March 23, 1943. D. A. WALLACE 2,314,533

LAPPING PROCESS

Filed July 17, 1941

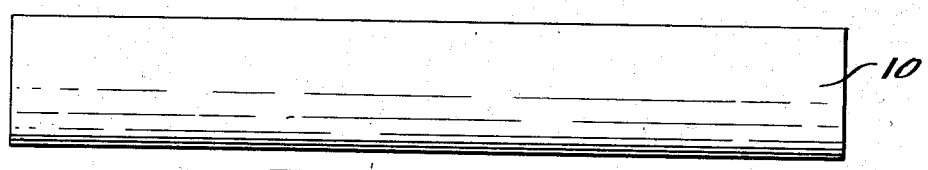


Fig. 1.

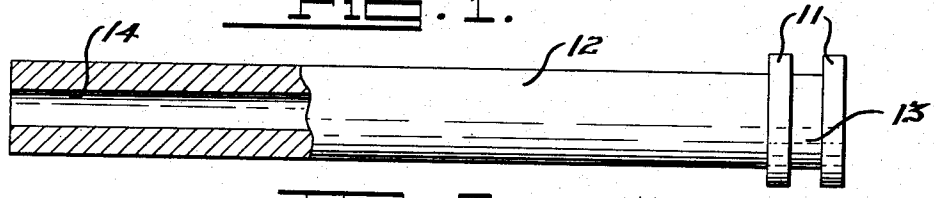


Fig. 2.

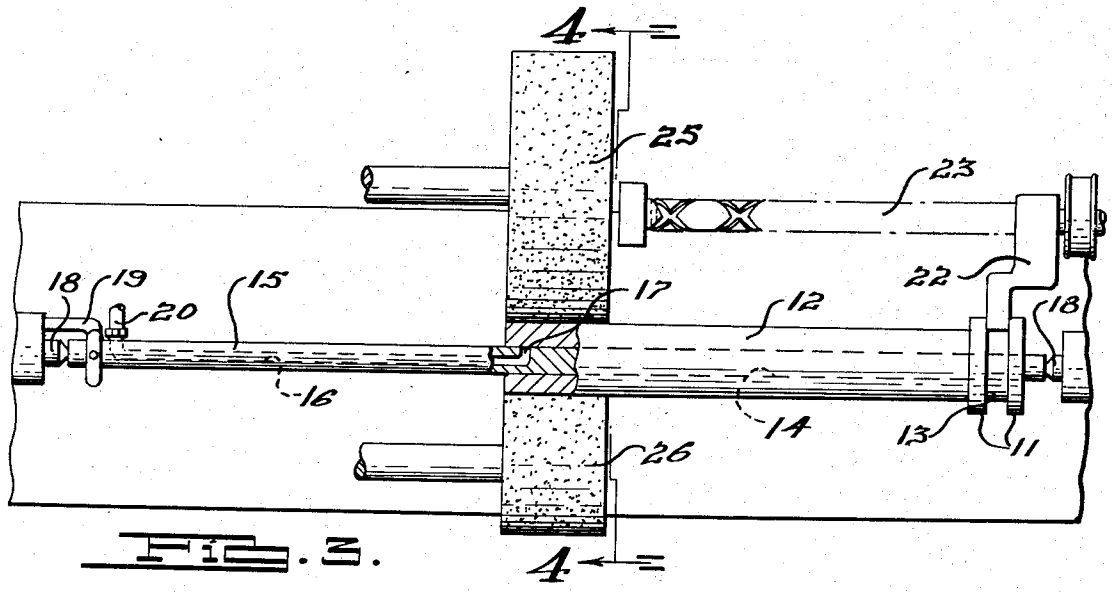
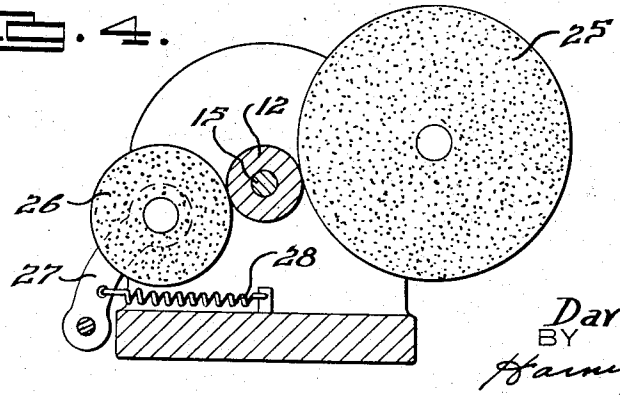


Fig. 3.

Fig. 4.



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2,314,533

LAPPING PROCESS

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6 Claims. (Cl. 51—290)

My present invention relates to a method and means for manufacturing a tubular shaft having its bore coaxial with its outer surface within unusually close tolerances. The present invention is of utility in manufacturing torque transmitting shafts, especially where lightness is of importance as in airplanes.

The object of the present invention is to provide a shaft having a bore which is concentric with the axis of the shaft and concentric with its outer surface within limits heretofore impossible to obtain. This object is achieved in part by providing a blank with an accurately finished bore, forming the outer surface of the shaft roughly concentric with the bore and slightly larger than the desired dimension, then mounting the shaft upon a mandrel having a true surface and a diameter slightly smaller than the diameter of the bore so as to provide a space between the surfaces of the mandrel and of the bore between which oil or other fluid under high pressures may be forced so as to form a cylinder of fluid under pressure floatingly supporting the blank with the axis of the bore accurately coinciding with the axis of the mandrel. Thereafter the outer surface of the blank is finished to size by surface finishing tools operating upon the blank while the blank revolves about and reciprocates along the mandrel.

The objects and advantages of the present invention will be more readily understood by reference to the following specification and drawing wherein like numerals refer to like parts throughout.

In the drawing,

Fig. 1 discloses a piece of round bar stock from which the shaft is to be manufactured;

Fig. 2 discloses the blank which is manufactured from the round bar stock;

Fig. 3 discloses the mechanism forming part of my invention with the blank in position thereon; and,

Fig. 4 is a sectional view taken substantially along line 4—4 of Fig. 3.

In practicing my invention a piece of round bar stock 10 is milled to provide spaced shoulders 11 adjacent an end and a shaft portion 12 having a rough finished diameter larger than the desired diameter. The particular shaft herein disclosed is adapted to be associated with connecting mechanism partly through the medium of the shoulders 11 so that the bar stock 10 is provided with sufficiently large diameter to provide the shoulders integrally with the shaft 12. However, the present invention is applicable to shafts which do not require such shoulders 11, in which case a piece of bar stock of substantially the desired diameter may be provided with a groove or grooves adjacent an end, which portion may be cut off after the final finishing operation. The purpose of the shoulders 11 is to provide a groove 13 by means of which the blank may be fed longitudinally, as will presently appear. The blank is now bored longitudinally to provide a central bore 14 having its surface as nearly concentric to the longitudinal axis of the blank as modern machinery can make it, the surface of the bore 14 being then honed or otherwise finished to the desired dimension. The blank is now preferably heat treated or otherwise processed to impart to the material thereof the characteristics desired of the finished article.

The outer surface of the blank is, as previously stated, of a diameter in excess of that desired. In order to remove this excess material the blank is finished in the apparatus of my invention. This apparatus comprises essentially a mandrel 15 having an accurately finished surface and a diameter slightly lesser than the diameter of the bore 14. The mandrel is preferably in excess of twice the length of the shaft portion 12 and is provided with a longitudinally extending bore 16 having an outlet 17 to the surface of the mandrel at the central portion thereof. The mandrel, with the blank mounted thereon, is now mounted in the finishing machine, preferably upon the centers 18 adapted to hold the mandrel firmly in position. The finishing machine is preferably provided with a clamp 19 by means of which the mandrel is prevented from rotating. The longitudinal bore 16 in the mandrel is connected to a tube 20 by means of which oil or other fluid under pressure may be forced into the space between the surface of the mandrel 15 and the surface of the bore 14. The fluid under pressure acts uniformly in all directions surrounding the opening 17 so as to form a cylindrical cushion floatingly supporting the blank upon the mandrel with the surface of the bore 14 concentric with the surface of the mandrel 15.

The blank is adapted to be reciprocated longitudinally of the mandrel 15 by means of a travelling fork 22 mounted upon a worm shaft 23, the tines of the fork fitting into the groove 13 between the shoulders 11. Obviously, if the groove 13 is sunk below the surface of the shaft 12, the fork 22 may be adapted to engage such a groove. The length of the worm shaft 23 is such as to traverse the surface of the shaft to be finished

past surface finishing means provided adjacent the central portion of the mandrel 15 near the outlet 17.

The work is preferably accomplished by means of a driven grinding wheel 25 revolving at high speed, past which the surface is reciprocated by the worm shaft 23. As the grinding wheel operates upon the surface, the blank itself is caused to revolve at a surface speed tending to approach the surface speed of the wheel so that a highly polished surface is imparted to the blank. A pressure wheel 26 may be provided to eliminate any tendency to vibrate. The pressure wheel 26 may be of such character as merely to press against the material or may in itself be composed of surface removing substance. The pressure wheel is preferably mounted upon a swinging arm 27 and urged toward the work by a light spring 28.

In practicing my invention the outer diameter of the blank is formed to a rough finish of approximately .01 of an inch larger than the desired final size before forming the bore 14 and heat treating the blank. The mandrel 15 is preferably provided with a true surface approximately .001 of an inch smaller in diameter than the diameter of the bore 14. The fluid provided for floatingly supporting the blank upon the mandrel is preferably oil and is preferably forced through the bore 16 under pressures of at least 25 pounds to the square inch and upward to as high as 500 pounds to the square inch. The surface finishing operation is preferably that type of operation characterized by lightly engaging an abrasive wheel of medium grain dimensions against the surface of the work so as to remove the surface inequalities above the base metal. When the extra .01 inch outer dimension is removed by the finishing operation the surface will have only few irregularities therein and such as exist will extend below the base surface. By means of this method and apparatus tubular shafts should be provided having uniform concentricity from end to end and wall thickness dimensions held closer than .001 of an inch.

Having described and illustrated the preferred embodiment of my invention, it should be apparent to those skilled in the art that numerous types of shafts may be formed thereby, and that numerous modifications in arrangement and detail of the mechanism may be provided within the scope of my invention. It should also be apparent to those skilled in the art that numerous variations in the steps to which the blank may be subjected before reaching final form may occur, and that, nevertheless, the process herein described and claimed in the following claims would not be affected by any treatment imparted to the blank prior to application of my process or subsequent thereto.

I claim as my invention the following method and apparatus:

1. The process of forming a tubular shaft having its bore coaxial with its outer surface comprising the steps of forming a tubular blank having its greater diameter slightly larger than desired and its bore finished to close tolerances, supporting the blank on a cylindrical mandrel having a diameter slightly smaller than the diameter of said bore, revolving the blank relative to said mandrel, finishing the outer surface of the blank to size by applying a finishing tool against said outer surface mainly from one direction substantially radially of said blank during revolving of the latter and forcing fluid under pressure into the space between the surfaces of said bore and said mandrel during said rotation and finishing whereby to provide a substantially cylindrical cushion of fluid under pressure floatingly supporting the blank with said bore substantially coaxially located with respect to said mandrel.

2. The process of forming a tubular shaft having its bore coaxial with its outer surface comprising the steps of forming a tubular blank having its greater diameter slightly larger than desired and its bore finished to close tolerances, supporting the blank on a cylindrical mandrel having a diameter slightly smaller than the diameter of said bore and a length in excess of twice the length of the shaft surface to be finished, revolving the blank relative to said mandrel, reciprocating the revolving blank past surface finishing means applied against said blank mainly in one direction radially thereof to finish the outer surface of the blank to size and forcing fluid under pressure into the space between the surfaces of said bore and said mandrel during said rotation and finishing whereby to provide a substantially cylindrical cushion of fluid under pressure floatingly supporting the blank with said bore substantially coaxially located with respect to said mandrel.

3. The process of forming a tubular shaft having its bore coaxial with its outer surface comprising the steps of forming a tubular blank having its greater diameter slightly larger than desired and its bore finished to close tolerances, supporting the blank on a cylindrical mandrel having a diameter slightly smaller than the diameter of said bore, revolving the blank relative to said mandrel, bringing successive longitudinal increments of the revolving blank into contact with a travelling grinding surface applied against said blank mainly in one direction radially thereof and held at a fixed distance from the axis of said mandrel and forcing fluid under pressure into the space between the surfaces of said bore and said mandrel during said revolving and grinding operations whereby to provide a substantially cylindrical cushion of fluid under pressure floatingly supporting the blank with said bore substantially coaxially located with respect to said mandrel.

4. The process of forming a tubular shaft having its bore coaxial with its outer surface comprising the steps of forming a tubular blank having its greater diameter slightly larger than desired and its bore finished to close tolerances, supporting the blank on a cylindrical mandrel having a diameter slightly smaller than the diameter of said bore, revolving the blank relative to said mandrel, passing the blank longitudinally between a revolving grinding wheel and a pressure wheel whose axes lie in substantially the same plane with, and parallel to, the axis of said mandrel and forcing fluid under pressure into the space between the surfaces of said bore and said mandrel during said revolving and grinding operations whereby to provide a substantially cylindrical cushion of fluid under pressure floatingly supporting the blank with said bore substantially coaxially located with respect to said mandrel.

5. The process of forming a tubular shaft having its bore coaxial with its outer surface comprising the steps of forming a tubular blank having its greater diameter slightly larger than desired and its bore finished to close tolerances, supporting the blank on a cylindrical mandrel

having a diameter slightly smaller than the diameter of said bore, revolving the blank relative to said mandrel, reciprocating the revolving blank longitudinally past the periphery of a revolving grinding wheel whose axis is substantially parallel to the axis of said mandrel and whose periphery is maintained at a distance from the axis of said mandrel equal to the desired outer radius of the finished shaft and forcing fluid under pressure into the space between the surfaces of said bore and said mandrel during said revolving and reciprocating operations whereby to provide a substantially cylindrical cushion of fluid under pressure floatingly supporting the blank with said bore substantially coaxially located with respect to said mandrel.

6. The process of forming a tubular shaft having its bore coaxial with its outer surface comprising the steps of forming a tubular blank having its greater diameter slightly larger than desired and its bore finished to close tolerances, supporting the blank on a cylindrical mandrel having a diameter slightly smaller than the diameter of said bore, reciprocating the blank longitudinally of said mandrel in contact with the periphery of a driven grinding wheel whose axis is substantially parallel to the axis of said mandrel and whose periphery is maintained at a distance from the axis of said mandrel equal to the desired outer radius of the finished shaft, permitting the blank to revolve due to the frictional drag of said grinding wheel while being reciprocated and forcing fluid under pressure into the space between the surfaces of said bore and said mandrel during said revolving and reciprocating operations whereby to provide a substantially cylindrical cushion of fluid under pressure floatingly supporting the blank with said bore substantially coaxially located with respect to said mandrel.

DAVID A. WALLACE.