TURBINE JOURNALS: MACHINING IN PLACE IN WAKE OF CARBON PACKING

In 1948 *the H.P. turbine rotor spindles in H.M.S. " Kempenfelt " in the wake of the carbon packing had become worn and badly grooved. In order to save time and the expense of removing the rotors from the ship, a special machine tool device was developed in H.M. Dockyard, Simonstown, to true up the spindles in place.*

The apparatus was designed by and manufactured and operated under the personal supervision of Mr. E. Byrne, B.E.M., Acting Foreman of the Engineering Branch at the dockyard, in June, 1948, *and this article is a description of the device and the method of operation.*

Preliminary Work

Apart from the necessary first step of removing the upper half of the carbon packing box and the carbon segments themselves to enable the shaft surfaces to be inspected, the only other preliminary work required was to :—

(i) Remove the end cover at the forward end of the turbine casing so as to expose the end of the spindle

(ii) Break the flexible coupling at the after end of the turbine so as to enable the rotor to be rotated independently.

DESCRIPTION OF THE DEVICE

The arrangement consists of two principal parts, viz., the driving mechanism, and the truing tool and holder.

Driving Mechanism

Motive power is provided by a low-geared pneumatic drilling machine which drives through a single train of two lathe gear-wheels, one (the driver) of 25 teeth and the other (the driven) of 75 teeth and both 3 inches wide.

The " driven " wheel is keyed on to an extension shaft which in turn is screwed on to the existing stud fitted in the end of the rotor spindle and normally intended for use in any axial adjustment of the turbine rotor. It is important to note that this arrangement means that the turbine must be driven only in the " clockwise " direction as otherwise the wheel and its shaft would be unscrewed from the stud.

The " driver " wheel and pneumatic drill motor are supported as convenient in suitable brackets and bearings which are readily fabricated from miscellaneous parts and secured to any convenient fixed points at the turbine end or its vicinity.

The Truing Tool and Holder

The truing tool and holder consists of two major components, the holder block and the sliding tool which slides within it (Fig. 1 and 2).

The holder block is of steel, machined all over, and forms the fixed part of a " slide rest " in which the sliding portion is the tool itself.

The block, when the device is in use, is mounted on that landing face at the

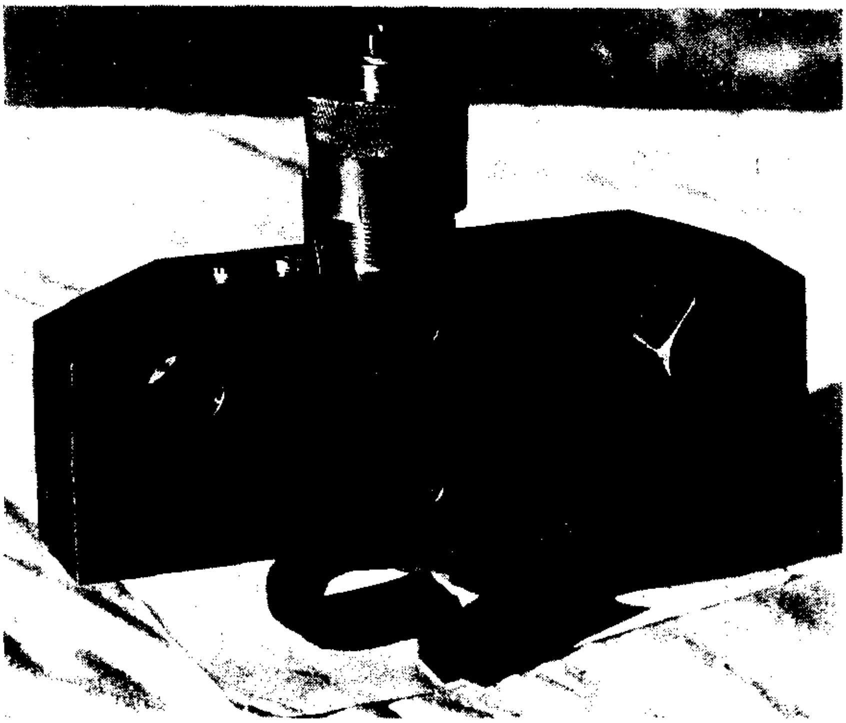

FIG. 1.—GENERAL VIEW OF TOOL HOLDER AND TOOL AFTER ASSEMBLY

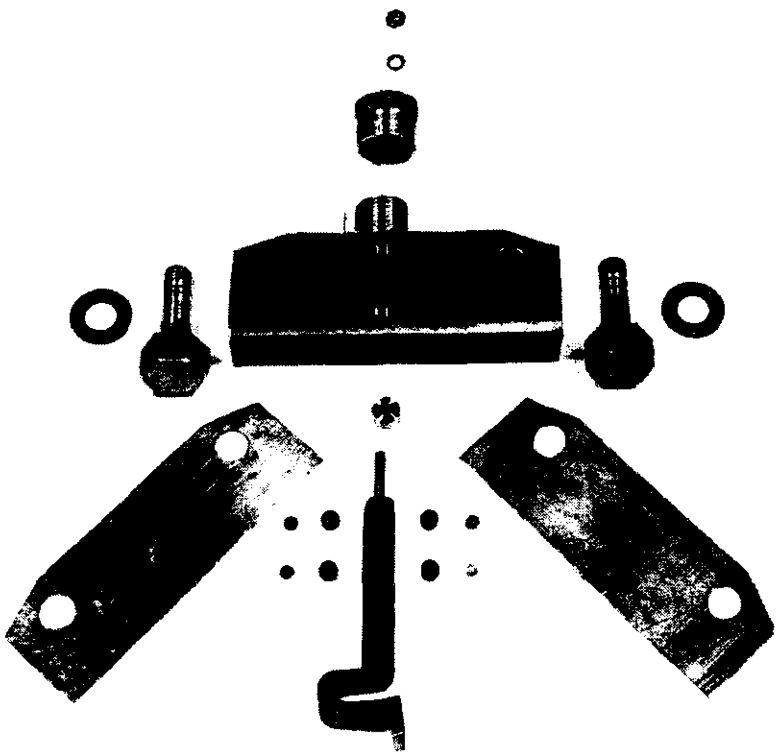

FIG. 2.—SEPARATE PARTS BEFORE ASSEMBLY

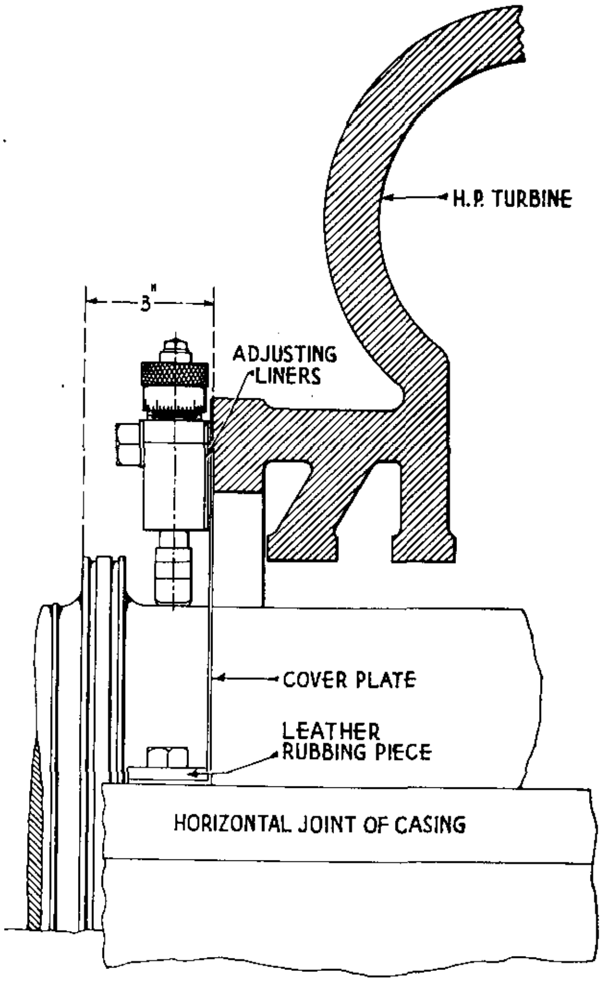

FIG. 3

end of the turbine casing on which the gland box is normally secured, and i held in place by two special bolts which are inserted into two of the gland-bo securing bolt holes (Fig. 3). These special bolts are given the minimur clearance in the bolt holes in the holder block.

The block is machined during manufacture to a thickness which allows fc parallel liners of suitable thickness to be sandwiched between the block's inne face and the landing face on the turbine casing ; this permits adjustment c the block (and tool) in the fore and aft direction so as to locate the tool relativ to the portion of rotor spindle to be machined.

These arrangements also ensure that the long faces of the holder block ar in the true plane, both vertical and lateral, normal to the plane of the turbin rotor shaft axis. The block is provided on its upper surface with a roun screwed boss, suitably offset from the fore and aft centre line.

Through this boss is drifted a square hole of accurate dimensions in whic the forward and after internal faces are parallel to the long faces of the bloc and the two side internal faces normal thereto. The tool itself slides in th internal square hole.

The boss and square hole are so positioned that, with the block secured i place, the side internal face remote from the direction of rotation (that is, th face on which the tool thrust is taken) is precisely in the vertical fore and a plane in which lies the axis of the rotor spindle (Fig. 4).

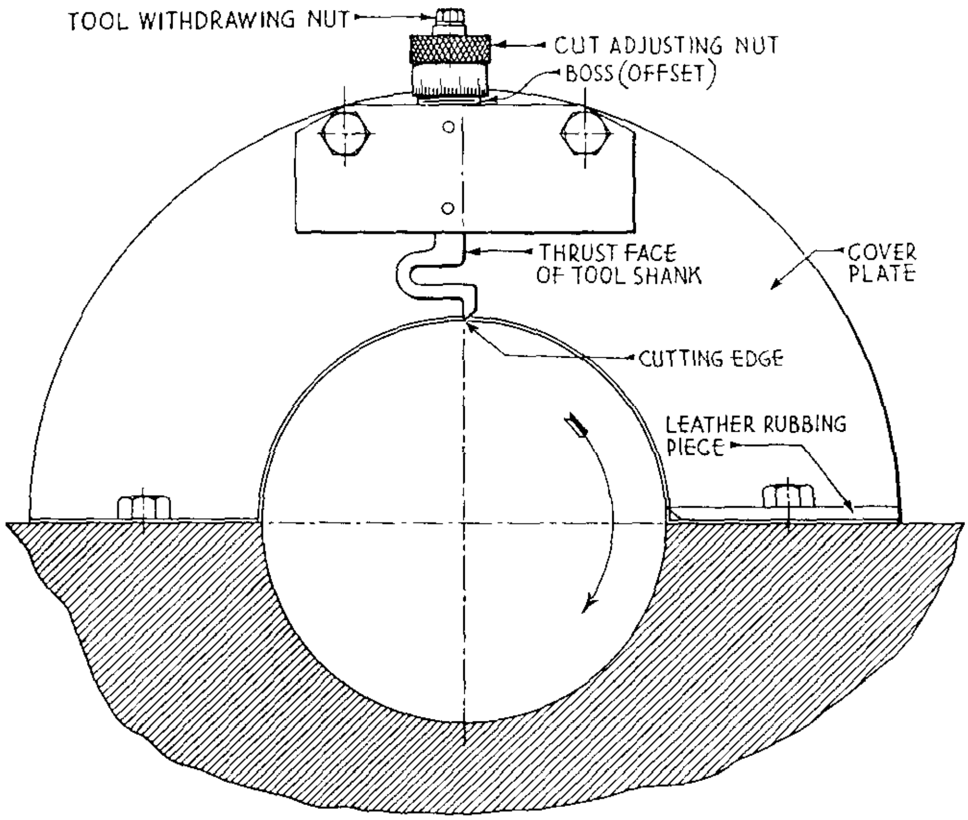

FIG. 4

Two sets of " Allen " screws are fitted, one on each side of the holder block, for adjusting the tightness of the sliding tool in its square hole at whichever end of the turbine the block is mounted.

Sliding Tool

The sliding tool is of high-speed steel and of the ordinary spring type but incorporates the following important details in its design (Fig. 5) :—

(i) the tool shank is ground truly square and is a neat sliding fit in the square hole in the holder block and its boss

(ii) the leading face of the cutting edge is exactly aligned with that side of the tool shank on which the thrust falls (the face remote from the direction of the rotor spindle) which, as already stated, is itself in the fore and aft vertical plane of the turbine rotor shaft axis

(iii) the cutting edge itself is also ground truly parallel in one plane and at right angles in the other to the sides of the square hole in the holder block ; this is done with the tool already fitted in the block and ensures that the finished machined surface of the rotor spindle will be parallel and in correct alignment with the unmachined part of the spindle

(iv) the tool shank being too hard for drilling and tapping, a round brass nut is brazed on to its upper end and into this is screwed a steel stud ; a small steel nut known as the " tool-withdrawing nut " is mounted on this stud for use in withdrawing the tool through the " cut-adjusting nut "

(v) the cut-adjusting nut, which operates on the screwed boss, is knurled externally and also graduated to show " cuts " of 1/1000 in or less ;

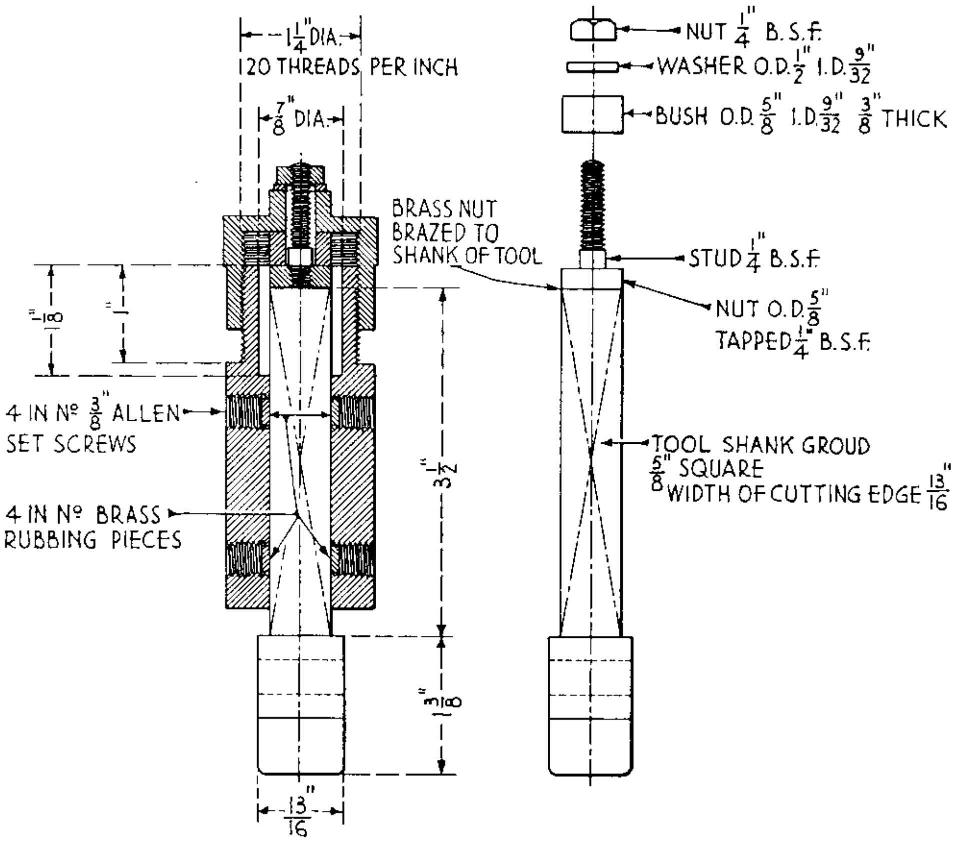

FIG. 5.—DETAILS OF TOOL ASSEMBLY

movement is indicated on a small vertical knife edge mounted on th upper surface of the holder block adjacent to the cut adjusting nut

(vi) the width of the tool cutting edge is made about $\frac{1}{16}$ in wider than th designed width of the carbon packing so as to ensure that the whole o the defective surface of the rotor journal is covered, and it is we radiused at the corners.

Special Feature of Design

It will be seen that the design is such that the line of contact of the toc cutting edge with the revolving rotor journal lies entirely along the highes points of the journal surface.

The cutting edge of the tool being in the same plane as the thrust face of th shank allows the tool to spring back under load or to return to its norma cutting position as the load reduces without any possibility of the tool " diggin in " ; it also allows for any lateral movement of the rotor itself in the hor clearances of its bearings.

Thus the design permits full freedom of both tool and rotor during machinin without detriment to the finished surface of the machined part of the journa and yet ensures that it will be parallel and in true alignment with the untouche portion.

OPERATION

Forward and after journals are both machined with the rotor revolving i the " clockwise " direction. During the whole machining operation the turbin forced lubrication system is functioning with supply from the electric drive F.L. pump fitted. In this way true running conditions are maintained durin machining with the rotor free from constraint and supported in its own bearings

It will be found necessary to assist the starting of the rotor by hand lever on the teeth of " driven " wheel ; thereafter the pneumatic drive, using about 10 lb/sq. in. air pressure, will revolve the rotor steadily at a speed of about 7 r.p.m. About 5 to 6 complete revolutions will suffice for each cut.

The cut is applied in steps of 1/1000 in by means of the " cut-adjusting nut " after first slackening the " tool-withdrawing nut " as necessary.

The tool is withdrawn when desired by tightening on the tool-withdrawing nut after first screwing back the cut-adjusting nut as necessary to permit withdrawal. Each cut of 1/1000 in should be allowed to run itself out completely before a fresh cut is taken.

The cutting lubricant used up to the final cut is tallow ; at the final cut, *i.e.*, when the whole surface has been cleaned up, " Solvac " and tallow should be used as lubricants. This will be found to produce a highly polished finished surface.

Special precautions are necessary to ensure that all " turnings " are collected and removed as they leave the tool. These can take the form of temporary closing plates with leather rubbing strips to shut off the lower half of the gland box and the annular space at rotor end. In addition, the use of a strong magnet is required.

The majority of turnings become embedded in the tallow during machining and are easily collected and removed. Removal and search of the lower half of gland box subsequent to machining in the operation described revealed that no fragments had escaped collection and removal from above the rubbing strips.

Three men are adequate for the operation ; one—adjusting the tool cut and spreading tallow on the journal ; a second—removing the cuttings by magnet and applying Solvac as necessary ; and a third—controlling the pneumatic drive and assisting generally.

Table I shows actual results obtained during the operation carried out in H.M.S. *Kempenfelt*.

TABLE I

DATA GAINED WHEN MACHINING JOURNALS AT CARBON PACKING SPACES

To rig up drive and disconnect coupling		Revolutions per Minute	Diameter of Journal Original (Inches)	Finished Diameter (Inches)	Reduction in Dia. (Inches)	Cutting Time	Remarks
Starboard Forward	4 hours	7	8.5	8.493	.007	7 min	—
Starboard After		7	,,	8.475	.025	55 min	Very hard skin and irregular wear.
Port Forward	4 hours	7	,,	8.471	.029	45 min	Very hard skin and irregular wear.
Port After		7	,,	8.437	.063	25 min	Very deep grooves.

NOTE.—Tool maintained its cutting edge throughout whole operation in each case.