Proceedings of the Institute of Acoustics

ATTENUATING THE NOISE FROM TUMBLING BARRELS CONTAINING STEEL BALLS

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1. INTRODUCTION

During the manufacture of ball bearings, the steel balls are tumbled for some hours in inclined rotating barrels. This intermediate process is part of the quality control procedure. The repeated impacts of tumbling show up any small surface defects/cracks which are visible at the subsequent inspection stage. This is followed by the final grinding and lapping processes.

The attenuation of the high noise level from the tumbling process, was originally investigated as a project for the Diploma in Acoustics and Noise Control of the Institute of Acoustics.

2. NOISE PROBLEM

A tumbling barrel machine is illustrated in Fig. 1. The barrel is a welded steel structure which is rotated at approx. 26 rev/min by a simple friction drive. The front of the barrel is normally left open, which contributes significantly to a very directional noise pattern. Normally 200 kg of steel balls are loaded into a barrel together with a caustic soda solution, and the contents are tumbled steadily for 4 - 8 hours depending on the size of the balls.

Two rows of 6 barrels are placed opposite each other with a gangway in between to facilitate loading and unloading. At least 10 machines are operating at any one time, and overall noise levels reach 110 dB(A) at various positions of the operator. In the hard reflective factory building the noise level holds up over long distances, and the noise is easily discernable above the noise from all the other processes which are occurring in the large open plan factory space.

3. MEASUREMENT OF NOISE

Because the noise was evidently very directional, it was decided to measure at multiple array points, as set put in B.S. 4196 for measurements of sound power. To accommodate the necessary microphone positions, one machine was removed from the line arrangement and set up independently. Details of these microphone positions are given in Fig. 2.

The noise was first measured from an untreated barrel when tumbling 200kg of 32mm dia. steel balls. The spectrum of Fig. 3 (Test (a) untreated barrel) shows noise levels averaged from the 16 microphone positions. The directional characteristics of the noise are detailed across the 16 positions in the top graph of Fig. 4.

4. NOISE REDUCTION TREATMENTS AND THEIR ATTENUATION

Various tests were carried out as detailed below (treatments [b] - [g] see Fig. 5). The actual work done was limited by the operating requirements of the factory, and the noise attenuating materials that were available at the appropriate time.

[b] and [c]. LIDS TO SEAL FRONT OPENINGS OF BARREL.
Prior to this testing work two lids of simple design were available: [b] a basic steel sheet lid, and [c] a lid with a rubber sandwich cover, further details of which are given in Fig. 6. Neither of these lids was a good fit in the barrel opening so that considerable noise leakage was possible. However their effect was tested as found, and the resulting attenuations are indicated on the spectra (average of 16 measurement positions) of Fig. 7. The directionality of the noise with for lid [c] fitted is shown in Fig. 4

[d] DAMPING LAYER + BASIC LID. After thoroughly cleaning and preparing the external surface of the barrel, a proprietary self adhesive damping layer was stuck in place. This bitumen layer was 4mm thick, with a superficial weight of 6 kg/m^2. Subsequent noise levels with the same operating conditions and measurement positions are indicated on Fig. 7.

[e] DAMPING LAYER AS [d] + LID [c] WITH IMPROVED SEALING. Test [d] clearly indicated significant noise leakage from the ill fitting lid, so attempts were made to better locate and seal a lid with foam linings. The subsequent noise readings are shown on Fig. 7.

[f] DAMPING LAYER AS IN [d] + 50mm THICKNESS ACOUSTIC FOAM JACKET + NEW IMPROVED DESIGN LID. The original intention was to enclose the added foam jacket with a further fitted steel insulating layer. However as the latter item did not become available within the testing period, it was decided to test with only the added foam, plus a new improved design of lid (see Fig. 5) which became available at the same time. The resulting noise attenuation can be assessed from the noise spectra which is also displayed on Fig. 7 for purposes of comparison. The directional effects can be noted from the levels plotted on Fig. 4.

[g] AS IN [f], BUT 50mm FOAM REPLACED BY MULTI-LAYER QUILTED MATERIAL. The latter proprietary material comprises a fibreglass-lead-fibreglass sandwich contained within a quilt, which is approx. 6mm thick overall, with a superficial mass of 6 kg/m^2.

The original intention was to have the quilt material tailored to fit over the acoustic foam layer of [f]. Unfortunately the final tailored quilt did not even fit completely round the damped barrel even with the foam layer removed. There was a large gap between the ends of the quilting around the periphery of the barrel, and to make matters worse this gap corresponded with a join in the damping layer material which gradually opened due to impact induced vibration. The measured results from this treatment have also been added to Fig. 7.

5. DISCUSSION AND CONCLUSION

Clearly the noise levels peaked in the 2k and 4kHz octave bands, as shown in Fig. 3, which incidentally ensured that the 'A' level was always greater than the 'LIN' value.

As the barrel slowly rotated it was very plain that the fluctuating noise in the 31 to 250 Hz octave bands was due to the drive mechanism. The cast iron friction drive wheels were considerably worn and pitted, so giving rise to a low growling type noise, the variation of which clearly coincided with the revolutions of the barrel. Future plans were considered to replace this basic friction drive with a direct hydraulic motor drive, or an electric motor-gearbox drive mounted directly on the barrel spindle. To maximise the vibrational isolation of the barrel from the drive mechanism, nylon or similar mounting blocks were also to be considered.

Fig. 4 indicates the directional nature of the noise, with the highest values usually at measurement positions 2, 3, 10 and 11 (Fig. 20. Positions 2 and 10 were nearest to the impacts of the falling balls as the barrel rotated, whereas positions 3 and 11 were opposite the open end.

Other directional effects were also noted. At the join the self adhesive damping layer started to come away and develop a gap. This caused a considerable increase in the local noise level, with variations of 10 dB or more as the barrel rotated. Larger variations of up to 15 dB were also noted due to the gap in the ill fitting quilt material of test [g].

The noise analyses compared on Fig. 7 show the practical effects of the various treatments. The lids tended to reduce high frequency and directionality as expected. The benefit of adding the damping layer to the barrel [d] clearly shows up as attenuating 500 - 16k part spectrum i.e. damping the free "ringing" vibration and noise arising from the impact of the balls. The additional lid sealing [e], and improved lid [f] further improved the attenuation to give a maximum overall reduction of some 15 d(A).

Unfortunately the results from adding the quilt were very unrepresentative. As mentioned earlier the quilt had a large gap, and this coincided with a join in the damping layer which was gradually deteriorating with continued use as the vibration tended to cause detachment of the damping layer. In this condition the noise level varied considerably as the barrel rotated. Depending on frequency the level rose by up to 14 db as the gap in the treatment passed the observer.

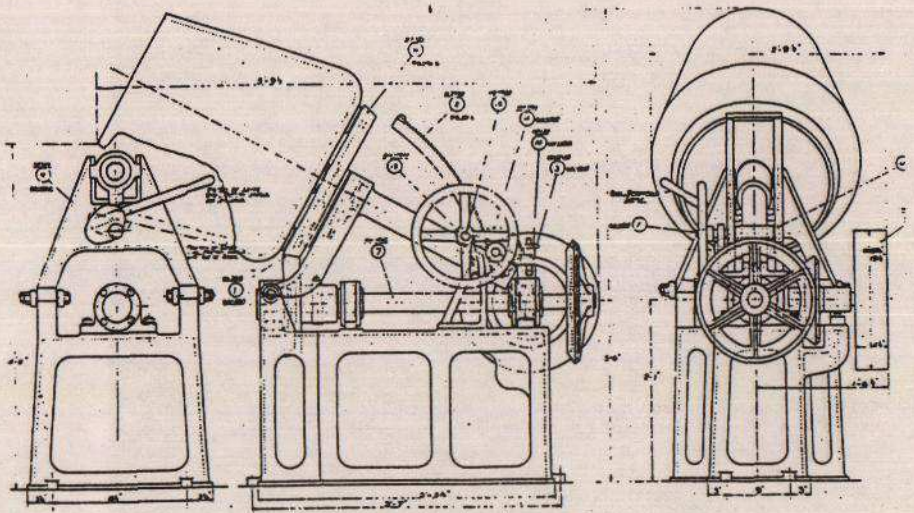
Due to various outside constraints, the test work did not proceed as originally planned, and was often frustratingly limited by the non-availability of treatments at the times when test work could proceed. In the end the experimental work was stopped short because of the sudden announcement to close the factory and transfer production to other sites in the country.

However this project certainly proved its worth as an educational/learning exercise. It clearly demonstrated such points as directionality of machines, the characteristics of vibration damping, the need for complete sealing and total enclosure treatment etc. Other real benefits did arise in that as a direct result of this exercise a list of priorities was drawn up for any future work to minimise the noise as follows:-

PRIORITIES

I) Well constructed and leak free lids
II) Good heavy damping layer well secured over whole surface area of barrel
III) Absorption layer over the top of the damping layer, with a two part steel casing finish (insulation), that needs to be carefully sealed to prevent the caustic soda solution penetrating the absorption material when the barrel is tipped for loading and unloading
IV) Revised drive arrangement to eliminate the noisy friction wheels

In this way with careful application of the techniques it should be possible to reduce noise to least 85 dB(A), with a possible target of 80 dB(A).



GEN. ARR^{T} OF PORTEUS TUMBLING MACHINE. FIG. 1.

SCALE:- 3" = 1 FOOT.

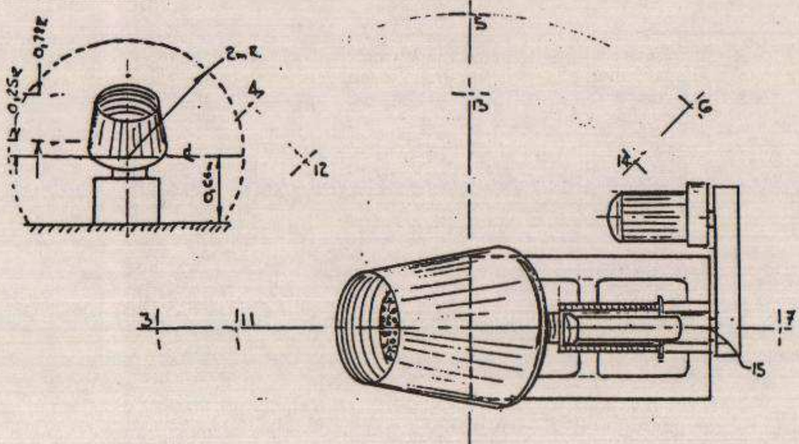
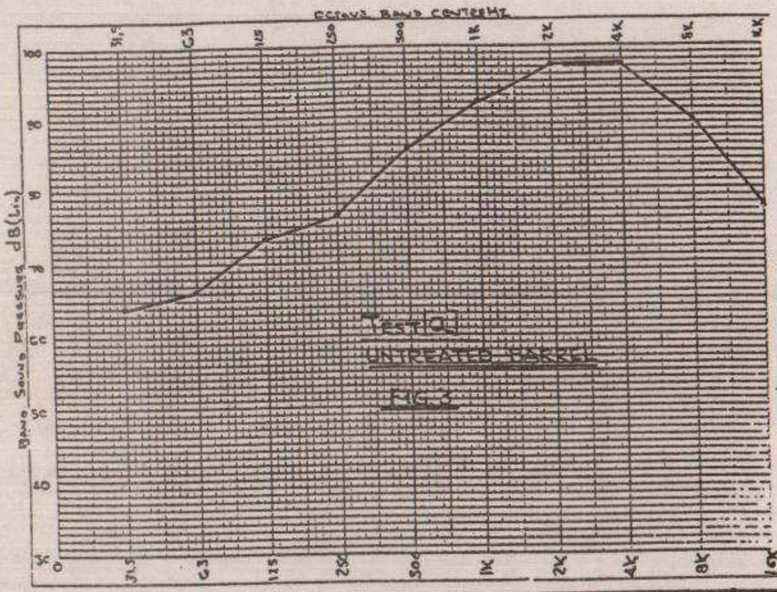
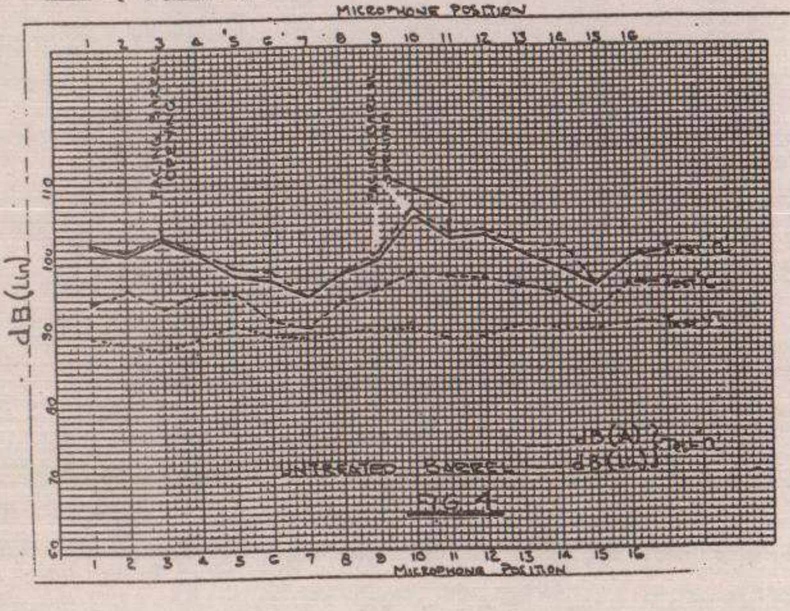
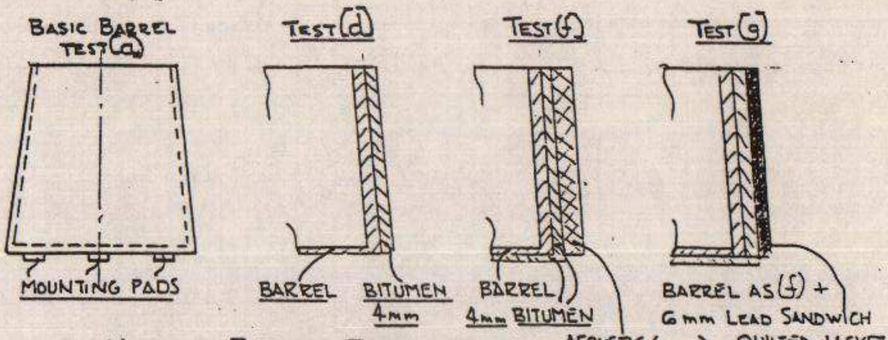


FIG. 2.

PLAN VIEW OF MIC. POSITIONS (NOT TO SCALE)


OCTAVE BAND CENTRE HZ
BAND SOUND PRESSURE dB(Lin)
TEST (Q)
UNTREATED BARREL
FIG 3


MICROPHONE POSITION
dB(Lin)
FACING BARREL OPENING
UNTREATED BARREL
FIG 4



VARIOUS BARREL TREATMENTS

FIG. 5.

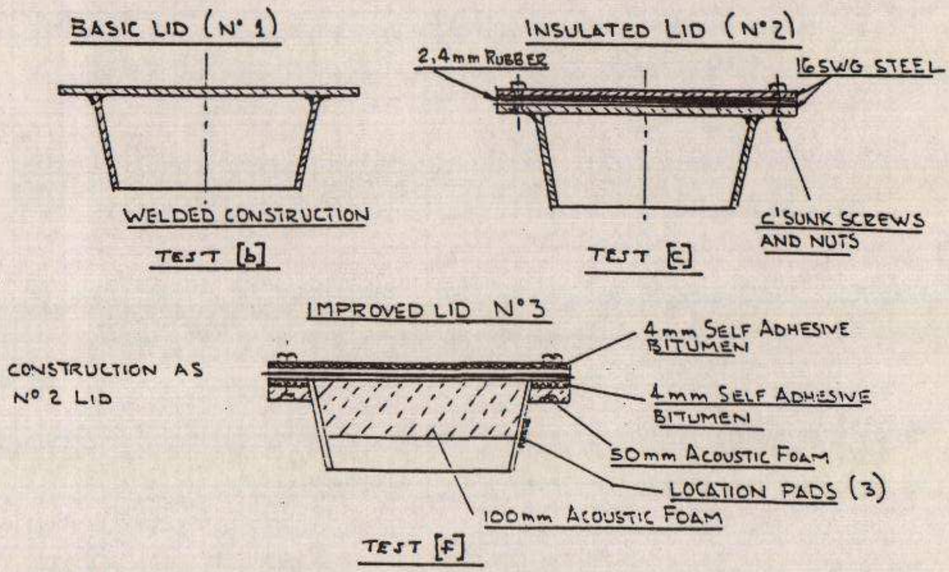


FIG.6. CONSTRUCTION OF LIDS USED IN TESTS

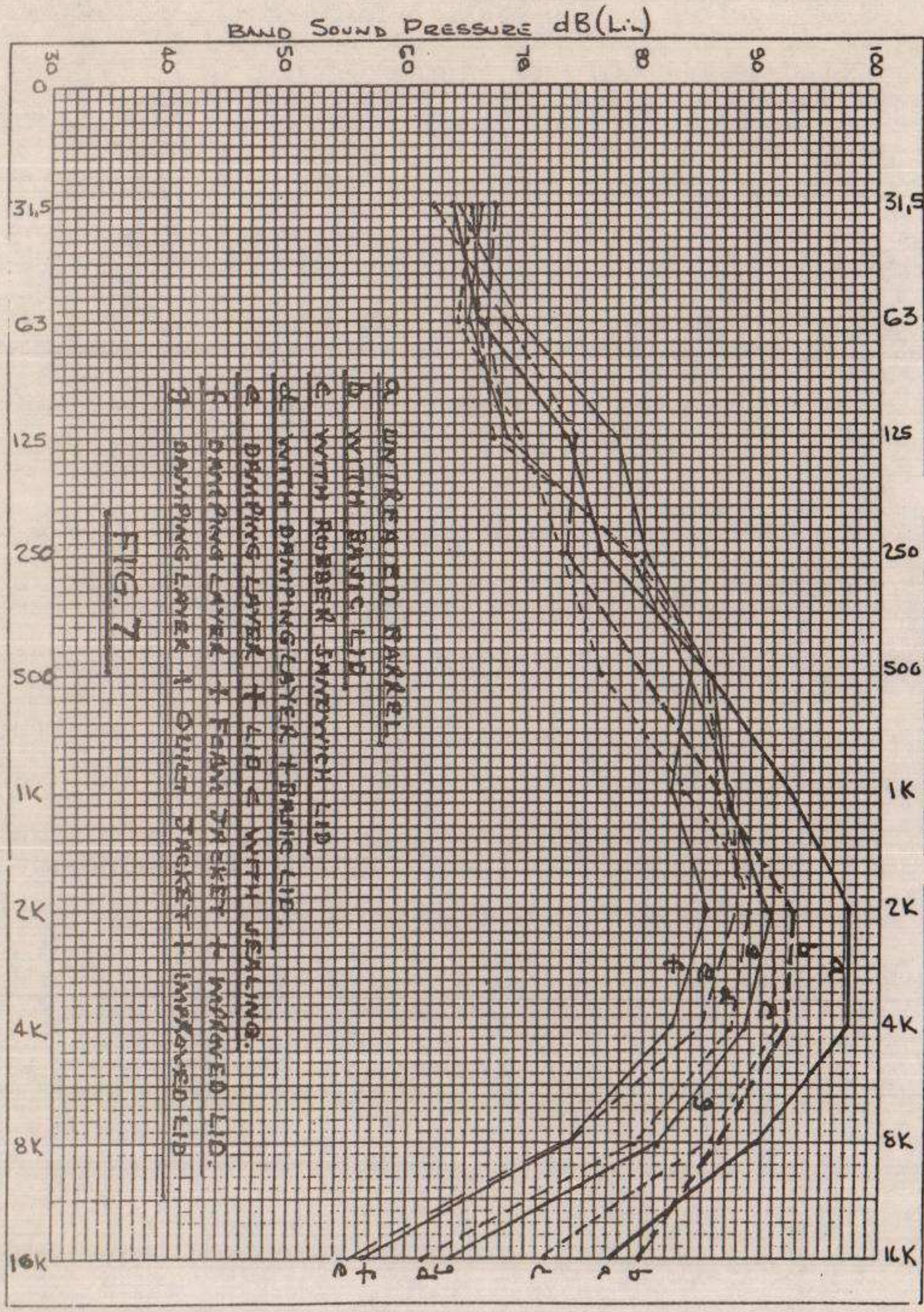

BAND SOUND PRESSURE dB(Lin)
30
40
50
60
70
80
90
100
OCTAVE BAND CENTRE HZ
31,5
63
125
250
500
1K
2K
4K
8K
16K
a UNTREATED BARREL
b WITH BASIC LID
c WITH RUBBER SANDWICH LID
d WITH DAMPING LAYER + BASIC LID
e DAMPING LAYER + LID & WITH SEALING.
f DAMPING LAYER + FOAM JACKET + IMPROVED LID.
g DAMPING LAYER + OUTER JACKET + IMPROVED LID

FIG. 7