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D. A. WALLACE

2,345,308

LAPPING APPARATUS

Original Filed July 17, 1941

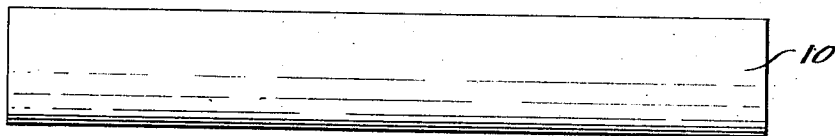


FIG. 1.

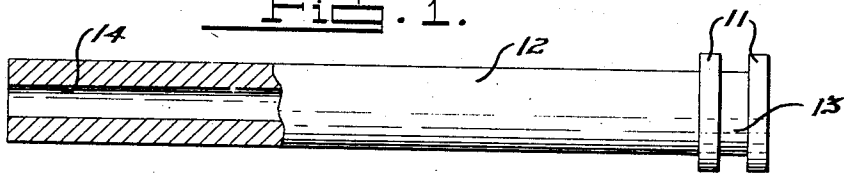


FIG. 2.

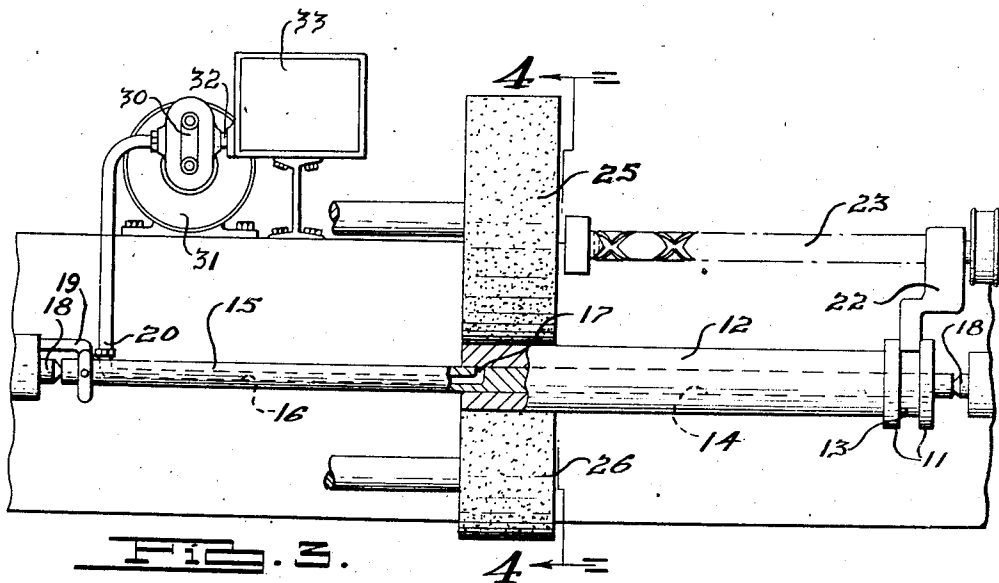
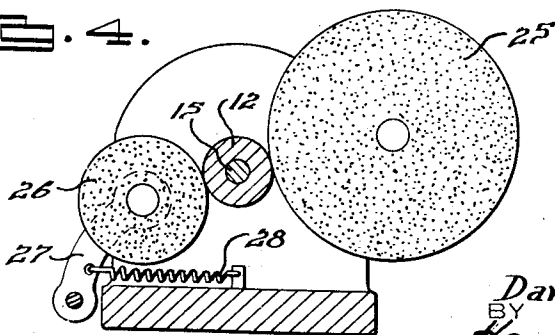


FIG. 3.

FIG. 4.



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UNITED STATES PATENT OFFICE

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LAPPING APPARATUS

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Original application July 17, 1941, Serial No.
402,734, now Patent No. 2,314,533, dated March
23, 1943. Divided and this application Decem-
ber 20, 1941, Serial No. 423,701

3 Claims. (Cl. 51—95)

My present invention relates to apparatus for manufacturing a tubular shaft having its bore coaxial with its outer surfaces within unusually close tolerances and is a division of my copending application, Serial No. 402,734, filed July 17, 1941, issued March 23, 1943, as Patent 2,314,533. 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. The 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.

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. Fluid under pressure may be supplied to the tube 20 by a pump 30, driven by a motor 31. The inlet of the pump 30 is connected by a pipe 32 with a fluid supply tank 33 which may be replenished from time to time. 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 traveling fork 22 mounted upon a worm shaft 23, the

times 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 a 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:

1. Apparatus for surface finishing a tubular shaft having its bore coaxial with its outer surface comprising a cylindrical mandrel provided with a longitudinal passage having an outlet to the surface at the central portion thereof

through which a fluid under pressure may be forced, and said mandrel having a diameter slightly lesser than the diameter of the bore of the shaft to be finished whereby when the shaft is rotated upon said mandrel a substantially cylindrical cushion of fluid under pressure may be formed in the space between the surface of the bore and the surface of the shaft floatingly supporting the shaft with its bore substantially coaxially located with respect to said mandrel a rotative finishing tool for operating upon the periphery of said shaft to finish the surface thereof while drivingly rotating said shaft upon said mandrel, and means for supplying fluid under pressure to said passage and to said space between said mandrel and shaft during rotation of the latter.

2. Apparatus for surface finishing a tubular shaft having its bore coaxial with its outer surface comprising a cylindrical mandrel having a length in excess of twice the length of the outer surface of the shaft to be finished, said mandrel being provided with a longitudinal passage extending from an end to an outlet to the surface at the central portion thereof through which a fluid under pressure may be forced, and said mandrel having a diameter slightly lesser than the diameter of the bore of the shaft to be finished for accommodating fluid medium under pressure whereby when the shaft is rotated upon said mandrel a substantially cylindrical cushion of fluid under pressure may be formed in the space between the surface of the bore and the surface of the shaft floatingly supporting the shaft with its bore substantially coaxially located with respect to said mandrel, means for drivingly reciprocating said shaft along said mandrel a rotative finishing tool for operating upon the periphery of said shaft to finish the surface thereof while drivingly rotating said shaft upon said mandrel, and means for supplying fluid under pressure to said passage and to said space between said mandrel and shaft during rotation of the latter.

3. Apparatus for surface finishing a tubular shaft having its bore coaxial with its outer surface comprising a cylindrical mandrel provided with a longitudinal passage having an outlet to the surface at the central portion thereof through which a fluid under pressure may be forced, and said mandrel having a diameter slightly lesser than the diameter of the bore of the shaft to be finished for accommodating fluid under pressure whereby when the shaft is rotated upon said mandrel a substantially cylindrical cushion of fluid under pressure may be formed in the space between the surface of the bore and the surface of the shaft for floatingly supporting the shaft with its bore substantially coaxially located with respect to said mandrel, means for drivingly rotating said shaft relative to said mandrel and simultaneously reciprocating said shaft along said mandrel, means for supplying fluid under pressure to said passage and to the space between said mandrel and said shaft while the latter is reciprocated and rotated, said means for drivingly rotating said shaft including a surface finishing element located opposite the outlet of said mandrel comprising a grinding wheel and an oppositely located pressure wheel both engageable with the surface of said shaft.

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