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BRÜEL & KJÆR application notes

In-situ Balancing helps the Production Engineer

For a particular skimming operation being carried out on a lathe in our own Production Shop, the unbalance of the rotating assembly limited the operating speed of the machine to 630 r.p.m. if its vibration were to be kept to an acceptable level. Any increase in running speed affected the quality of the surface finish, reduced the life of the cutting tool, and caused local disturbance due to the resulting vibration of the machine itself and of a nearby wall partition. By balancing the machine in its normal operating mode a 50% increase in work rate was achieved.

Actually there were two problems to be solved. The workpiece comprised an aluminium component located on a steel jig in the form of a large steel disc. The jig was mounted in the chuck of the lathe itself. However, the workpiece was asymmetric in shape yet required to be surface finished on both sides: effectively, the unbalance condition was different for each orientation of the workpiece. The time available for correction of the unbalance without affecting production schedules for the batch was very limited, but the Portable Balancing Set enabled the machine to be balanced under its normal operating conditions.

To sense unbalance vibrations, an accelerometer was attached by a magnet to the bearing cap adjacent to the chuck: it was positioned to measure radial vibrations perpendicular to the axis of rotation. The optical tachometer probe was taped to a dial gauge support which incorporated a magnetic base, and was positioned to project onto the outer surface of the rotating jig: a length of black insulating tape of approximately 5 cm was attached to the jig to generate the tachometer pulse which would give the phase reference enabling the unbalance to be located.

First, the steel jig disc was removed completely, noting its position in the chuck: the machine was run up to 1,000 rpm and the "ambient" vibration level was measured at 15 μm rms. This is within the unbalance grade G6,3 recommended in ISO-1940 for machine tools. The jig was refitted and the aluminium workpiece was mounted in the usual way. The machine was run up to 1,000 rpm again, to measure the initial unbalance condition. The vibration level was measured at 67 μm, with a phase angle of 184° between the tachometer and transducer pulses being indicated on the digital display of the balancing set.

To estimate the size and location of the unbalance, a trial mass in the form of a brass disc was used to measure the effect on the state of unbalance of the addition of an arbitrary mass. The trial mass was bolted to a tapped hole near the outer rim of the jog disc, at a radius where further drilling could be carried out to secure correction masses. The new vibration level at the same test speed was measured at 49 μm, with a phase display of 70°. The fact that a reasonable phase change had been measured following the addition of the trial mass, indicated the mass was of a suitable size to enable the unbalance correction to be calculated. The mass was weighed at 146 g. The correction was calculated at 100 g located at 27° from the trial mass location contrary to the direction of rotation. The vector representation is shown in Fig. 1.

The workpiece was turned over, and a similar procedure was carried out to measure values of vibration amplitude and phase for the initial condition, and with the trial mass fitted. The size and location for the second correction mass was also calculated. In fact, for one-plane balancing operations of this type, the two calculations could be performed simultaneously using a 2-plane balancing program card and a programmable calculator such as the Texas TI 59. Entering the values for each side as the values for each plane eliminates the need for any vector drawing, as the correction values are output directly to the display.

The jig was removed from the lathe, the angles were marked off, and holes were drilled to enable machined brass washers to be fitted to reduce the unbalance for each case. The production operation was performed in a batch mode with typically 150 items, so it was no great penalty to work on one side of the component, and then to interchange the correction masses to work on the second side. With the correction masses attached as appropriate, final vibration levels were less than 7 μm which is below the unbalance quality grade G2,5 of ISO-1940.

As a consequence of the unbalance reduction, the operating speed of the machine was increased from 630 r.p.m. to 1,000 r.p.m. so that a harder tool with a longer service life could be used. The upper operating speed was now limited by the requirement for adequate surface finish on the component, rather than by vibrations caused by unbalance. This balancing procedure is readily carried out on multi-purpose machine tools where jigging arrangements may have to be changed to suit different jobs. The reduction of unbalance of an asymmetric jig-/component assembly may enable the work rate of that machine to be greatly increased, as well as making life easier for the operator. The Portable Balancing System offers a solution using equipment which can be operated on the shop floor, causing minimum disruption to normal production.

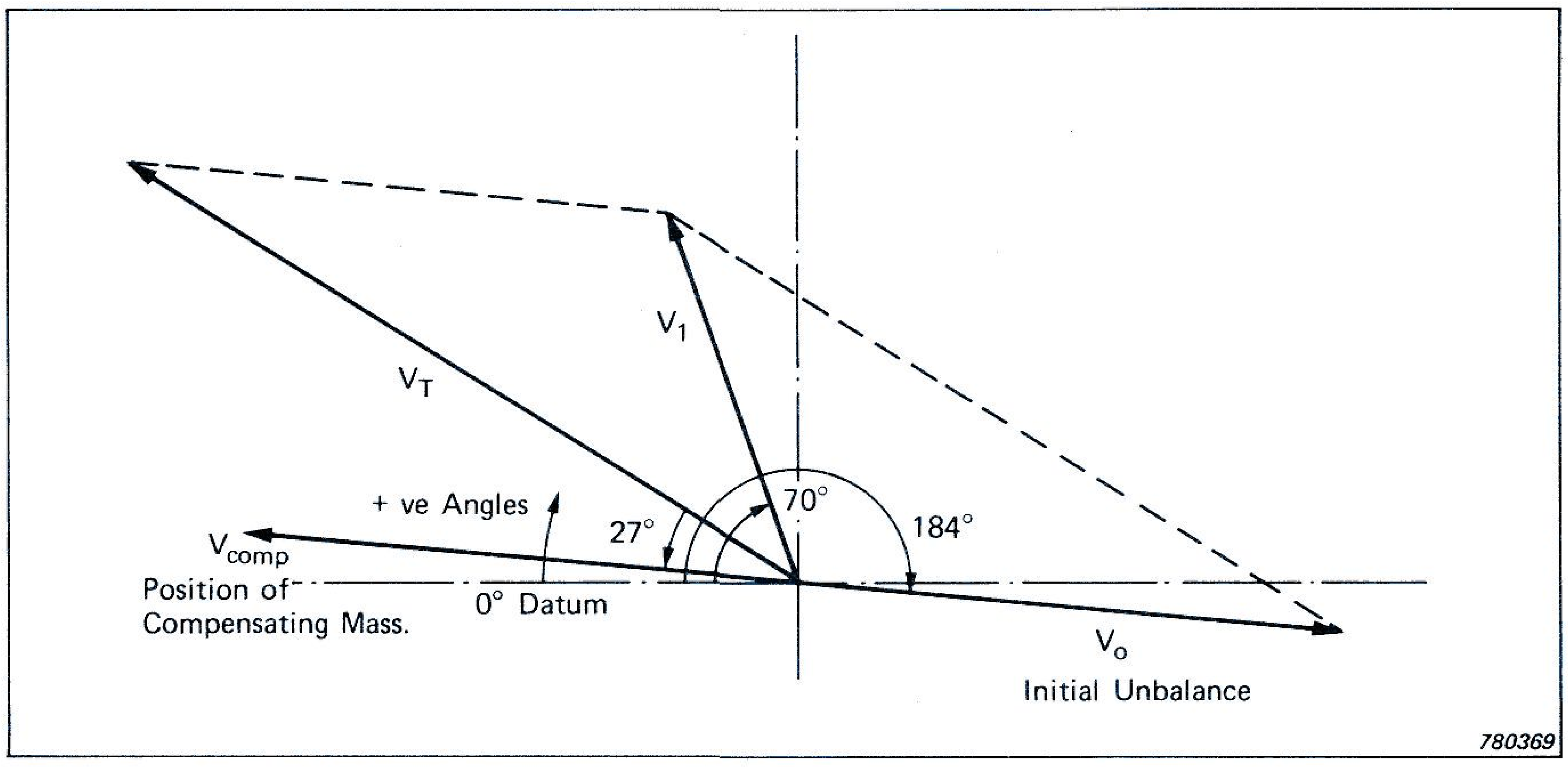

Fig. 1. Vector diagram for unbalance correction in one plane

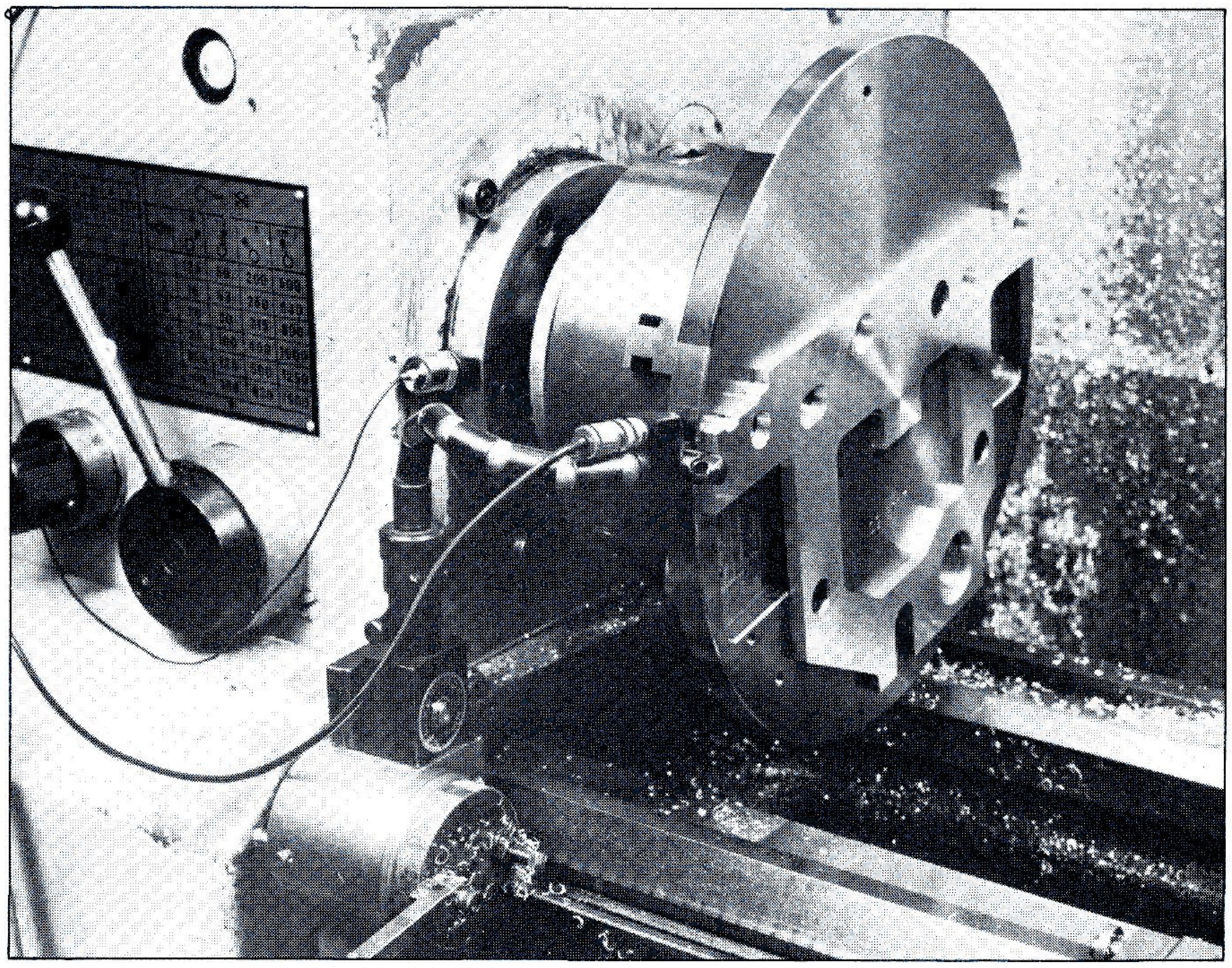

Fig. 2. Installation of the Accelerometer and Photoelectric Probe on the lathe head-stock

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