, thereby largely confining the hardness in the metal at the wearing places where most needed.

The pressed product of Fig. 3 can be made directly from blank 2 by a single hot-pressing operation, omitting the preceding step and blank of Fig. 2, but, I prefer a sequence of hot and cold pressing steps as described to derive the benefit of the hardness imparted to the hub-ends and to the outer tapering portion 7.

The next step involves a splitting or parting of the pressed disk, and the parting takes place on the median line of the disk beginning at the periphery under greater or less pressure dependent upon the type of parting tool employed. As shown in this application parting is effected initially by the cutting action of a sharp edged parting tool such as a reversely beveled cutter or roller 9. In this proceeding the disk-shaped body 3 is held securely between a pair of clamping holders or dies 10 having opposed faces of conical form and central sockets to receive the hubs 4 and constructed to interlock with ribs 5 so that the clamping holders and the work may be jointly rotated at a speed of approximately 200 to 300 revolutions per minute and the work solidly seated against the heavy pressure brought to bear against it by parting roller 9 which is fed forward by a screw or any other suitable means not shown.

As the parting roller 9 enters the work the stock at each side of the median line spreads outwardly and curls away from the tool on curved lines until the desired depth of parting is reached, substantially as shown in Fig. 5, wherein dotted line *a* indicates the depth of entrance of the cutter or roller. This operation starts the formation of a groove in the wheel body 3 and is important in that the disk is divided without waste or loss of material and in that the cold rolling of the material toward the axis and bending of the material sidewise acts to harden the copper and to make a hardened finish for the groove in the wheel.

In lieu of parting the stock as described, I may use a somewhat thicker disk blank and cut a circumferential groove within its periphery, but this has the disadvantage of wasting material, it is a very difficult operation in copper, the base of the slot develops improperly for effective future working, and the material in the sides does not flow or roll upon itself to effect hardening.

In parting the material with a sharp tool or roller 9 the bottom of the groove or channel is of acute V-shape and there is a tendency in the metal to split or crack beyond the sharp edge of the roller. Whether this split or crack actually occurs or not if further spreading and shaping operations are performed on the diverging sides from within the tendency is to produce a seam or crack in the body on the parting line and to break off the side flanges before they can be shaped or expanded to their proper width. Therefore, the next step consists in feeding a narrow cutting tool 10 with a round cutting edge into the bottom of the V-shaped groove to remove a portion of the stock, the work rotating until the desired depth of cut is obtained substantially as indicated by the dotted line *b* in Fig. 6. As a result any crack or seam at the parting line is obliterated and a round bottomed groove or slot 11 is produced therein which greatly facilitates the subsequent bending and shaping of the side flanges 12 on straight diverging lines without splitting the body or causing the flanges to crack or break away at their base. Briefly, cutting a round slot at the finish of parting operations involving the use of sharp tool removes any fractures or cracks and leaves the central body of metal intact, and the stock at each side of this round groove is also made thinner to facilitate bending of the side flanges. The reason for producing the annular convex enlargements at each side of body 3 also now becomes apparent as without this extra stock and rounded outline it would be difficult to cut the circular base slot without sacrificing strength and still permit the development of a relatively wide flaring groove in the wheel and cold working of the side flanges.

Such cold working proceeds when the slot cutting operation is finished, and consists in either rolling or swaging the parted wheel to effect the spreading and shaping of the side flanges on greatly increased and straight diverging lines, and what is more important, to effect a flowing movement of the metal upon itself to harden the base and sides of the trolley wire groove and the peripheral edges of the side flanges to a scleroscopic hardness approaching or equal to the hardness of trolley wires in general use. To exemplify the rolling operation I show in Fig. 7 a heavy roller 14 having flat converging working surfaces 15 terminating in a round edge 16 of slightly larger diameter than the round slot 11 in the wheel body and when this roller is fed under pressure between the flanges while the work is revolving the curved inner sides of the flanges are rolled and worked substantially flat until finally the round edge 16 of the roller enters the round groove and cold works the sides thereof in the same way. This operation may be repeated with a slightly larger roller, and carried to completion with still another roller 17, or the last roller may be used immediately following the use of roller 14, which is broader and possesses different angular working surfaces and a larger rounded edge 18 than roller 14 to spread the flanges of the wheel to a greater degree and to enlarge the radius of the groove in the wheel. In spreading and cold working the flanges the pressure which is applied moves toward the axis of the wheel, and the material involved in the surface of the grooved area is gradually rolled or caused to flow upon itself toward the base of the groove and there is a slight though actual tendency to elongate the side flanges. In so doing the outer or peripheral edges of the flanges are engaged by curved shoulders 19 at each side of roller 17 and also rolled and cold-worked which hardens these edges. This last result is important because this portion of a trolley wheel frequently strikes or meets with obstructions and if too soft, would become marred or dented. In the final cold working operation the side flanges are pressed flat against the sloping faces of the holding dies 10 and the flange edges are confined on all sides. This practically completes the trolley wheel which now possesses a permanent change in form and a uniformly hard surface in its grooved area where the wheel is adapted to bear against a trolley wire and at its hub ends where the outer faces are adapted to engage the current-conducting contacts used in the trolley harps in actual service.

However, to actually complete a copper wheel it is desirable to provide a hardened bushing 20 within a round opening drilled

and reamed through the hub of the wheel. A completed wheel with such a bushing is shown in Figs. 9 and 10. This bushing may be provided with grooves to hold graphite or other lubricant, but as this is a common practice it has not been shown.

I have already stated that swaging instead of rolling operations may be employed to spread and cold work the flanges of the wheel subsequent to making the grooved article shown in Fig. 6, and to illustrate this conception I show in Fig. 11 a tapered swaging die 21 entered within a partly finished wheel such as shown in Figs. 7 and 8. In swaging, the die is forced into the groove between the flanges at timed intervals while the wheel and its clamping holders are at rest, and is withdrawn and held out of action while the wheel is revolved part way to permit the operation to be repeated in an adjacent sector in the wheel. These swaging steps may proceed successively in different radial portions of the wheel with one set of dies until the wheel is given one complete revolution, and then similar step, by step swaging operations may be repeated with one or more larger dies to produce the finished article shown in Figs. 9 and 10. If desired, swaging and rolling operations may proceed alternately, and the final operation may involve the use of a roller to work the surface material in the grooved area downwardly at each side into the base of the groove on a line moving spirally toward the axis of the wheel, thereby producing a permanent change in form and property of the metal resulting in a hard smoothly finished surface capable of resisting persistent wear and usage. In forming the groove the sides of the groove in the finished wheel will eventually conform to the beveled sides of the roller but there is a definite limit of movement of the roller into the wheel. This limit is determined by the bottom of the groove and by the difference in speed of rotation at the pressure applying apex of the roller as compared with the beveled sides thereof. In other words, in applying pressure beyond a certain point the bite at the apex of the roller tends to dilacerate and peel the surface of the metal, and the sides will slip where engaged and moving at differential speeds.

What I claim is:

1. A method of making trolley wheels, consisting in forming an annular groove in a body of ductile and tenacious metal of high electrical conductivity and subjecting the metal involved in the surface of the groove to cold-working operations under pressure until hardened.

2. A method of grooving a wheel, consisting in parting a metal blank annularly to provide a groove and flaring side flanges, and in flowing the metal involved in the sur-

faces of said groove and flanges upon itself under spreading pressure to harden such grooved surfaces.

3. A method of grooving a wheel consisting in forcing a parting tool into the peripheral edge of a rotating disk-shaped metal blank until diverging flanges are produced, and then forcing a spreading tool between the parted sides and reshaping and working the material in the flanges while the parted blank is revolving.

4. A method of making a grooved wheel, consisting in parting a disk-shaped metal blank annularly at its periphery; in removing a portion of the stock at the base of the parting; and in spreading and shaping the parted sides.

5. A method of making a grooved metal wheel, consisting in clamping a metal disk upon a rotatable member and rotating said parts; in forcing a beveled tool into the peripheral edge of said disk a predetermined distance until the opposite sides of the disk curve outwardly; in rounding the metal at the base of the parting in the disk; and in forcing the material involved in the parted surfaces to flow under the action of great pressure moving inwardly from the periphery to the rounded base.

6. A method of making trolley wheels composed of ductile and tenacious metal of high electrical conductivity, consisting in compressing a body of the desired material between dies into the form of a disk; in parting the disk circumferentially under the action of pressure until an annular groove is formed; and finally in working the material in the area of the groove under the action of pressure moving inwardly toward the base of the groove.

7. A method of making trolley wheels composed of ductile and tenacious metal of high electrical conductivity, consisting in subjecting a blank of the desired material to the action of pressure moving to flow the material upon itself externally of the blank; and in forming a relatively deep circumferential groove in the edge of the blank under the action of pressure moving to flow the material upon itself in the area of the groove.

8. A method of making trolley wheels composed of ductile and tenacious metal of high electrical conductivity, consisting in first forming a disk-shaped blank of the desired material; then in subjecting said blank to the action of pressure adapted to

distend the blank circumferentially and compact its central portion; and then in grooving the blank circumferentially to a predetermined depth under a moving pressure capable of producing a permanent change of form and property in the metal involved in the grooved area.

9. A method of making trolley wheels, consisting in crowding an annular groove to a substantial depth in the periphery of a disk composed of unalloyed copper until outwardly curving side flanges are produced, and subsequently pressing said flanges outwardly on different lines and hardening the grooved area.

10. A method of making trolley wheels composed of ductile and tenacious metal of high electrical conductivity, consisting first, in shaping a blank of the desired material into a disk having central enlargements; secondly, in subjecting said disk to the action of pressure to flow the metal upon itself in its central and circumferential portions; thirdly, in producing an annular groove in the circumferential portion of the disk under the action of pressure moving inwardly toward the axis; and fourthly, in subjecting the grooved area of the disk to the action of pressure moving to effect a permanent change in form and property of the material in said area.

11. A method of making trolley wheels composed of copper or an alloy having substantially the same properties as copper, consisting in shaping a body of the desired metal into a disk having laterally extending enlargements at its center and of tapering thickness in its circumferential portion, and in parting and spreading the circumferential portion of the disk to produce an annular groove and flaring side flanges under the action of pressure moving inwardly from the peripheral edge of the disk toward the axis of the central enlargements.

12. A method of making trolley wheels composed of a ductile and tenacious metal of high electrical conductivity, consisting in forming a body of the desired metal into a disk-shaped blank at a high temperature; in compressing and reshaping the said blank at a relatively lower temperature; and in grooving and working the material involved in the circumferential portion of the disk under a cold rolling pressure.

In testimony whereof I affix my signature to this specification.

WILLIAM S. BIDLE.