July 16, 1968 L. J. MOLINARO 3,392,610

MACHINE AND METHOD FOR REPAIRING ROTOR SHAFTS

Filed June 12, 1964 2 Sheets-Sheet 1

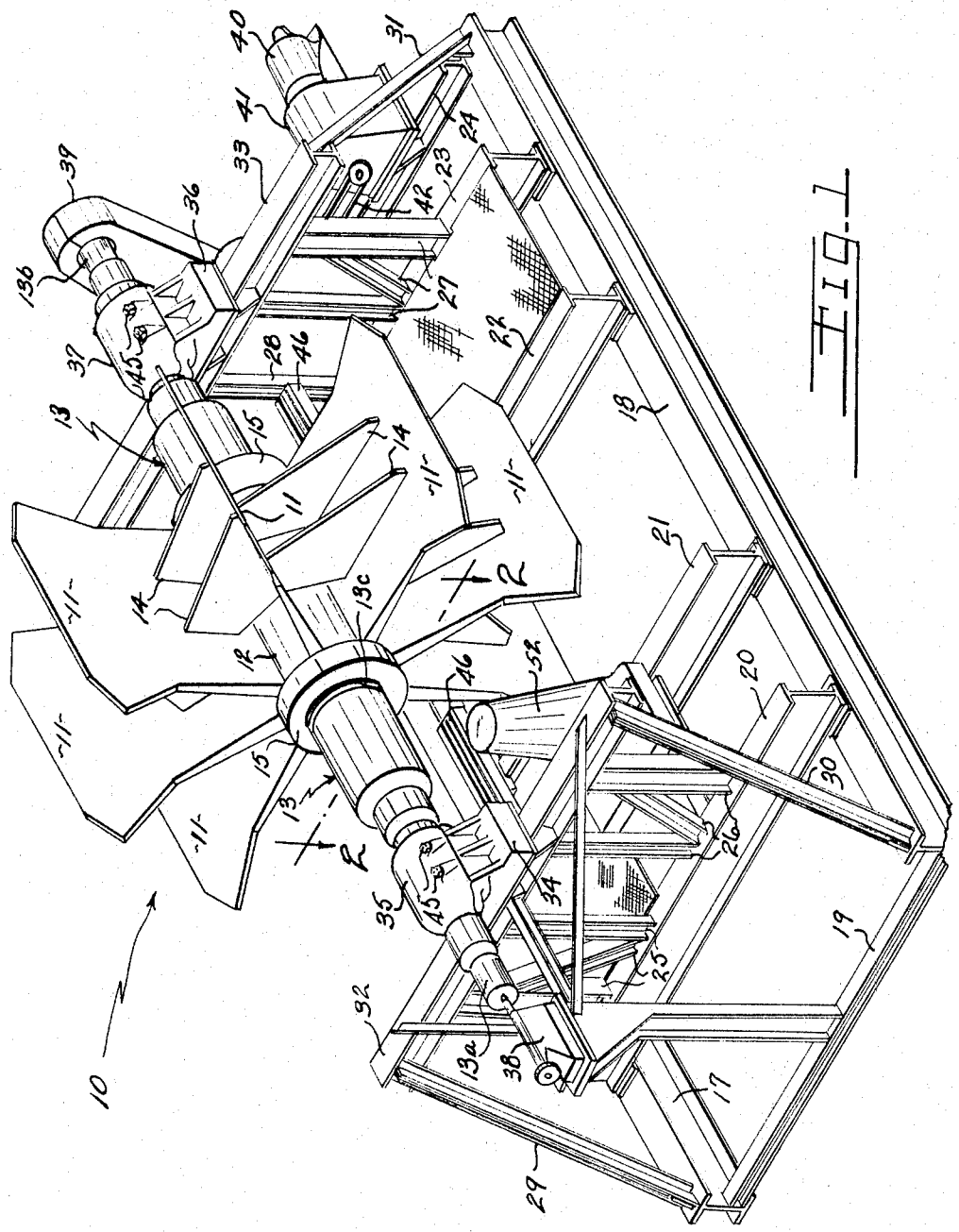


FIG. 1

INVENTOR.
LAWRENCE J. MOLINARO
BY
Meyer, Baldwin, Doran & Egan
ATTORNEYS

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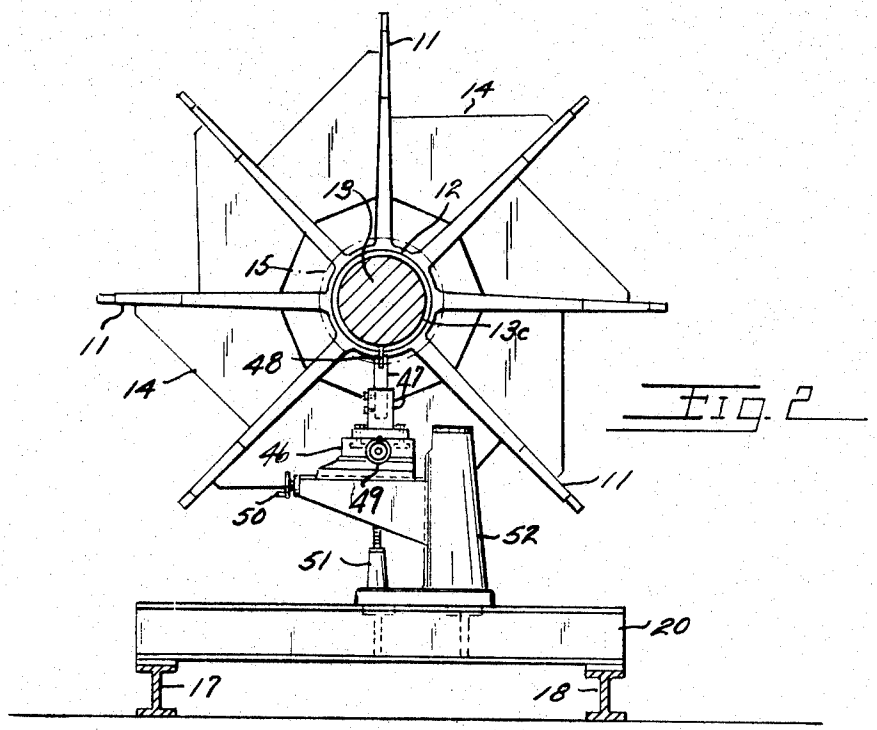


Fig. 2

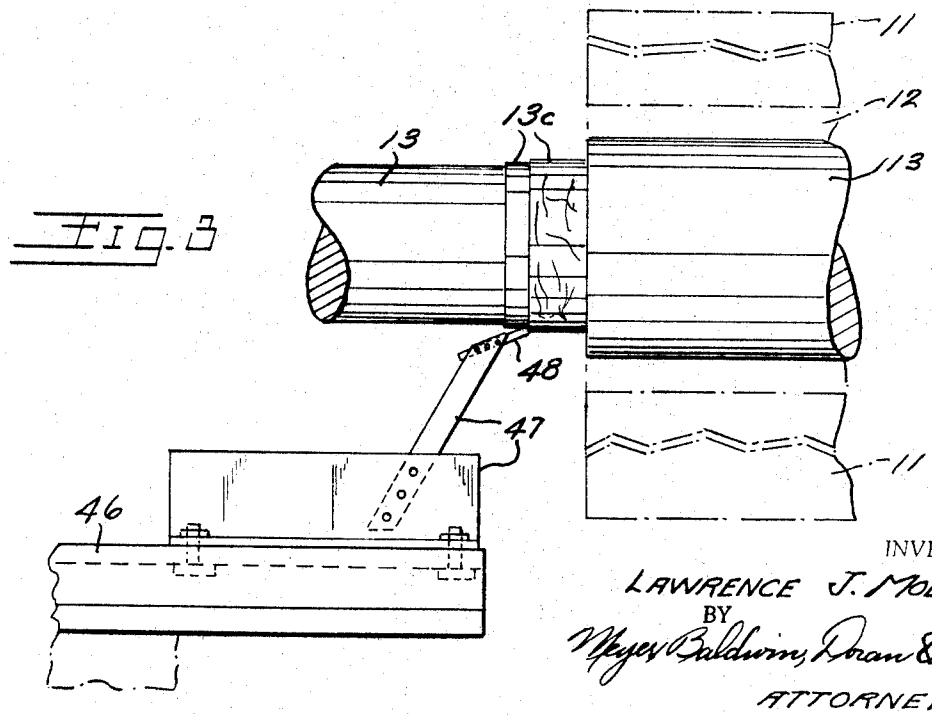


Fig. 3

INVENTOR.
LAWRENCE J. MOLINARO
BY
Meyer, Baldwin, Doran & Egan
ATTORNEYS

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MACHINE AND METHOD FOR REPAIRING ROTOR SHAFTS

Lawrence J. Molinaro, Silver Bay, Minn., assignor to Reserve Mining Company, Silver Bay, Minn., a corporation of Minnesota

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3 Claims. (Cl. 82—1)

The invention relates to a novel and improved apparatus for facilitating and expediting the servicing of extra large rotor-and-shaft assemblies such as are used in moving large volumes of air or other gases in certain metallurgical processes and elsewhere. In one such process with which applicant is familiar, namely the heat indurating of pellets made from taconite ore concentrates, the rotor or impeller blade or vane assembly can have a diametrical span of twelve feet and an axial width of six feet, the rotor being fixed on a shaft almost two feet in diameter and about twenty-two feet long. As will appear of significance later herein such a rotor-and-shaft assembly weighs in excess of twenty tons and costs more than fifty thousand dollars. In operation the rotor is in effect a rotary pump, being installed in a suitably sized conduit where it feeds tremendous volumes of gas or air, sometimes at temperatures up to or above one thousand degrees Fahrenheit.

The customary manner of mounting the rotor wheel which carries the impelling vanes is to pin it on the central part of the shaft, and retain it in place by means of two rings or collars on the shaft, one on each side of the impeller hub. The collars are first highly heated so as to have a close but slidable fit on the cold shaft. They are advanced to abutment with the wheel hub and then cooled to tightly grip the shaft, this being conventionally known as a "shrink fit."

When a fan wheel is assembled on a shaft and placed in service under wide temperature differentials, trouble is encountered from excessive vibrations arising from loosening of the retaining collars which expand in the higher temperature ranges thereby permitting the impeller wheel to become loose on the shaft. This causes surface damage in the shaft portions beneath the collars, and it is necessary to take the assembly out of service for repairs.

Repair procedure heretofore has involved shipping the entire rotor assembly, as a unit, back to the manufacturer's shops where the shaft is cut from the wheel, the wheel hub is re-bored, and a new shaft is installed. This procedure is lengthy, operationally unsound, inconvenient, costly, and time consuming. Shafts of the size mentioned above are not standard items kept in stock, but have been manufactured to fit when needed. It has taken approximately two months to procure the billet stock and forge and machine a shaft. In shipping a large assembly of the dimensions set forth hereinabove, the railroads classify it as a "high-wide" load which is moved under restricted conditions and by daylight only. Slow transit time is added to the manufacturer's delay in making repairs. The whole repair process, including loss of time and production interruption, greatly increases production costs.

An object of the present invention, therefore, is to devise means for readily, rapidly, and cheaply repairing rotor shafts for an assembly of the magnitude above indicated.

A further object of the invention is to devise means as defined in the last preceding paragraph which assures alignment accuracy during the shaft refinishing process.

A further object of the invention is to devise means as defined in the last two preceding paragraphs, by the use of which the expensive shaft can be salvaged and re-used.

A further object of the invention is to devise means as defined in the last three preceding paragraphs, by the use

of which complete repairs can be completed in a few days, instead of the replacement time of many weeks heretofore experienced.

A further object of the invention is to devise an apparatus for the reception and repair of a rotor shaft assembly of the magnitude above indicated whereby complete shaft repairs can be effected without removal of the rotor assembly from the apparatus.

Other objects and advantages will be apparent from a study of the present description of a preferred embodiment of the invention in conjunction with the accompanying drawings wherein

FIG. 1 is a perspective view of a rotor and shaft assembly disposed on my repair rack, but without the cutting tool set-up.

FIG. 2 is a vertical sectional view taken transversely to the axis of the rotor shaft.

FIG. 3 is a fragmentary side elevational view showing a portion of the shaft and cutting tool set-up.

Referring now to the drawings, and for the time being to FIG. 1, the arrow **10** indicates a wheel or impeller having in this instance eight vanes **11** fixed on a hub **12** on a shaft **13**. Plates **14** serve as braces or stiffeners between the vanes. Retaining collars **15** are shrunk on shaft **13** in tight abutment against the hub **12**.

In FIG. 1 the rotor assembly, comprising the shaft **13** carrying the impeller wheel **10** and collars **15**, is disposed on a repair rack built up from structural members including the longitudinal I-beams **17** and **18**, the cross beams **19, 20, 21, 22, 23** and **24**, and various upright or inclined columns **25, 26, 27, 28, 29, 30** and **31**. These upright and inclined columns serve to support two end rails **32** and **33** which in turn carry the rotor assembly in the following manner.

A bearing pedestal **34** supports a shaft bearing beneath cap **35** and a bearing pedestal **36** supports a shaft bearing beneath cap **37**. The pedestals or bearing blocks **34** and **36** are carried on the end rails **32** and **33**. The shaft end **13***a* extends through and beyond the bearing on block **34** and is further aligned by means shown as a lathe tail stock **38**. The other end **13***b* of the shaft has keyed thereon a sprocket (not shown) driven by a chain within housing **39**. A motor **40** through a gear reduction unit **41** drives a belt **42** which through suitable intermediate driving means drives the chain in housing **39**.

By reason of the mechanical arrangement shown in FIG. 1 the rotor and shaft assembly can be removed as a unit from its conduit and lowered to rest on the blocks **34, 36**. The same bearings are used in the repair rack of FIG. 1 as are used on the shaft in its working position. Actually the same bearing caps **35, 37** are transferred to the repair rack and are secured by bolts **45**. As will appear, when the shaft is being refinished it is being done while aligned in the same identical bearings as will be used in service, making it possible to achieve a high degree of accuracy in re-aligning the shaft when putting it back in service.

On each side of the wheel **10** there is a portion **13***c* of the shaft **13** which is slightly raised (FIG. 3) and which receives the collar **15**. Beneath the shaft on each side of the wheel I dispose a finishing tool and means for holding and positionally adjusting such tool. In the present instance such means includes a conventional milling machine bed **46** (FIG. 2) which carries tool holding means **47** and a cutting tool **48**. A grinding tool or polishing means can readily be substituted. The machine bed has a longitudinal feed **49**, a cross feed **50**, and a vertical adjustment **51** as will be familiar to those skilled in the mechanical arts.

Assuming that a shaft assembly needs service it is removed from its conduit. The collars **15** are loose, as hereinbefore described, resulting from thermal differentials in

service, and are readily removed from the portion **13***c* of the shaft. The shaft assembly including its end bearings is then positioned on the repair rack so that the driven end **13***b* of the shaft is in mesh with its driving gear or sprocket (not shown) and the bearings are supported on bearing blocks or pedestals **34**, **36**. The caps **35**, **37** are bolted down and the tail stock **38** is centered on the shaft end **13***a*. The rotor assembly is then ready to be rotated at any suitable speed for cutting, grinding, or polishing.

I have shown only in bare essentials the tool supporting bed **46** which is carried on a column **52** for vertical movement. I have used, for example, a commercially available milling machine bed and support with all upper turret mechanism removed from column **52** to afford clearance under shaft **13**.

Only the shaft portions **13***c* beneath and immediately adjacent collars **15** actually require refinishing as indicated on FIG. 3. These portions **13***c* are machined and ground to a suitable diameter to remove all traces of damage and to receive the new collars, although in some instances I machine and polish all exposed portions of shaft **13** to retain the step fit. With the arrangement as shown, and herein described, I have found it possible to attain a dimensional accuracy of 0.0005 inch by machining, and a further accuracy of 50 micro-inches (0.00005) by finish grinding and polishing. In FIG. 3 the depth of cut being taken is exaggerated.

The use of a standard milling machine bed affords three-dimensional positional adjustment of the finishing tools, namely vertical, longitudinal, and cross feeds. Other machining apparatus set-ups can be used which provide suitable tool adjustments.

After the shaft portions **13***c* are refinished new collars **15** are provided, the shaft assembly is lifted from the rack, the collars are heated to slip over the shaft and over portions **13***c*, and are then cooled to a tight shrink fit and pinned. The rotor assembly is then returned to its place of normal use in the conduit.

I claim:

1. A machine for repairing a rotor shaft having bearings thereon spaced apart a predetermined distance and having at an intermediate point thereon an impeller wheel and having collar-receiving portions disposed immediately adjacent to and on each side of said impeller wheel upon which wheel retaining collars are fixedly disposed in service, said machine comprising a base, bearing support means at each end of the base spaced apart said predetermined distance and suitably dimensioned and shaped to respectively receive the bearing in which said shaft operates, two shaft finishing means spaced longitudinally to receive said impeller wheel between them and carried on said base one beneath each said collar-receiving shaft portions, means for bringing each said finishing means to finishing relationship with its associated collar-receiving shaft portion, and means for rotating said rotor-shaft assembly at a speed suitable for the finishing operation.

2. A machine for repairing rotor shafts of predetermined length between end bearings and requiring refinishing of diameters intermediate the ends thereof, comprising a base, horizontal end rails on said base at opposite ends thereof having the same spacing between them as the end bearings of a shaft, means on each end rail specially shaped for receiving and supporting the working end bearings of a shaft, shaft rotating means on said base, and shaft finishing means on said base in position to engage said shaft diameters intermediate the shaft ends when a shaft is supported by said bearings on said end rails, said finishing means positioned to clear said shaft and parts thereon as said shaft is lowered into said bearings.

3. The method of refinishing shaft diameters intermediate the ends of a shaft having a predetermined length between bearings, comprising providing repair means having means for supporting shaft bearings at said predetermined spacing, said repair means having shaft refinishing means between said shaft bearing support means, removing said shaft from its bearings, placing said bearings in said bearing support means, securing said shaft in said bearings, rotating said shaft, and operating said shaft refinishing means in engagement with said shaft.

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LEONIDAS VLACHOS, *Primary Examiner.*