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THE SHOCK PULSE METHOD FOR CONDITION ASSESSMENT OF ROLLING ELEMENT BEARINGS.

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This paper discusses the mode of operation and failure of rolling element bearings and looks in detail at one technique for condition monitoring of such bearings. The Shock Pulse Method is a patented technique and the differences between it and other methods such as vibration analysis are discussed.

No rolling element bearing will last forever. Even if a bearing is set up correctly, properly lubricated and loaded according to its design limits, it will have a finite life. This is because the cyclic loading of raceways and rolling elements will eventually lead to fatigue cracking of these elements. When fatigue cracks spread and spalling occurs, the bearing can no longer be said to be operating correctly.

Fatigue cracking however is not the only means of failure, the majority of bearing failures are due to poor lubrication, lack of alignment (giving rise to increased loading) and foreign particles and contaminants entering the bearing. All of these failure mechanisms have the common feature that they result in a deterioration of the rolling element and raceway surface conditions.

Assessment of the surfaces of a bearing would therefore provide a measurement of bearing condition. However direct measurement of surface finish is not possible without stripping the bearing and this is not commensurate with the requirements for condition monitoring equipment.

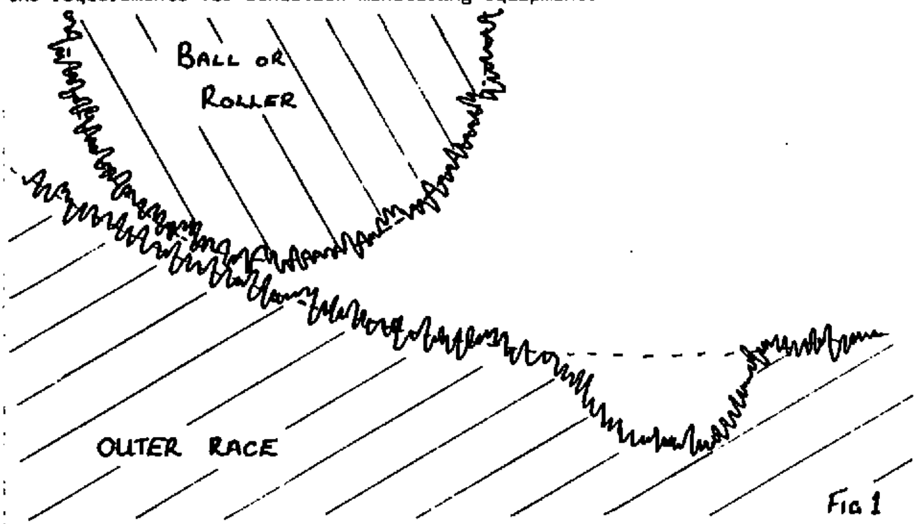

Fig 1

THE SHOCK PULSE METHOD FOR CONDITION ASSESSMENT OF
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One must therefore look for a parameter directly related to surface conditions that is measurable during normal operation. Fig.1. shows the surface roughness (much exaggerated) of a ball and raceway in a typical rolling element bearing suffering some minor damage. There is lubricant present but the surfaces are not completely separated. Also the motion is not truly rolling "contact", there is some skidding. Consequently there will be impact shocks as firstly the small surface roughness collide and later when the ball comes into contact with the edge of the damage region. The magnitude of these impact shocks will depend on the relative velocity of the ball and raceway, the magnitude of the surface roughness and oil film thickness and later the depth of damage.

The Shock Pulse Method measures the magnitude of these impact shocks and uses this measurement to assess bearing condition. Other techniques measure the effects caused by the impacts since the vibration of the bearing and its housing is caused by these impacts and other outside influences such as out of balance forces etc. It should be stressed that the vibration of the bearing and housing will depend on the size, material, mounting, environment etc. of that bearing assembly as well as the magnitude of the impact shocks occuring within it, whereas the Shock Pulse Method measures only those shocks and hence ignores variations due to outside vibrations, differences in mounting etc.

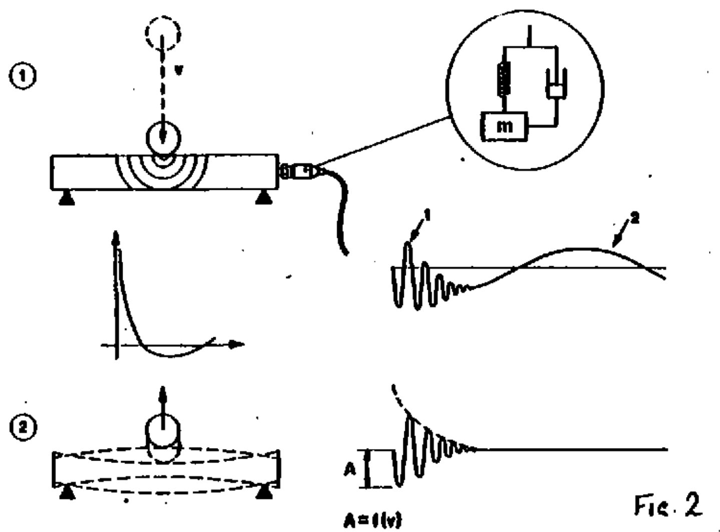

Fig. 2

Fig.2. shows the basic principle of shock pulse measurement. Consider a single impact due to a sphere dropping onto a beam. Initially there is a very high particle acceleration as the first particle of the sphere makes contact with the beam and causes the initial distortion of the sphere. This particle acceleration propagates through the material of the beam and excites the Shock Pulse Transducer.

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The transducer is mechanically tuned to have a resonant frequency of 32khz, and consequently the arrival of the wave front due to the intital contact will cause the transducer to resonate at its own natural frequency. The transducer design is such that its output will be a damped transient of constant frequency (32khz) with an initial magnitude proportional to the velocity of impact of the ball on the beam.

The transfer of energy that occurs during the collision will cause the beam to vibrate at its own natural frequency, and this vibration will also be picked up by the shock pulse transducer.

The transducer resonant frequency is chosen to be well above all normally occuring natural frequencies of bearing housing. Consequently all vibrations that are not at 32khz can be filtered from the transducer output and neglected.

Thus in a good condition bearing running under its normal load, there will be a series of impact shocks due to surface roughnesses, as the surface condition deteriorate the shock pulse measurements will increase since the impact shocks increase in magnitude (the impact velocity increases).

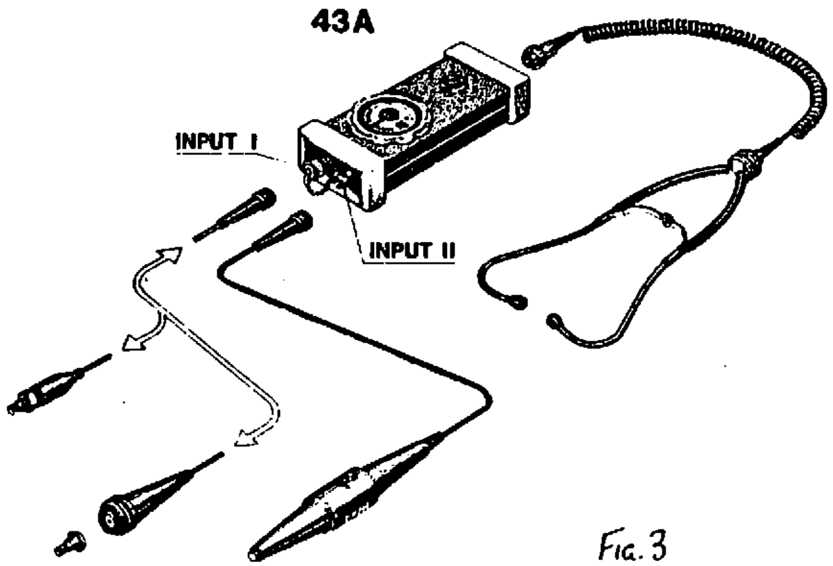

FIG. 3

To use the Shock Pulse Meter 43A Fig.3. the speed and bore diamter of the bearing under test are dialled into the instrument, which establishes initial conditions (i.e. the magnitude of shock pulses to be expected from the bearing in good condition) and the condition is read directly from the instrument scale.

THE SHOCK PULSE METHOD FOR CONDITION ASSESSMENT OF ROLLING ELEMENT BEARINGS.

Although the instrument is unable to measure the surface roughness directly it is able to indicate whether lubrication conditions are adequate as well as showing overall bearing condition.

The technique is able to be used on all types of rolling element bearings including needle rollers, but since it relies on the features of the rolling elements, it cannot be used on plain bearings or hydrostatic bearings since theoretically there is no metal to metal contact and consequently no impact shocks to be measured.

The principle of operation of the instrument means that it can also be used for various types of leak detection. Around most small leaks the flow of leaking fluid is strongly turbulent. The small shock waves associated with this turbulence can be detected by the instrument provided the correct form of transducer is used.

In the case of internal leaks in valves the hand held probe is used since the shocks to be detected are propagated through the metal of the valve or pipework. In the case of leaks to the atmosphere (vacuum leaks may also be detected) the shocks associated with the turbulence are propagated through the air. To detect these shocks the basic Shock Pulse transducer is attached to a diaphragm and consequently acts like a "shock pulse microphone". The signals are processed in exactly the same way as those emanating from solids.

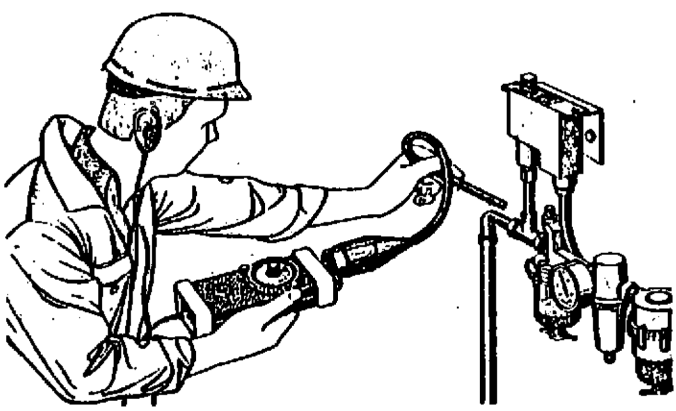

FIG. 4

The technique will not give any quantitative information but will enable the source of a leak to be located for maintenance purposes. Fig.4. shows the leak detecting "microphone" in use with a rubber extension tube fitted to increase the positional sensitivity of the equipment.