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Noise Reduction on Road-Breaking Drills

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V. ROADWAY NOISE

Noise reduction on road-breaking drills

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Introduction

The noise generated by impulsive road-breakers is probably the most annoying part of the noise generated at construction and demolition sites and at roadworks. The problem was put into its proper perspective in the Wilson Committee's report on the problem of noise (1963). It was shown by implication there that orthodox pneumatic road-breakers were unacceptable as far as noise is concerned, a reduction of some 7 to 15 dB(A) being desirable (i.e. from a present level of 82 to 85 dB(A) at 50 ft. radius to a level of 70 to 75 dB(A) outside the nearest window). Hydraulic road-breakers available at that time were as noisy as their pneumatic counterparts but were considerably more powerful. Electric and hydraulic breakers commercially available now (1967) are, as will be seen, considerably quieter than pneumatic drills. The use of an enclosure for the operator was encouraged in the Wilson report and the reductions in the noise radiation so obtained are quite high, but this device is in some ways difficult for the contractor. The breaker is usually working at an edge beyond which is broken rubble or a hole. It is difficult then to move the enclosure on its wheels over such terrain.

The report also suggested that other means of concrete breaking were available or under development but that they were prohibitively expensive. In 1965 the Building Research Station were experimenting with the use of microwave devices to break concrete but these were then at a very early stage in development. It is immediately clear that this process is an expensive one, although it promises to be most useful where extra quiet conditions are necessary.

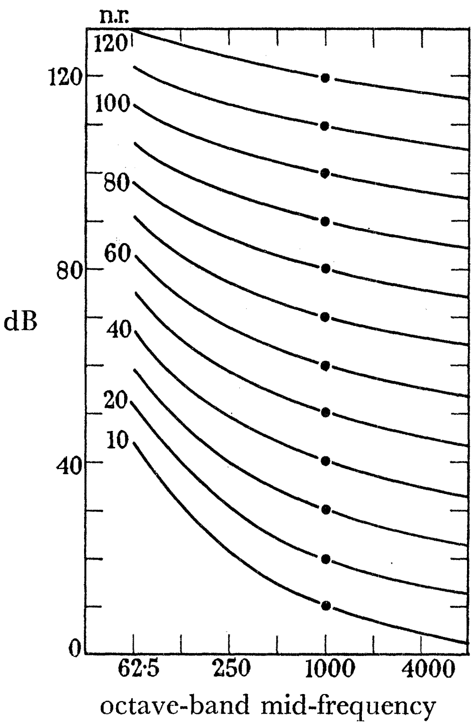
The noise from road-breakers is of high intensity (typically 88 dB(A) at a distance of 7 m for a pneumatic road breaker in the open), it is an intermittent noise, and it generally contains considerable energy in the frequency band 3 to 5 kHz which is a particularly annoying band. It is necessary at this point to consider the subjective aspects of this noise so that the quantitative measurements which will be discussed can be put into perspective and so that the conclusions arrived at in this paper can be assessed.

The people who are annoyed by road-breakers are for the most part, those who are indoors but close to the machine in question, such as office-workers in the case of site-works and housewives in the case of road-works. People who are in the open air are generally in transit from one building to another and are therefore less annoyed by a road-breaker because of the rapid passing of the source of annoyance. Therefore, to make a reasonable assessment of the annoyance caused by road-breakers the octave-band figures which have been obtained by various authors (listed later) have been modified in this paper to give an estimate of their values had a wall been placed between the listener and the noise source. The curves so obtained have then been compared with an accepted noise criterion. This comparison based on an octave-band analysis is a rather more elaborate one than that of quoting a single dB (A) figure for the noise (as in the Wilson report) and it has the advantage of pinpointing the frequency bands and the components in which most offence is being caused and which can therefore be dealt with first. This analysis shows right away that even the best of road-breakers should be improved if this is at all possible technically and economically. In most instances, the sound penetrates an open or shut window. The method of assessment here is therefore conservative, and even greater reductions are really necessary.

It remains to find the sources of noise in road-breakers and to suggest means by which these noises can be reduced. There is remarkably little published literature concerning the noise from road-breakers. However, some work has been published concerning the noise from rock drills. The construction of these drills is almost identical to the construction of road-breakers so that an analysis of noise sources in rock drills is, with suitable modifications, valid for road-breakers. Unfortunately, the subjective aspects of rock-drill noise are quite different from those of road-breaker noise. The person annoyed by the rock-drill is the operator who is often in a reverberant field. There is thus a real danger of physical damage and the operator normally wears ear-plugs. One result of this situation is that rock-drill noise measurements are usually made at the operators ear position and the results obtained here are neither very uniform nor do they compare well with results obtained on road-breakers at the standard distance of 7 m.

The tracking down of the major noise sources in pneumatic-breakers has for all useful purposes been completed. The exhaust noise is the larger part of the noise and however well silenced or muffled it may be it still remains, together with the mechanical noise radiated by the drill bit or steel, the predominant noise. Practical silencing can at its best only achieve about 85 % reduction in exhaust noise energy. For breakers of a non-pneumatic type though, a proper analysis of the noise sources has yet to be published. Included in this paper are some new results and deductions for a hydraulic breaker.

The methods of silencing breakers which are described in this paper for the larger part are known to be technically and economically feasible. There are other non-technical factors though which must be taken into account. One of these is a psychological factor. The operators of road-breakers relate the breaking capacity of the machine to the noise it makes. There is then a tendency for the operator to prefer a more noisy machine to a less noisy one even though one can demonstrate that the breaking capacities are equal. A need exists for the education of the operator as well as for the silencing of the breaker. Otherwise standard distance used in many tests is 50 ft. Theoretical conversion from one type of measurement to the other can be achieved by the addition or subtraction of 6·8 dB(A). The operator faces the centre (north) measuring position. In comparing the noise from a series of pneumatic breakers in this way, Akam has also correlated the breaking efficiency of the machines using another standard test which he has suggested. A measurement of breaking efficiency is most important in the silencing of pneumatic breakers as a considerable reduction in breaking power can occur.



	criterion
broadcasting studio	15
concert hall	20
class room, t.v. studio	25
sleeping room	25
cinema, hospital, church, library, courtroom	30
living room	30
private office	40
restaurant	45
office	55
workshop	65
corrections for dwellings	
pure tone easily perceptible	−5
impulsive, intermittent	−5
working hours only	+5
noise for 25% of the time	+5
6%	+10
1·5%	+15
0·5%	+20
0·1%	+25
0·02%	+30
economic tie	+5
very quiet suburban	−5
suburban	0
residential urban	+5
urban near industry	+10
local heavy industry	+15

FIGURE 1. Abbreviated noise acceptability curves (after Kosten & van Os 1962).

The single figure-noise measurement in dB(A) is in many ways unacceptable. For comparative purposes in tests on a large number of machines it has the virtue of giving a rapid result. For a comparison on a proper subjective basis it is better to use the method outlined by Kosten & van Os (1962) and adopted by the International Standards Organization. This method involves the measurement of the octave-band spectrum at the hearer position and the comparison of this with the appropriately acceptable spectrum suggested in the report (figure 1). The acceptable curve for a living room in a suburban area when the noise is operating only during working hours is that which has a noise rating number of 35. This is the typical situation for annoyance to the public and it is suggested that the n.r. = 35 curve is that to which the road-breaker manufacturers should aim. This criterion corresponds roughly, for road-breakers, to a single-figure measurement of 68 dB(A) at 50 ft. which compares well with the figure of 70 to 75 dB(A) recommended in the Wilson Committee report.

The noise measurements themselves are, of course, made under 'free-field' conditions or as near to this condition as is possible in order to be able to compare the results of the tests made at different times in different places. As explained in the introduction, to obtain a noise spectrum for the living room in a house the figures obtained from various noise tests have been reduced by the author by varying amounts at each octave-centre frequency to compensate for the likely attenuation of a typical wall. This typical wall attenuation curve is shown in figure 2 and is derived from the British Standard Code of Practice CP 3; it is

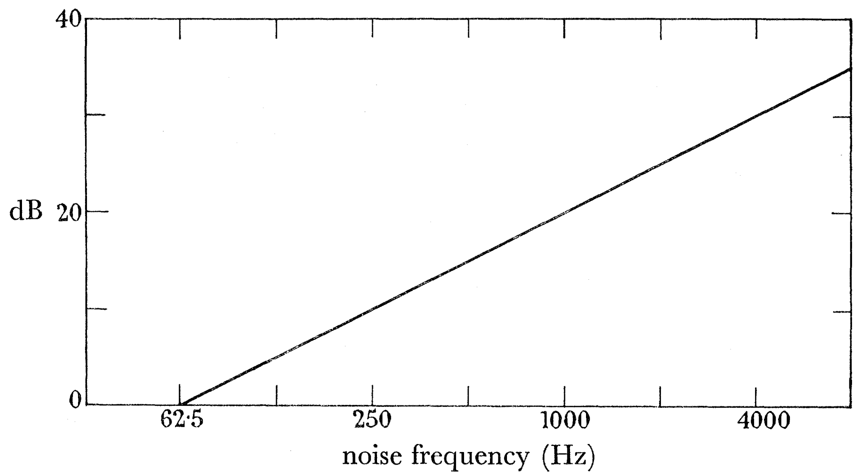


FIGURE 2. Ideal facade noise attenuation for the living room of a typical house. Slope, 5 dB/octave.

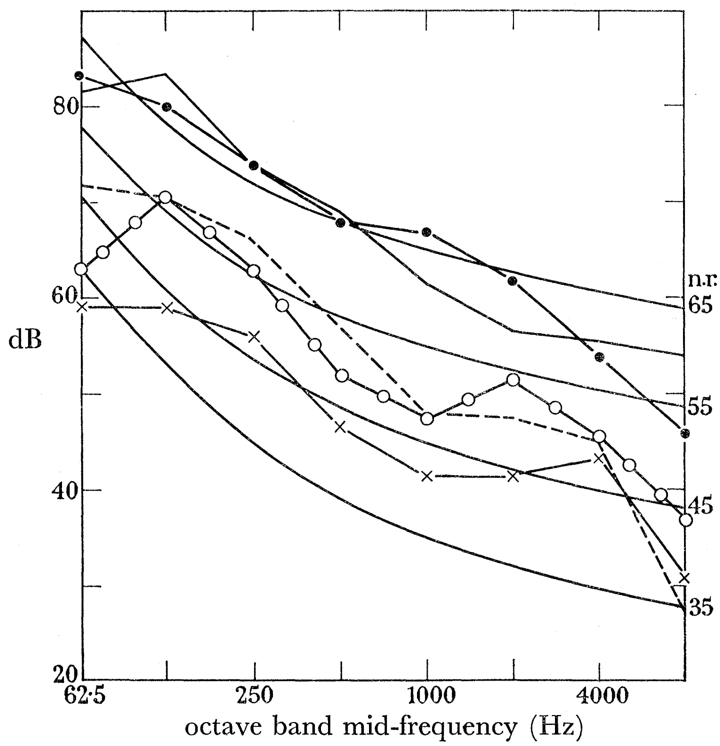


FIGURE 3. Octave-band sound-pressure levels for various unsilenced breakers at a range of 50 feet. The graphs are all attenuated according to figure 2 and are compared with the noise acceptability curves as in figure 1. ——, Atlas-copco, TEX 30 (Revander 1965); –●–, Holman SS 80 (Barber & Adamson 1966); – – –, Broom & Wade, RB 770 (Pretlove 1964*b*); –○–, Macdonald (Pretlove 1964*a*); – × –, hydraulic (Pretlove 1964*a*).

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relevant to a $4\frac{1}{2}$ in. wall with one-third of its area single-glazed. It comprises an attenuation of 0 dB at 62·5 Hz increasing by 5 dB per octave. Figure 3 shows the various octave-band analyses for several different types and makes of road-breaker derived from various sources as shown. The figures have all been (*a*) converted to correspond to a measurement at a radius of 50 ft. and (*b*) attenuated corresponding to transmission through the wall. Also plotted on the graph are the noise-rating curves n.r. = 35, 45, 55, and 65.

Table 1. Noise values (dB (A)) for various unsilenced breakers at 7 m range

source	make	type	dB (A)
Revander (1965)	Atlas-Copco	pneumatic	98
Adamson & Barber (1966)	Holman	pneumatic	94
Pretlove (1964*a*)	Macdonald	pneumatic	89·6
Pretlove (1964*b*)	Broom & Wade	pneumatic	89·5
Wilson Report	type A	pneumatic	88·9
Wilson Report	type D	pneumatic	88·4
Wilson Report	type B	pneumatic	87·9
Wilson Report	type C	pneumatic	87·1
Wilson Report	—	hydraulic	85·7
company pamphlet	Steelfab	hydraulic	83·0*
Pretlove (1964*a*)	—	hydraulic	82·2
company pamphlet	Sonomotive	hydraulic	79·4*
company pamphlet	Kango	electric	77·8

It can be seen that the Atlas Copco and the Holman breakers are 'acceptable' according to Kosten & van Os's criteria at a noise rating of n.r. 65. They are therefore about 30 dB too noisy at all frequencies and are 'totally unacceptable' against a noise rating of n.r. 35. It should be said that these breakers are probably two of the largest and most powerful of the pneumatic breakers and it has come to the authors notice that measurements on these two breakers were not made under 'free-field' conditions. The other pneumatic breakers (these are not muffled or silenced at all) are too noisy by about 18 dB and the hydraulic breakers are too noisy by about 10 dB when compared with the n.r. = 35 curve. There is therefore considerable room for improvement, on these grounds, not only of the noise performance of pneumatic drills but also that of hydraulic drills, although the noise performance of the latter is considerably the better of the two types.

The single figure dB (A) noise values for various breakers measured at or converted to measure at 7 m are tabulated in table 1 and, as for the octave-band curves, are given only for unsilenced breakers of various types. Some of the figures given (marked by an asterisk) are of doubtful value as they have been derived from measurements actually made at very close range.

If the values given in this table are compared with the 70 dB (A) recommendation of the Wilson Committee (i.e. 77 dB (A) at 7 m) for a suburban area it can be seen that the average pneumatic drill is about 11 dB (A) too loud and the average hydraulic breaker about 5 dB (A) too loud. These figures agree well with the octave-band analyses. It is noteworthy that the electric breaker is only 1 dB (A) too noisy and is about 3 dB (A) less noisy than the average hydraulic breaker. Not too great a reliance can be placed on this figure, however, as only one measurement is available.

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The sources of noise in road-breakers

The sources of noise from road-breakers are, in general, threefold: (i) aerodynamic exhaust noise; (ii) mechanical noise (subdivided into body-radiated noise and steel-radiated noise; the 'steel' is the manufacturer's name for the chisel or bit of the breaker); and (iii) operating surface noise.

If the breaker is hydraulic or electric the noise source (i) above is absent. The operating surface noise, that is, noise radiating from the concrete surface being broken, is a component which cannot in practice be much reduced so that this represents the lowest level of noise which can be attained. Evidence suggests that this noise is at most 20 dB less than aerodynamic exhaust noise.

Table 2. Noise balance (dB) (s.p.l.) for a hypothetical pneumatic road breaker based on figures for a rock drill (Beiers 1966)

noise source	position: A (15 in. above drill exhaust)	position: B (30 in. above, 20° from axis)
exhaust noise*	122·5	113
mounting noise	113	112·5
percussion noise (body-radiated mechanical noise)*	110	98·5
penetration noise (steel noise plus operating surface noise)*	114·5	109·5
pawl noise	82·5	77·5
rifle bar noise	110	111·5
valve noise*	101·5	100

* These items are relevant to road breakers.

Published results of experiments to trace the sources of noise in breakers are rare. Holdo (1958) Beiers (1966), and Barber & Adamson (1966) have each presented an analysis of the noise sources of rock-drills. These analyses are closely related to the similar analysis for road-breakers. It is therefore of value to discuss these papers.

In Holdo's paper, noise measurements are given relating to experiments with a pneumatic breaker at close range (1 m) under reverberant conditions. He measured the noise from a standard Atlas Copco breaker type BBD 45 (pneumatic), a similar machine with silencer, and a machine with the exhaust air conducted away in a long hose to eliminate exhaust noise. The noise measurements were, in dB (not dB(A)): (A) standard machine, 119 dB; (B) standard machine with silencer, 113 dB; (C) standard machine with exhaust air conducted away, 110 dB. An analysis of the total noise energy deduced from these results is exhaust noise energy, 87·5 %; 'impact' noise energy, 12·5 %. In impact noise the mechanical noise and operating surface noise are included through the latter is not mentioned as such. The aerodynamic silencer appears to be about 86 % efficient.

Beiers (1966) also gives a complete breakdown of the noise energy from various sources in a rock-drill obtained by some carefully designed experiments. Unfortunately his measurements relating to minor noise sources in rock-drills are not applicable to road-breakers because of the differences in construction of the two types of drill. Measurements were made at two points A and B close to the rock-drill. If the noise radiated by components which are on rock-drills but not on road-breakers is neglected, such as the mounting noise (the mounting applies the penetration load of up to 200 lbf.) and the rifling mechanism noise, then a crude estimate can be obtained of the energy breakdown for a road-breaker. The figures derived from Beier's paper in such a way are given in table 2. The analysis of the total noise energy deduced from table 2 is:

	position A (%)	position B (%)
exhaust noise	81·8	65·3
percussion noise plus valve noise	5·3	5·6
penetration noise	12·9	29·1

These results show how variable the noise-energy breakdown can be when measurements are made at close range. Most of the penetration noise in this table is attributable to steel-radiated mechanical noise.

Table 3. Octave-band sound-pressure levels for pneumatic (unsilenced), hydraulic, and quietened hydraulic breakers at 50 ft. range

octave-band centre frequency (Hz)	octave-band sound-pressure levels (dB) pneumatic drill	hydraulic drill	hydraulic drill with damped steel
62·5	72·0	59·0	58·0
125	75·5	64·0	63·0
250	76·0	66·0	62·0
500	72·0	61·5	61·5
1000	68·0	61·5	54·5
2000	72·5	66·5	58·5
4000	75·0	73·5	59·0
8000	62·0	66·0	45·5
16000	—	51·0	—
over-all s.p.l. sum	82·1	76·1	68·8

Barber & Adamson (1966) give a breakdown of the noise energy of an experimental rock-drill in the form of a diagram. It is unfortunate that there was not space enough in their very readable and exhaustive general account of the subject to say how they obtained these particular results. However, there is no doubt that their results were again obtained at very close range as the basic machine noise level is 124 dB. The breakdown of noise energy here is

exhaust noise,	87·5 %;
steel radiated noise,	11·3 %;
machine noise (body radiated mechanical noise plus (probably) any operating surface noise)	1·2 %.

It is interesting that none of the authors cited has recognized the separate existence of the operating surface noise and its fundamental importance in limiting the obtainable improvement in noise level for impulsive breakers.

Another crude estimate of the energy breakdown for a pneumatic breaker can be derived from Pretlove (1964*a*, *b*). These papers are specifically a report on the noise testing of a hydraulic breaker but measurements were also made on a pneumatic breaker of similar breaking power for purposes of a comparative assessment. Octave-band sound-pressure levels were measured for the pneumatic breaker, the hydraulic breaker, and the same hydraulic breaker after steps had been taken to eliminate the steel-radiated mechanical noise. The octave-band levels of these breakers are shown in table 3 with the appropriate sums. If it is assumed that the pneumatic and hydraulic breakers radiate the same amount of sound energy under the heads (ii) and (iii) above then the analysis of sound energy for a pneumatic breaker derived from the sums in table 3 is exhaust, 75 %; steel noise, 20·3 %; the remainder, 4·7 %.

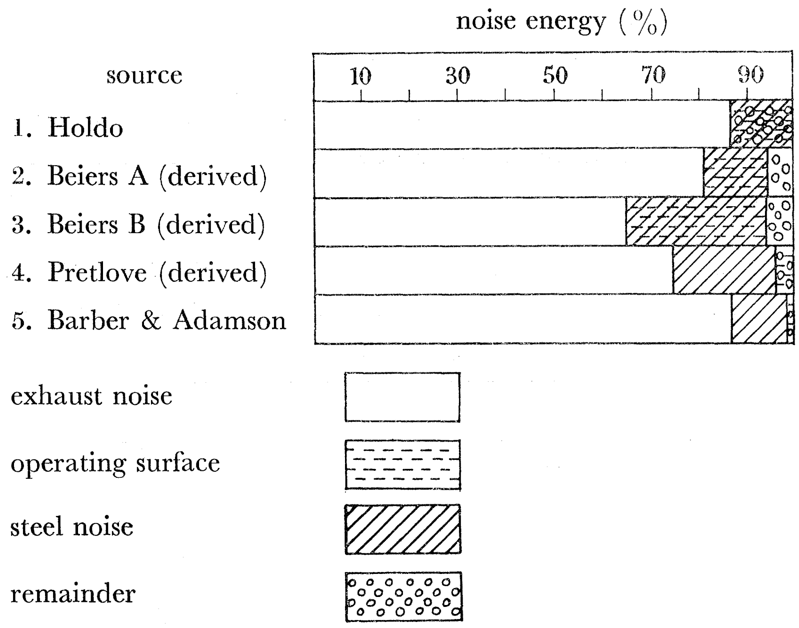

FIGURE 4. A comparison of available noise energy analyses for pneumatic road breakers.

A comparison of the noise-energy analyses given above is shown in figure 4. It is remarkable how closely these analyses agree in view of the reservations applying to rows 2, 3 and 4. It is clear that the exhaust noise is the predominant part of the noise from pneumatic breakers. It is equally clear that the steel radiates mechanical noise which is second in importance to the exhaust noise for pneumatic breakers and is the major part of the noise from hydraulic and electric equipment. A further breakdown of the noise energy which remains has not yet been achieved. This, however, is important information especially for the manufacturers of hydraulic and electric equipment because the steel-radiated noise can be attenuated to a high degree by means which will be discussed in the next section. It is to be hoped that further research will be undertaken to obtain this information. One of the difficulties envisaged for a deeper analysis of noise sources in breakers is their certain variability. The operating surface noise depends on the physical size and material properties of the surface to be broken. This is partly true of steel noise also. It is known that the depth of penetration, the general condition, and the hardness of the surface to be broken, are important factors in the emission of steel noise. Another variable minor source of noise is the body-radiated mechanical noise. The variability here is a result of differences in internal construction of the breaker motor.

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Methods of noise reduction

The exhaust noise from breakers is generally reduced in one of three ways; an aerodynamic exhaust silencer, a muffler bag, or a 'noise converter'. All of these silencers have disadvantages, some of which are common to all three, such as the added bulk and especially the reduction in breaking efficiency. In practice the reduction in breaking efficiency is probably the most important factor in the choice of a silencer. The aerodynamic silencer and the muffler reputedly reduce the breaking efficiency more than does the noise converter. However, they both reduce the radiated noise energy more than the noise converter does. One would expect the back pressures from the aerodynamic silencer and the muffler to be much greater than that from the noise converter so that a greater reduction in breaking efficiency would occur. The measurements which Akam has made at the Building Research Station should shed light on this situation of compromise between noise reduction and breaking efficiency. Beiers (1966) has reported a reduction in penetration rate by a factor of about two for a rock-drill when fitted with an exhaust hose and muffler. An excellent summary of the various aspects of silencing exhaust noise has been given by Barber & Adamson (1966).

The aerodynamic silencer is of the same type as that on a motor car and is designed to attenuate high-level impulsive sounds. A considerable amount of work has been done on the design of such silencers for rock-drills by the U.S. Bureau of Mines (Miller 1963; de Woody, Chester & Miller 1964; Chester, de Woody & Miller 1964). They have investigated various silencers of single- and double-expansion chamber type and various petal diffusers all of which were effective to a greater or lesser extent but all of which suffered from being bulky. They eventually recommend a multiple opening integral silencer. Barber & Adamson (1966) point out that the U.S. Bureau of Mines designs are largely based on simple acoustic theories which do not satisfactorily account for pressure ratios of 6 to 1, and they suggest that better silencers could be designed on the basis of the work by Davies & Dwyer (1964) on shock-wave behaviour in pipes. However, the main disadvantage of aerodynamic silencers is that they are prone to icing and this largely precludes their use. One commercial firm at least has stopped their production on this account. Barber & Adamson's paper contains a description and photograph of a silencer which they claim is less prone to icing problems. The efficiency of a good aerodynamic exhaust silencer (in noise-energy reduction terms) is around 85% (several authors). Typical octave-band noise levels are shown in figure 5 for a pneumatic breaker with and without an aerodynamic silencer.

A muffler bag consists of an absorbent-lined jacket which fits over the exhaust ports of the breaker and is tightly laced on to the breaker. The exhaust air eventually escapes at the bottom of the bag usually through a ported disk. This type of silencer also reduces the body-radiated mechanical noise. The muffler is generally lighter, less bulky, and cheaper than an aerodynamic silencer. It is also less easily damaged. The noise attenuation of a breaker with a muffler bag is shown as an octave-band analysis in figure 6. The figures given there suggest that acoustic efficiencies of mufflers are very variable and depend to a large degree on good design. The Pfister bag is as efficient as an aerodynamic silencer, whereas the other muffler (make unknown) can be only about 50% efficient in acoustic energy terms.

It is claimed for the noise converter that it converts acoustic energy being emitted at the exhaust at one frequency to energy at a different frequency. Thus although no total decrease in energy emitted occurs a reduction in annoyance is achieved by moving the bulk of the noise power spectrum downward in frequency. A corresponding reduction in the dB(A) figure occurs as well. The converter consists of a hollow rubber cylinder of somewhat larger diameter than the breaker and lined with retained absorbent material. An end cap

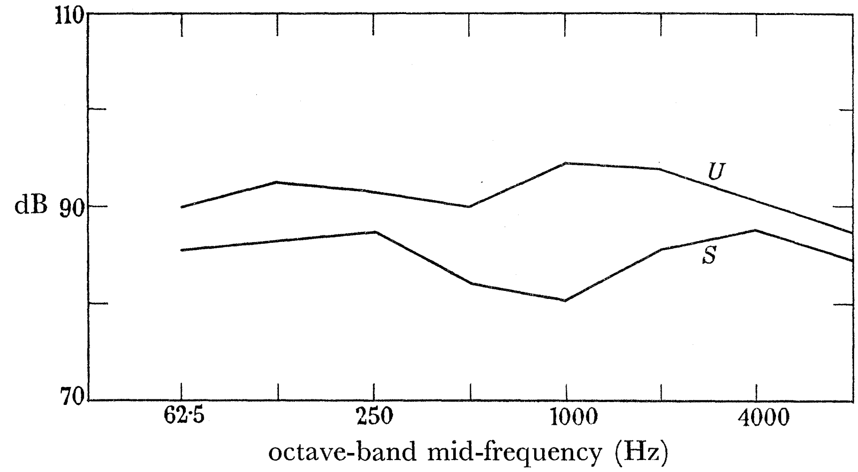

FIGURE 5. Octave-band sound-pressure levels for a pneumatic breaker with and without aerodynamic silencing at 7 m range (after Barber & Adamson 1966).

overall s.p.l.	by addition	measured dB(C)
unsilenced, *U*	100·9	102
silenced, *S*	94·5	95·5

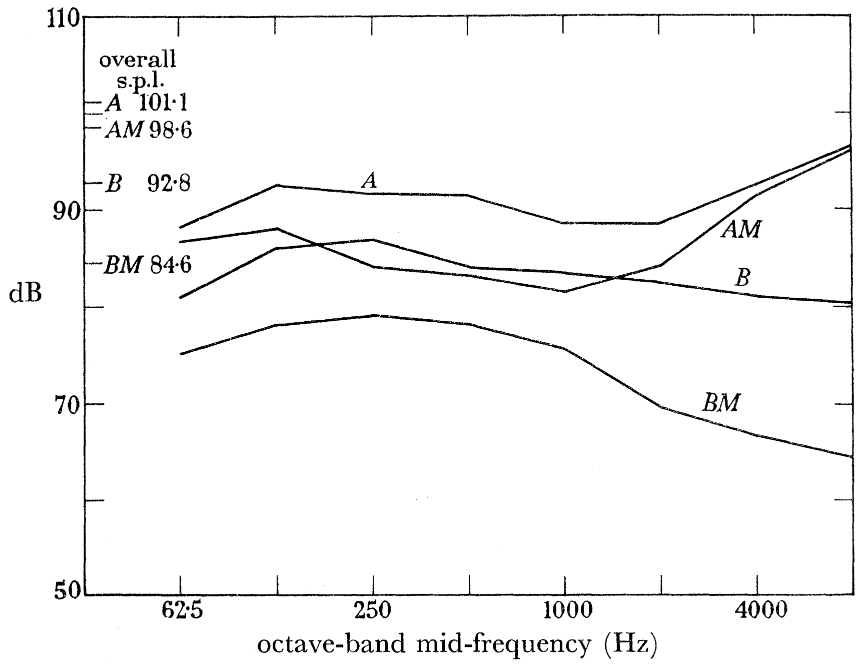

FIGURE 6. Octave-band sound-pressure levels for two pneumatic breakers with and without mufflers at 7 m range. *A*, *AM*, Atlas-copco TEX 30 (muffler unknown); *B*, *BM*, Holman (Pfister muffler).

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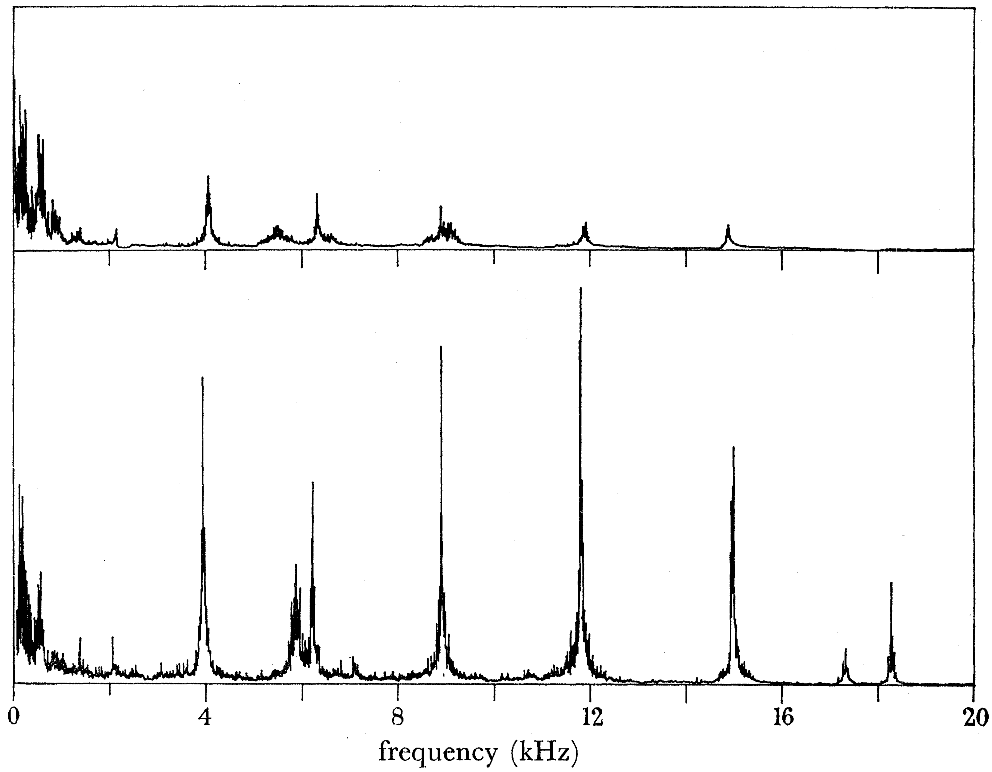

FIGURE 7. The effect of a damped steel on narrow band power spectra of the noise from a silenced pneumatic breaker. Top: Broom & Wade RB 770, Burgess silencer; lead shot damped steel overall level 103·7 dB(A). Bottom: Broom & Wade RB 770, Burgess silencer; standard steel; overall level 110·6 dB(A).

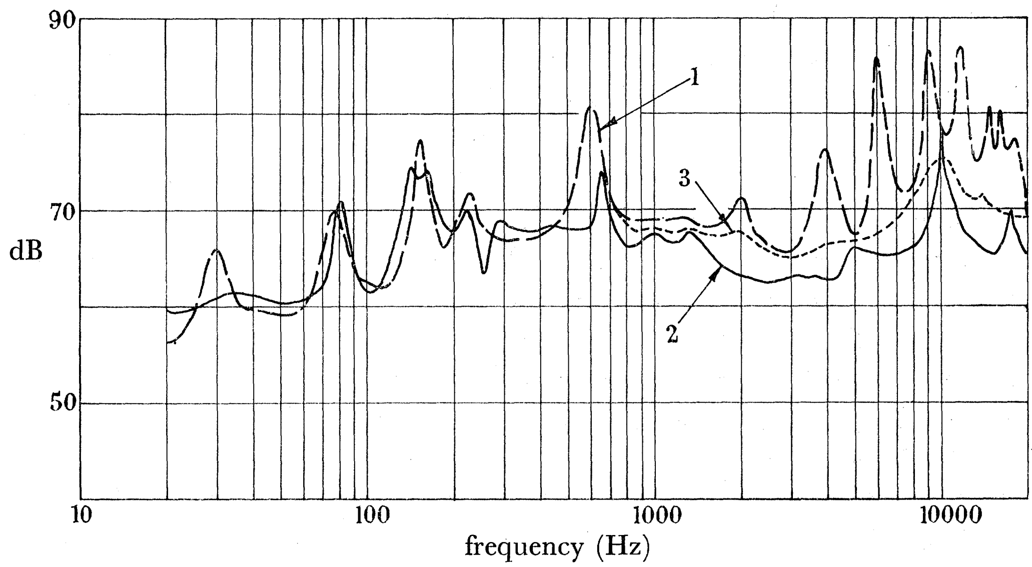

FIGURE 8. Narrow-band power spectra of pneumatic drill noise with: 1, standard steel; 2, damped steel (Mn/Cu alloy); 3, damped steel (steel shot) (after Richards 1965).

fits the cylinder to the breaker at the top. In the absence of noise figures for it no comparative assessment can be given here.

Turning now particularly to non-pneumatic breakers, that is, electric and hydraulic breakers, the major source of noise is the ringing of the steel after each impulsive blow. Cremer (1950) showed that considerable noise could be radiated by the passage of longitudinal waves in bars due to the accompanying lateral contraction which results in a rod surface velocity which is normal to the surface. The steel is set into a longitudinal transient motion at a natural frequency by each impulse delivered by the anvil. Thus the motion is quasi-resonant in character and can be controlled by the addition of damping. The present author, and some colleagues at the University of Southampton, constructed a hollow steel containing loosely packed lead shot and carried out some experiments with it in 1961. One of the curves obtained is shown in figure 7. This figure shows the narrow-band noise power spectra for a Broom and Wade RB 770 road-breaker fitted with the Burgess aerodynamic silencer: and (i) fitted with a standard steel; (ii) fitted with the lead-filled steel. The difference in weighted overall level is 7 dB (A) but one can see that in the band 0 to 1 kHz the noise power is about the same. The large attenuation obtained is at frequencies above 1 kHz. It is clear that the major part of the noise is due to steel ringing because of the attenuation obtained. Additionally, the crude theoretical longitudinal frequencies for the steel were 4, 8, 12, 16 and 20 kHz, in the range considered which correspond reasonably well with the experimental peaks. As a practical method of reducing noise the lead-filled steel is not satisfactory as the shot heats up and forms into compacted cubes. Various methods of providing damping have since been tried including steel shot and the use of a copper-manganese insert and the effect of these damped steels are shown in figure 8 taken from the paper by Richards (1965).

These methods provide quite appreciable noise reductions but they are not considered to be practicable as modifications to standard steels. This is because the steels are very highly stressed under the impact conditions and consequently the removal of some of the cross-section is said to cause failures. Also, it has been found (as it has with other structures too) that the application of discrete damping causes the steel to find a mode of vibration in which the damped part is almost unstrained whilst the undamped part vibrates in an almost undamped fashion. However, carefully used, this last difficulty can be turned to advantage by raising the frequency of the undamped modes above the audio range.

Clearly, what the makers of hydraulic and electric breaking equipment can do is to redesign the steel so that it is satisfactorily quietened and does not fracture. The steel will presumably need to be of larger diameter than at present. It should have a damped insert which stretches along almost the whole length of the steel allowing only sufficient room for sharpening. The insert must be in intimate contact with the steel and a shrink fit would probably be best although this could lead to triaxial stresses and early brittle fractures. The material for the insert could be either copper-manganese or a cast iron of high damping capacity. Unfortunately neither of these materials will be as effective in damping as the impracticable lead shot. It is worth noting that a damped insert in the steel will only negligibly affect the performance of the drill as the attenuation of the passage of the first high intensity wave is only small. One of the main advantages of a damped steel is that it attenuates most of the noise in the frequency range 3 to 20 kHz which contains what is subjectively the most annoying part of any noise. Subjectively the reduction in noise is remarkably good. Figure 9 shows octave-band spectra comparing the performance of a typical pneumatic breaker, a hydraulic breaker, and a hydraulic breaker with damped steel (steel shot) as heard inside a dwelling at a range of 50 ft. using the same corrections as before (derived from the figures in table 3). All three are compared with the noise rating curve n.r. = 35. It is seen that the hydraulic breaker with damped steel is almost completely satisfactory. The hydraulic breaker with damped steel was also fitted with a nylon bush into which the steel fitted. This was to reduce the rattle between steel and drill body.

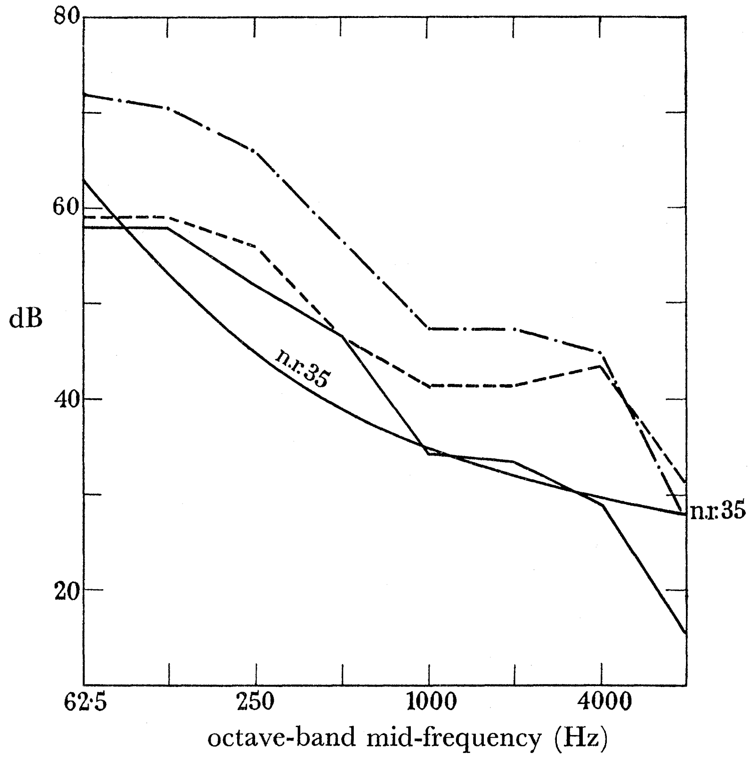

FIGURE 9. Octave-band sound-pressure levels for a pneumatic, a hydraulic, and a hydraulic with damped steel breaker at 50 ft., attenuated as for figure 2 and compared with the n.r. = 35 acceptability curve. – • –, pneumatic; – – –, hydraulic; ——, hydraulic with damped steel.

Other methods have also been suggested to further reduce noise from the internal moving parts of breakers such as the use of tough nylon parts where possible (Beiers 1966; Adamson & Barber 1966) and the use of a copper-manganese anvil and piston. Some nylon components not only reduce the radiated noise but also last longer than their conventional counterparts. Damped alloy anvils and pistons, however, have been difficult practicably in that they are insufficiently strong, they heat up and swell (Miller 1963), and they lose their damping capacity. They seem also to cause some reduction in breaking efficiency. Beiers (1966) reports an unexplained increase in noise with the use of a damped alloy (spheroidal graphitic cast iron) outer casing.

Conclusions

It seems then that considerable headway can be made in the silencing of road-breaking drills at source. The means of doing so are not new, but even so little is being done on sites to reduce the noise from breakers. Moderately efficient silencers and mufflers are available for pneumatic equipment which reduce noise levels by 5 or 6 dB (A) although they do incur some penalty (at present unknown) on performance. Hydraulic and electric breakers are on average 6 to 7 dB (A) and 12 dB (A) quieter respectively than unsilenced pneumatic equipment. However, their breaking efficiency compared with pneumatic equipment has not yet been assessed scientifically. Current work at the Building Research Station should assess noise and performance together for pneumatic breakers silenced and unsilenced and for the only electric breaker on the market. Work is still needed to find accurately the power of lesser sources of noise such as the body-radiated noise and the operating surface noise. The latter is most important in that it sets the lower limit of noise from impulsive road-breakers. Considerable development work also remains in the matter of silencing steel-radiated noise although the principles involved are clearly understood. Considerable advantage subjectively is to be obtained from the quietening of steel noise. It would seem that with all these measures it is possible to reduce the noise from road-breakers to near the level suggested by the Wilson Committee of 70 to 75 dB (A) outside the nearest window and also to keep the octave-band spectrum of the noise near the noise rating curve n.r. = 35 inside the nearby dwelling.

Little is said in this paper about the noise from prime movers such as compressors as they are not of direct concern. These engines are marginally important in that they can set limits for the obtainable noise level from their associated breaker. However, the quietening of this type of machinery has made great strides forward in recent years and it is at present only a secondary problem. With the more efficient silencing of breakers it could again become a primary noise source.

The newer types of drill are only just breaking into the market. Inevitably there will be a considerable time lag before quieter machinery replaces the unsilenced pneumatic drill. However, this time could be considerably shortened if suitable legislation could be introduced on the lines of that recommended by the Wilson Committee which over a period of time could set limits to the noise from such machinery.

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