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NOISE LEGISLATION AND REGULATION

THE PROCEEDINGS OF THE 1972 ANNUAL CONFERENCE

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AUSTRALIAN ACOUSTICAL SOCIETY

NOISE LEGISLATION AND REGULATION

THE PROCEEDINGS OF THE 1972 ANNUAL CONFERENCE

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THE N.S.W. DIVISION OF THE AUSTRALIAN ACOUSTICAL SOCIETY.

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NOISE CONTROL AND THE LAW.

by

The Hon. Mr. Justice R. Else-Mitchell

Judge of the Supreme Court of N.S.W. since 1958.

Additional Judge of the Land and Valuation Court since 1962.

Judge of the Land and Valuation Court since 31st July, 1972.

I.

In earlier times, when man did not have the means of generating power at will by artificial means, society had little need for a code of legal remedies to protect the individual against noise. The law recognised the right of a householder to the free and peaceful enjoyment of the land and premises he occupied and it conferred a right of action at law to enforce such enjoyment. An occupier could either bring an action for damages to compensate him for any loss or injury sustained by excessive noise or seek an injunction restraining the continuance of repetition of the noise. In each instance the cause of action was nuisance (a word derived from French - nuire, to hurt) which connotes any conduct or act which, without direct physical interference, materially impairs the use and enjoyment by another of his property or prejudicially affects his health, comfort or convenience.

Until the industrial revolution, the occasions on which such a right had to be exercised by legal proceedings were rare. The only machine power available was provided by wind or water and was relatively quiet in operation; street noises seldom exceeded the occasional rattle of a coach over cobbles or the stamping of horses' hooves and the worst domestic noises were probably made by the howling of dogs, the crowing of cocks or the nagging of unhappy couples. Even so, the law books record instances of injunctions being granted to restrain other noises, such as the use of firearms in rifle practice, the ringing of church bells, whistling for horses and coaches late at night, and other noises of a non-industrial character.

Actions in the courts for nuisance, whether to recover damages or to restrain the continuance of repetition of noise, could be a cumbersome process and early in the nineteenth century some noises were regarded as warranting special legislative treatment so as to provide a simple means of control through the police forces. In illustration, the English Metropolitan Police Act, 1839, which was copied by the New South Wales Legislature in 1853, gave power to any householder to require a street musician to depart from the neighbourhood "on account of the illness of any inmate ... or for other reasonable cause" and provided that the failure to do so would be a punishable offence; that Act also authorised the arrest and fining on conviction of any person, except a guard or post-man of Her Majesty's Post Office, who should blow any horn or use any other noisy instrument for the purpose of announcing any show or entertainment or for hawking or selling any article or obtaining money or alms: another provision of the same legislation made it an offence to wilfully and wantonly disturb any inhabitant by pulling or ringing any doorbell or knocking at a door without lawful excuse. Such provisions no doubt assisted in achieving some quietness in city and suburban environments, but they were of limited scope as in due time became evident.

With the growth of cities and the widespread use of steam power for industrial purposes a greater need was found for legal means of protecting a householder against the invasion of his privacy by noise. Actions in the courts for damages for nuisance were of little value because financial loss could seldom be proved and an award of nominal damages would be no deterrent. Suits for an injunction had to be instituted in the Equity Court and were both an expensive and protracted method of obtaining relief; they also might entail a single householder of limited means challenging a large industrial enterprise with unlimited financial and legal resources at its disposal.

Various powers to control noises, additional to those conferred by the various police Acts, were granted to local authorities under local government legislation as local government developed and other categories of noise, such as those produced by internal combustion engines and noisy trades, became the subject of special legislative provisions now incorporated in road traffic and local government Acts.

In the late 19th and early 20th centuries the major noises of concern to the ordinary householder were caused by industrial activities. Indeed, these activities also gave rise to other sorts of nuisance such as the emission of smoke and fumes, whilst the conduct of quarrying and mining operations also caused pollution in various ways. In the course of time people seeking a quiet environment exercised a measure of self help against the intrusion of industrial activities by isolating their residences from industrial centres, although workers living in industrial villages had little option to do likewise. Two separate modes of ensuring the isolation of residential areas from industrial intrusions were the creation in new residential estates of covenants restricting the conduct of trades, industries and businesses, and the proclamation under local government legislation or residential areas in which trade and industry were forbidden.

These processes of isolation, however, have also become ineffective to provide protection because in the last fifty years new sources of nuisance by noise of a mobile character have emerged. The chief of these are the internal combustion engine and the electronic amplifier. Sources of major noise are no longer localised in industrial or non-residential precincts but have complete mobility. Aircraft flying at heights diffuse engine noises over wide areas; motor vehicles of all sorts use public streets in choice residential areas as main thoroughfares; portable appliances powered by small internal combustion engines are in daily use by tradesmen, handymen and home owners, whilst in the domestic sphere, radios, amplifiers and instruments like electric guitars reproduce speech and music at noise levels never before possible.

This element of mobility has largely destroyed the protection which was once given by restrictive covenants and residential area proclamations under local government legislation and it seems also, in spite of the precautionary provisions which are incorporated in modern town planning legislation and schemes, that little protection can be provided from those sources.

II

There are in most of the Australian States legislative provisions enabling public or local authorities or councils to control noise of nuisances resulting from noise. For the most part they provide for the abatement or regulation of nuisances and of objectionable noises at unreasonable times, but the sanction for breach of such provisions or of by-laws made or directions given by such authorities or councils is merely a penalty exacted by prosecution before a Magistrate, Court of Petty Sessions or local court.

It must at once be conceded that there are shortcomings in statutory provisions which seek to minimise noise or achieve compliance with by-laws prohibiting or regulating noise by the imposition of penalties in criminal or penal proceedings. Such provisions are not only inconsistent with the conception that prevention is to be preferred to penalty, but they have

other major disabilities, not the least of which is the fact that the imposition of a penalty carries with it a commercial implication that the penalty is the price for violating the proscription or, in other words, the cost of conducting a noisy enterprise; they entail also difficulties of enforcement because of the principle enshrined in the law that criminal or penal offences must be proved beyond a reasonable doubt and not on a mere balance of probability.

The law, of course, is usually laggard in fields of social reform but Governments have, in recent years, given some consideration to the inadequacy of the legal measures available to limit or control noise or nuisance by noise. Environmental protection legislation has been passed in the States of Victoria, Queensland and Western Australia to facilitate the prescription of standards or limitations which will have to be complied with by industrial and business undertakings and probably public and transport authorities as well; as yet, however, no detailed controls have been formulated under these Acts. In New South Wales a preliminary report issued by the Department of Environment in May, 1971, pointed to the need for a new approach to noise abatement, with particular reference to industrial noise and community noises from electronically amplified sources and air conditioners, places of entertainment, private dwellings and motor vehicles as well as aircraft. This report mentioned that shire and municipal councils have power under the Local Government Act to control and regulate objectionable noises, but added -

> "In practice, local authorities usually employ persuasion and solicit co-operation, and then only in respect of industrial premises. Noise arising from private dwellings is presently a complex matter to control. There is not only the free enjoyment of individual householders to protect, but also the fact that human tolerance and sensitivity to noise are far from uniform. Specialist consideration of this aspect of noise will be enlisted to assist the government to frame more effective control measures." (pages 11-12).

In South Australia the subject of noise control was considered by the South Australian Local Government Act Revision Committee, which recommended the consolidation of existing powers of control and a wider discretion to local authorities to deal with nuisances of all kind, particularly nuisance by noise. The report of the Committee stated:

> "The age in which we live is one in which there is a growing range of activities that can cause a nuisance. What is more, where as in the past a nuisance could be said to emanate from a particular property, today the nuisance can be a mobile one. For example, 40 years ago a wireless was a curiosity: today a teenager can carry a blaring transistor radio through the streets to the discomfort not only of those in the streets but also of the many householders in the area. A teenager's street corner meeting continuing, as it can, for a considerable time with blaring transistors is certainly a nuisance problem.
>
> In the technological age in which we live the means of making noise and the means of amplifying

> noises are increasing rapidly, and there is little the ordinary person can do to prevent the destruction of the amenity of his home by those who are not prepared to behave in a good neighbour way. Theoretically, of course, he has his remedy through the courts. Practically, in many cases, the remedy is illusory because the person or company making the noise has financial resources far exceeding those of the person suffering from it." (paras. 6874, 6890.)

As yet, however, no major new legislative control over noise has been enacted in any State but the Government of New South Wales has recently proposed legislation to impose detailed noise controls.

III

It is not possible in these introductory observations to expound in full detail the present legal position in each of the Australian States and Territories, but the following may be said to set out broadly the nature and extent of the legal powers presently available to control excessive noises.

First, there is the common law right to complain of noise as a nuisance affecting the peaceful enjoyment of premises, which is enforceable by an action of damages or a suit for an injunction to restrain the continuance of repetition of the noise.

Second, local governing councils have powers variously framed to prohibit or regulate nuisances arising from noise, objectional noises generally, or noises at unreasonable hours, and to prohibit certain specific noises. Exercise of any of these powers requires action by the council to order the cessation of the noise and the prosecution and fining of the offender for any continued breach.

Third, there are certain noises, such as those created by motor vehicles, bells, sirens and other means in public places, which are punishable by prosecution and the imposition of a fine pursuant to road traffic, police and summary offences Acts.

Fourth, there are some diverse powers under town planning legislation to refuse approval to the new establishment of new developments which may cause injury to the amenity of a neighbourhood or locality by the emission of noise.

Finally, there are inchoate powers under environmental control legislation which may lead to the adoption of noise-insulating methods in the conduct of industrial or other enterprises and the formulation of noise controls of general application which will be enforceable by prosecution or injunction.

It cannot be doubted that these legal controls and processes have shortcomings, some of which have already been mentioned. More specifically, the shortcomings lie in the inadequacies of the procedures which must be pursued to assert or enforce a right of protection against excessive noise, rather than in the substantive legal rights or obligations which the law confers or imposes. In illustration, it is quite absurd that an injunction to restrain nuisance by noise can only be obtained by instituting proceedings in the Supreme Court or some Court of superior status according to detailed and sometimes technical legal forms, and only after protracted delays in

bringing the case to hearing and at considerable, if not crushing, cost to the person complaining. It may not be unreasonable for wealthy companies or even large local governing councils to pursue such a procedure to prevent disturbances such as may ensue from mining, quarrying, or other large-scale industrial operations, but it is proposterous that an ordinary householder in a residential area can prevent his neighbour playing an electric guitar at high volume or carrying out desultory panel-beating in his back-yard only by commencing an action for an injunction in one of the State Supreme Courts at great expense.

The powers which local governing councils have to prohibit or regulate objectionable noises, noises at unreasonable times or those which amount to nuisances also afford little comfort to the ordinary householder because, as has been pointed out, councils are seldom eager to initiate action by making by-laws or taking other steps to prohibit noise activities which may be a nuisance to local residents. Unless pressed by a substantial body of public opinion they tend to avoid involvement in disputes between neighbours and, even when prepared to intervene, often encounter legal problems in enforcing their edicts becuase the only proceedings available are of a criminal or penal character in which the person charged is not bound to justify his conduct and the case against him must be proved beyond a reasonable doubt.

Again, some of the legislation which proscribes specific categories of noise, such as that made by motor vehicles, is not capable of ready enforcement owing to the lack of adequate personnel to police the legislation. How often, for example, are the drivers of motor vehicles with noisy exhausts stopped or apprehended on the highway; and, if they are, the only course usually available is to prosecute the offender for breach of the appropriate regulation, a course which will merely result in the imposition of a fine weeks, or perhaps months, later. There is no general power to require the person in charge to immobilise the vehicle and take steps to modify its mechanism so that the noise will be reduced; and yet the police forces in several States have similar powers in relation to vehicles having other mechanical defects.

Further, in those cases where town planning legislation provides for new industrial and other developments which may cause injury to the amenity of a locality by the emission of noise being undertaken only with some consent, no procedure is available to enforce conditions attaching to the development consent which require compliance with minimum noise standards: the planning authority concerned is remitted to a common law right of action to seek an injunction restraining the conduct of the activity, or to the prosecution of the person or company concerned for breach of the condition, a course which involves the same disadvantages as attach to other proceedings of a criminal or penal nature.

Finally, even when the existence of a noisy activity in a give place is clearly established and is causing concern to members of the public there is (subject to exceptions in some States) no single authority with the responsibility and power to require the emission of noise to be reduced by the undertaking of specific measures such as the construction of baffle walls, the sound-proofing of working places in workshops and factories, or the installation of sound absorbing materials.

The foregoing observations show that existing legal machinery for controlling excessive noise and, in particular, the processes available to the individual to restrain such noise are outmoded and inadequate. It cannot, I suggest, be doubted that there is a pressing need for a thorough-going overhaul of the legal processes available for the prohibition and control of noises of all sorts, whether they are created on privately owned land or in public places. As to those which are emitted from privately owned land to the prejudice of occupants of other premises, the law of nuisance confers an adequate right not to be disturbed but simple enforcement procedures for abatement of noises, or for restraining their continuance or repetition are sorely needed. Legislation similar to that of the English Noise Abatement Act, 1960, under which a complaint may be made by three occupiers of land to a Magistrate or Court of Petty Sessions, might go a long way towards providing a suitable summary remedy. In addition to providing for some such procedure, it should also be possible for Courts other than the Supreme Courts, and particularly District, County or Local Courts, to be given jurisdiction to entertain claims for injunctions to restrain nuisances by noise and to do so according to simple forms without the necessity for pleadings of any complexity. Appropriate public bodies, such as environmental protection authorities and local governing councils, should also be given power, subject to some right of appeal, to compel positive steps to be taken by an occupier to prevent or limit the emission of noise from premises and to abate nuisances arising from noise.

Those noises which are caused in public places and which have a transient quality present a different and more difficult problem of control. The scope of the present legislation in all States on these topics is unduly limited and most Acts spply only to particular noises generated by such things as motor vehicles, musical instruments and noises from specified trades. Not only is it desirable that appropriate legislation should proscribe all noises, or a wider range of noises which are excessive in nature or beyond limits to be prescribed, but particular public authorities should be charged with the responsibility of ensuring compliance with the standards and given powers to order abatement. Such powers should extend to require the immobilisation of vehicles and the taking of positive steps to reduce the emission of noise.

Amendments of the existing law along the lines that have been briefly outlined cannot be expected to achieve a perfect system of control but should provide a better basis for dealing with noises which are excessive in nature, quality or otherwise. They certainly would not meet every situation - for example, noise from aircraft - and detailed legislative provisions might be needed for many individual sources of noise. Research and study of the problems of noise generation and of the impact of noise of all sorts will undoubtedly reveal a need for other controls and possibly disclose means whereby they can be implemented within the basic structure of the amendments suggested.

This is a difficult field in which to reach firm conclusions not only because noise is intangible and transitory but also because its volume or impact can often be assessed only in broad terms which are based on subjective evaluation. Even so, it cannot be denied that there are serious problems of noise generation in the community today which are affecting health, enjoyment and quality of life of urban dwellers to a point that many people are likely to develop neurotic disorders or suffer substantial impairment of their senses of hearing.

It is in the interests of protecting a large segment of our urban populations that the freedom of others to generate noise without limit must be curbed by appropriate legislation which will provide simple processes to give protection from the deleterious effect of excessive noise.

THE PRESENT STATE OF NOISE LAW - A FEW EXAMPLES.

by

J.H.H. Blackman,
Barrister, Sydney.

The necessity for "noise law" is of comparatively recent birth. The first cases reported in our law reports were in England. Perhaps this was because of the quietness of the Australian way of life, the tolerance of our inhabitants, or lack of heavy industries. Or perhaps it was that our lawyers had not yet reached the adventurousness of those across the seas.

The earliest case I have been able to find in Australia in which a compliant of noise interference has been upheld by the Courts is Re Dakin.(1) This was decided in 1887 in Victoria when Mr. Dakin was instructed by his next door neighbour to desist from making so much noise in his business of constructing large noticeboards. He did not comply with the direction, which to me seems quite extraordinary, when it is considered that the direction came from the Chief Justice of the Supreme Court of Victoria, and he was eventually fined for contempt of court.

The law reports do not seem to show any further activity with regard to noise cases until 1911 when, again in Victoria, it was held that it was unreasonable to ring Church bells before 9.00 a.m. on a Sunday morning. (2).

Perhaps the residents of South Australia are more hardy, for in 1916 it was held that it is not unreasonable for people to meet at 7.00 a.m. on a Sunday for religious worship, and in so doing to sing hymns (3). This was the first case that is reported of sounds coming from a Church service or other religious meetings being the subject of a nuisance application. In this case the defendants were the Salvation Army and the Chief Justice remarked, regarding the singing, "I am not prepared to say that 7.00 o'clock on Sunday mornings is an unreasonable hour for people to meet for religious worship, and to sing hymns. And I am not prepared to hold, as we were invited to do, that those who do not attend such services have a right to lie in bed on Sunday mornings undisturbed by the sounds that arise from them. There is no law to that effect, and I am not going to be the first to establish one". The defendant was, however, stopped from using its band, clapping in time to hymns, and shouting "Hallelulah", because the plaintiff's house was so close to the Salvation Army meeting hall - a matter of some 17 feet.

In 1928 noise came to the New South Wales Court when St. James' Theatre in Sydney was being altered - the building that is now a very large hole in the ground (4). The Judge held that the defendant had not taken all reasonable precautions to minimise noise of its building operations and that it was practically impossible for the plaintiff to carry on its business or part of its business. It was therefore ordered that the use of mechanical drills in the manner employed before the matter came to a hearing was banned during ordinary business hours.

In 1929 and 1930 the Queensland Courts considered a case where poultry was kept in a residential area (5). The Court refused to grant an injunction sought by people complaining of the crowing of roosters because there was not sufficient evidence before it to establish the grounds of nuisance. This was one of the rare reported cases where the plaintiff failed to gain some sort of an injunction for noise nuisance.

It may be convenient at this stage to look at the various way in which noise can presently be stopped or prevented:

First, there is the injunction proceeding by way of an allegation of nuisance (which is a legal term): the plaintiff uses the Equity Court to stop the defendant annoying him. There is a private nuisance where one person or family only is affected or a public nuisance where a section of the community is affected.

Secondly, under New South Wales Local Government Act, 1919, section 289 provides that a Council may: "(c) control and regulate the use of premises so as to prevent objectionable noises thereon or noises thereon at unreasonable hours; (d) control and regulate noises in or near any public place and in particular noises from the exhaust gas of internal combustion engines other than the engines of motor vehicles".

This section is of no effect unless it can be given teeth and there are various ways in which it can be so equipped.

Section 632(1) provides that where something is directed or forbidden to be done under the Act, and the direction or forbidding is not carried out, the person offending shall be guilty of an offence under the Act. And Section 633 provides the penalty for disobedience: fine of up to $200.00 plus an additional daily penalty of up to $10.00.

I might mention here Section 587 of the Local Government Act which provides that a local Council may take action which the Attorney General could have taken and I shall discuss this later.

Section 303(1)(q) provides that ordinances may be made under Part X of the Act (the part containing Section 289) "prohibiting and regulating the making of noises and the use of premises so as to prevent or minimise the emission of noises therefrom and prescribing the noises to which any ordinance made under this paragraph may relate". Which would mean that the New South Wales Parliament could bring in an ordinance under the Local Government Act which would define the limits of noise in particular areas or whatever appropriate mechanism was chosen. However, this has not so far been done.

It may also be that under this section a local planning ordinance could make provision controlling noise level or emission from a particular building or within particular times etc.

Before coming back to the cases in our own country, perhaps I should first quote some authority which comes to us from the common law in England which is the basis for our own laws.

One case that is quoted widely is that of Walter v. Selfe (6) which was decided in 1851 and which concerned a case of private nuisance, where it was alleged that what one man was doing on his property was interfering with the enjoyment by his neighbour of his property. It was there said that the question was whether what the defendant was doing was "an inconvenience materially interfering with the ordinary comfort physically of human existence, not merely according to elegant or dainty modes and habits of living, but according to plain and sober and simple notions among the English people".

The difference between a private and a public nuisance was discussed in 1957 by the Court of Appeal (7) where Lord Romer said that "any nuisance is public which materially affects the reasonable comfort and convenience of life of a class of Her Majesty's subjects .... It is not necessary to prove that every member of the class has been injuriously affected; it is sufficient to show that a representative cross-section of the class has been so affected". And Lord Denning, who is now Lord Chancellor of England said "a public nuisance is a nuisance which is so widespread in its range or so indiscriminate in its effect that it would not be reasonable to expect one person to take proceedings on his own responsibility to put a stop to it, but that it should be taken on the responsility of the community at large."

Where a private nuisance is of such magnitude, it will become a public nuisance and, in addition to the right of an individual to try to prevent it by injunction in the Equity Court, the Attorney-General may also bring the action. And the Attorney-General is paid by the government and not by the individuals whose welfare is affected: It is part of his public duty.

In another case decided in the Supreme Court in Englamd in 1930 (8), it was said that it is necessary to take into account the circumstances and the character of the locality in which the person affected is living and after referring to the classic statement above, said "it is no answer to say that the best known means have been taken to reduce or prevent the noise complained of, or that the cause of the nuisance is the exercise of a business or trade in a reasonable and proper manner".

And now perhaps we can come back to Australia to look at a case decided in our own Supreme Court in 1957: Williams v. Storey (9). This is a case in which the Leichhardt Council sought to control the noise emanating from a ship building yard at Balmain on the foreshores of Sydney Harbour.

The Council received complaints about noise from the yard and wrote to the proprietors who replied with an explanation and the defendants were informed that their premises would be kept under observation and in the event of "objectionable noises or noises at unreasonable hours" notice would be served under the provisions of section 289(c) and (d) of the Local Government Act. Nearly a year later the Council received an unfavourable report from its officers in relation to the ship building yard and it passed a resolution prohibiting certain activities within the yard within certain hours. Notice of the resolution was serviced on the proprietors and immediately thereafter the council's servants inspected the premises to see if the Council's prohibition was being obeyed. When it was not, the Council's officers laid an information in the Petty Sessions Court under the provisions of the Local Government Act and when the magistrate dismissed the information the Council (in the name of its officers) appealed to the Supreme Court.

There were various attacks made on the power of the Council to do what it had done and perhaps the different aspects of the case can be taken individually.

I quote a passage from the judgment which, after looking at section 289 (c) and the resolution that was passed, considered the power of the

Council to prohibit the defendant's use of their property: "It would be erroneous to regard the exercise of power under the relevant section in the present case as an unqualified power since its operation must necessarily interfere with the common law right of user of a person's land conjoined with an interference with the business carried on upon that land. To hold otherwise would be to overlook the principle that no man shall be deprived or injured in his property without the opportunity of being heard in this defence". In other words, the Council must have regard to both sides of the argument: it must act in a "quasi judicial" manner.

The opportunity of being heard against the making of an order can be given in one of two ways, either the Council could give the maker of the noise notice that it intended to prohibit some of his activities or it could make an order and give him notice of the order before acting upon it. In this case the defendants had been previously put on their guard and they were also given notice of prohibition, admittedly only a short time before the particular act complained of in the Court.

It was held that it was not possible to go behind the resolution to see if it was "reasonable" provided there was sufficient connection between what the resolution sought to prohibit and the authority given by the Act.

Although Section 289 is in Part X of the Local Government Act which deals with "public health, safety and convenience" the act complained of need not have some detrimental effect upon the health of the residents of the locality. However, the prosecution must prove that a resident or residents have suffered an inconvenience materially interfering with the ordinary physical comforts of human existence along the lines laid down in England so long ago. "The test must always be, does the noise which is sought to be controlled, amount to a nuisance?".

The next case we come to is Farley and Lewers v. The Attorney General, a case which started off as Hornsby Shire Council v. Farley and Lewers in 1960 (10). The Council had sought to rely on Section 587 (quoted above) as giving it the right to bring an action for public nuisance. What a council can do under that section is bring an action for public nuisance where the Attorney-General could have brought one against the defendant because of the infringing of some provision made by or under the Act in the nature of a command or prohibition addressed to the prospective defendant. Or as was put in another case "the effect of section 587 of the Local Government Act is to enable a council to represent the interests of the public and to restrain a public nuisance by the institution of a suit in equity whenever there has been a command or prohibition addressed to an individual such that the Attorney-General could proceed for breach of it" (11).

In the Farley and Lewers case there was evidence from highly qualified acoustic experts and the Full Court considered the weight that this evidence must be given in comparison to the evidence of people who lived in the neighbourhood, and who were complaining of the noise: "The true criticism is that instrumental records do not of themselves disclose the effect of sound upon the human being". The measurement of decibels will not determine what effect the sound has on the comfort of the neighbours nor whether there is material interference with the amenity of the residents in the locality. These are subjective matters which will vary

between localities and at different times of the day. The Court expressed decibel measurements in general terms, which will probably make the scientists at the Conference shudder, ranging from "very noisy" to "very quiet", and held that the level of sound in the vicinity of the quarry had been raised from "somewhere between very quiet and quiet to somewhere between moderately noisy and noisy", and that there had been a nuisance extending over a sufficient neighbourhood for it to be a public nuisance.

As experts in New South Wales will no doubt recall, that quarry in Hornsby is still operating but now it is effectively silenced.

The last case I want to look at is Allen Commercial Construction v. North Sydney Municipal Council which was decided in the High Court of Australia in 1970 (12).

In this case the North Sydney Planning Scheme Ordinance provided, amongst other things, that the consent of the Council had to be obtained to the erection of a commercial building in the relevant zone when it was proposed to be more than three floors above ground level. When considering any application the Council had to have regard to "the existence and future amenity of the neighbourhood, the circumstances of the case and the public interest, and the provisions of the scheme". The appellant had put in its application and consent was granted subject to various conditions including the term that building work was only to be done during the hours of 7.00 a.m. to 5.00 p.m. Monday to Friday and 7.00 a.m. to 1.00 p.m. on Saturday. When the building company did not comply with this condition the Council sought an injunction in the Equity Court which eventually came on appeal to the High Court.

Part XIIA of the Local Government Act deals with the preparation and approval of planning schemes for local government areas. Section 342G provides "(2) A scheme may contain provisions for regulating and controlling the use of land and the purpose for which land may be used" and "(3) Without prejudice to the generality of subsection 2 of this section a scheme may contain provisions for or in relation to all or any of the following matters ... (i) the regulation of building and of matters relating thereto; (q) the provision of amenities".

The Judgment of the Court stressed the words "for or in relation to" in holding that the provisions of the section allowed a scheme to regulate the way in which building work is carried out. The Court further held that "the taking of measures for the protection of residents from noise and from the disturbance of their rest may properly be regarded as included in the expression the 'provision of amenities'" in paragraph (q) above.

A scheme may contain provisions by which the giving or refusing of consent to the use of land in certain ways may be entrusted to an authority (in this case the North Sydney Council) which may make decisions in accordance with the circumstances of particular cases and from time to time.

The Council did not have unlimited discretion under this scheme to impose conditions but only those conditions reasonably capable of being related to the purpose of implementing the planning policy

contained in the Act and the planning scheme ordinance. The provisions of the Act and the Ordinance are not to be taken as restricted to the use of the building after it is completed but also to the effect which the building operations will have on the neighbourhood during erection of the building.

This case would seem to suggest that a local council could, on a development application, lay down conditions as to what sort of tools should not be used in the construction of a building, the hours during which industrial operations may be carried on in the completed building, types of machinery that may be installed, numbers of people who may inhabit a certain area, etc. If a council did avail itself of these powers it would always be a matter of the reasonableness of the condition imposed within the ambit of the Local Government Act and the relevant local scheme. This would devolve responsibility for protection of a locality upon the local council with rights of appeal to the new Local Government Appeals Tribunal. This could, and no doubt would, mean a variation in standards from municipality to municipality.

I have said nothing about the body of cases in which damage has not been to the comfort of neighbours but to their property, partly because of lack of time and partly because such cases can more easily be the subject of monetary compensation.

What I have been talking about are examples of how the lawyers have been making the present law work to control excessive noise. But the test of what is excessive will vary from neighbourhood to neighbourhood, from time to time, and from person to person. I have no doubt that Mr. Justice Higinbotham who, in 1887 prevented hammering close to the Court, would be offended by the noise made in the course of construction of the new Supreme Court building in Sydney. But the development of silencers for excavation equipment has meant that the surroundings of Farley & Lewers' quarry are now more peaceful.

The measures that are available are hardly enough to keep in control all sources of noise irritation and damage. Perhaps it is up to the imaginateness of the public and their legal advisers to make fresh inroads into noise pollution by the presently available means or perhaps the government should "do something about it". Whatever the answer is, it must be remembered that it is not the absolute prohibition of loud or any noises that is to be aimed at: it is a balance between what the human ear can stand and what is needed to keep the man whose ear is assailed in employment and in the enjoyment of his work and leisure.

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NOISE MEASUREMENT TECHNIQUES

by

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A.J. King, in his book 'The Measurement and Suppression of Noise', devotes the second chapter to Subjective Noise Measurement, the third chapter to Objective Noise Measurement, and the next chapter is entitled Calculation of Loudness from Objective Analysis. I trust this serves to emphasise the gap that exists between measurement and assessment of noise.

Measurement of noise is not difficult; instrumentation has advanced in the past ten years, to the point where measurements and analysis can be made with great accuracy, the difficulty in some cases is only how to describe the measurement levels in such a way that the amount of noise present is understood. In the final analysis the effectiveness of legislation depends on the ability of others to understand the assessed value.

This paper confines itself to explaining the instrumentation and measurement associated with the objective measurement of noise, other papers later in the conference will deal with the problem of rating noise with regard to annoyance or noisiness.

The quantity normally measured when dealing with airborne noise is RMS sound pressure. The range of sound pressure perceived as sound is extremely large, varying from 0.00002 N/m^2, approximately the weakest sound pressure to be detected by an average person, to 100 N/m^2, the largest sound pressure perceived without pain. The scale of sound pressure covers a dynamic range of around 1:1,000,000.

The use of a unit of pressure, say the Newton per square meter, directly as a unit in the measurement of sound is therefore not convenient. Further, the hearing mechanism responds to changes in sound pressure in a relative manner rather than in an absolute way. Thus a more suitable measure of sound pressure is a relative scale rather than the absolute scale; such a scale is the decibel scale.

The use of decibel reduces the scale of sound pressure of 1 . 1,000,000 to sound pressure levels that vary between 0 and 120 dB. 0 dB indicates the reference level and 120 dB indicates the upper level, before the onset of pain.

A device for the measurement of the RMS sound pressure levels consists of a microphone, amplifier and meter. The microphone converts the sound pressure wave into an electrical voltage fluctuation, the amplifier raises the electrical signal to a level where they can operate the meter to provide a visual indication. Unfortunately no meter could indicate accurately over a range of say 100 dB or more, thus a stepped attenuator is included to allow the meter to read over a limited range of 10 to 20 dB; adjustments to the attenuator provide the additional range of levels. Most sound level meters will have connections to which external equipment such as tape recorders and other measuring equipment could be connected.

Besides a linear reading sound pressure level most meters are capable of recording measurements of sound pressure level with one of the standardised frequency weighting characteristics A, B or C.

The sound level meter may take many forms, it may be a small compact instrument of the hand-held type, including microphone and weighting networks; it may be a little more sophisticated and applicable for use with analysing filters, but still intended for hand held operation, or

it may consist of stationary instruments powered from the mains and automatically recording the measured data. A somewhat more sophisticated version of the hand-held type of sound level meter belongs to the so-called precision sound level meter group, fulfilling the requirements of Australian Standard ASZ 381967.

While all the instruments contain standardised weighting network the precision sound level meter also allows for the insertion of more specialised external filters, for instance an Octave Band Filter Set. A feature of the instrument is that the Octave Filter Set can be connected mechanically directly onto it. In this way a very compact and readily portable 1/1 octave band analyser is obtained. Also, the output from the instrument is available on a set of output terminals allowing the noise signal to be recorded or monitored on an external recording device if desired.

The built-in read-out consist of an RMS rectifier and a meter circuit the dynamic characteristics of which are specified in the international standard. Two different meter damping characteristics, termed 'fast' and 'slow' respectively are included in the instrument; the 'slow' characteristic is intended for use in situations where the reading obtained with the 'fast' characteristic fluctuates too much (more than some 4 dB) to give a reasonably well defined value of the sound level.

A still more sophisticated version of a hand-held type sound level meter for use in the field is available. This is the impulse precision sound level meter. Here special circuits in the detecting and metering system of the instrument take certain characteristics of the human perception of impulsive sounds into account. These characteristics have been discussed internationally for some time and a proposed Australian Standard recommendation for their utilisation of precision sound level meters has been drafted. In Germany the recommended characteristics are included in the DIN 45633-2 Standard.

All of the particular sound level meters mentioned up to now are of the battery-powered type, suitable in the main for field use, in addition to the sound level meter, it is convenient and sometimes necessary to be able to record and store the original noise signal for later reproduction and analysis in the laboratory. Typical examples are the measurement and evaluation of varying noise, impulsive noise, transient noise and intermittent noise.

Normally the output signal from the measuring microphone is fed to a magnetic tape recorder, either directly or via some amplifying device. Certain requirements have to be fulfilled by the tape recorder. Firstly, it must be absolutely dependable to that there is no risk of not recording data because of improper functioning. Secondly, it must have a flat frequency response, wide dynamic range and a minimum of wow and flutter. Many modern magnetic tape recorders fulfil most of these requirements. The choice of a recorder may be dictated finally by its portability and performance.

The point of operation of the sound level meter and the point of operation of the tape recorder should be arranged to provide optimum performance with regard to signal to noise ratio and maximum allowable input to the tape recorder. During recording care should be taken not to overdrive the recorder amplifiers. In cases where impulse noise is recorded it is advisable to set the recorder gain control to 10 to 30 dB lower than

normal due to the very high crest-factors involved.

Calibration of the measuring and recording chain during the first seconds of each recording will ensure a reasonable degree of accuracy in reproduction and analysis. Where possible notations related to the particular measurement should be included on tape during the recording.

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Preparing a paper on Noise Measuring Techniques at a Conference entitled 'Noise Legislation and Regulation', one would expect to be presenting an impressive array of new measuring techniques, new methods, together with descriptions of complex new instruments designed to respond in diabolical ways to the noises fed to them. Instead, the analysis required to obtain measurements in accordance with a number of recent Draft recommendations of the Standard Association are less complex in terms of actual field measurement than their equivalent in 1965. The recommended method of measurement of sound, the dB(A), was included in an American Standard for weighting networks as long ago as 1944. Two Draft Australian Standards currently proposed as Australian Standards use the dB(A) almost exclusively to rate noise levels.

The Draft Australian Standard Code of Practice for Hearing Conservation, DR 72084, which gives a method of assessing hearing damage risk includes methods of determining an equivalent continuous sound level per 40 hour week in terms of dB(A). The Draft Standard is not applicable to impulsive noises consisting of single bursts of noise or for single high level transients of a very short duration, nevertheless, it provides a measuring and rating scheme that is broadly applicable in industry; the instrumentation required by those controlling or conforming to the recommendation are readily obtainable and easily used.

The Draft Australian Standard Code of Recommended Practice for Noise Assessment in Residential Areas (DOC 1707) includes methods of determining the expected noise annoyance based on relatively straight forward use of the dB(A). Here again the minimum standard of instrumentation and technique of measurement is stipulated, allowing those involved in the application of the code to make their approximate assessment without involving themselves with an extensive outlay of equipment.

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To summarise, this paper has attempted to show that the final objective of noise in a given situation is not difficult, that the expression of results in objective terms is straight forward and the adequate instrumentation exists for the measurement of noise.

Further, that the results that can be achieved in the field with simple hand held precision instrumentation, can provide as much meaningful information as effective legislation requires.

Finally, the general acceptance of the 'A' weighted decibel in measurement of noise emitted by machines which presumably covers domestic appliances at this stage; the acceptance of the 'A' weighted decibel in the measurement of noise in industry related to Hearing Conservation; and the acceptance of the 'A' weighted decibel in the assessment of community noise annoyance appears as a triumph for those advocating simplicity and uniformity and should greatly contribute to the more general understanding of the measurement of noise.

THE PHYSIOLOGICAL, PSYCHOLOGICAL AND SOCIOLOGICAL EFFECTS OF NOISE ON MAN.

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1.0 INTRODUCTION

2.0 AUDITORY EFFECTS

- 2.1 Ear Damage and Hearing Loss
- 2.2 Masking and Interference with Speech Communication

3.0 GENERAL PSYCHOLOGICAL AND SOCIOLOGICAL EFFECTS OF NOISE

- 3.1 Interference with Sleep
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4.0 HEARING CONSERVATION PROGRAMMES

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1.0 INTRODUCTION

May I begin by quoting Professor Hallowell Davis who is recognised as one of, if not the greatest, physiologist in the field of sound. In the introduction to "Sound and Hearing" (reference 9) he states that sound "is of great use to us and to all animals. Many events of nature, whether the meeting of two objects or the turbulent flow of air, radiate a tiny part of their energy as pressure waves in the air. A small fraction of the energy that is scattered enters our ears, and we hear it and thus we know of the event. Hearing is a late development in evolution but it has become the sentinel of our senses, always on the alert.

But hearing does more. The ear and the brain analyze these sound waves and their patterns in time, and thus we know that it was a carriage, not footsteps that we heard. What is more, we can locate the position of the carriage, and tell the direction in which it is moving.

Many birds and animals have also learned to signal one another by their voices, both for warning and for recognition. But we humans, with good ears and also mobile tongues and throats, and above all, our large complex brains, have learned to talk. We attach arbitrary and abstract meanings to sound, and we have language. We communicate our experiences of the past and also our ideas and plans for future action. For human beings, then, the loss of hearing brings special problems and a special tragedy. Human society creates a special problem even for those with perfect hearing - the problem of unwanted sound, of noise, which is as much a hazard of our environment as disease germs or air pollution.

All of these subjects are important. Sounds may be small and weak, but civilization could not have grown without them.

It is interesting to contrast the visual and auditory systems in this regard. Visual animals that engage in important activities during both day and night developed visual mechanisms that function, without damage, during sustained periods that differ greatly in luminance. Daily changes of luminance equivalent to about 100 decibels have occurred for as long as the earth has rotated on its axis. The eyes are provided with lids that can block out light, pupils which vary in size and thus control the amount of light entering the eyes, and sensory receptors that have mechanisms to alter their sensitivity with these very large changes in luminance.

The situation for sound and hearing is quite different. As the ear developed it did not need to contend with large daily variations in average sound levels. Indeed, one imagines that only rarely were intense sounds sustained for very long periods of time. To be sure, the ear had to be able to withstand the intense but brief sounds of thunder, the moderately intense sounds of windstorms and sustained rain, but these rarely lasted more than a few hours. In general, the evolving ear did not have to cope with either frequent, very intense sound or even moderately intense sounds that were maintained day after day. Only near some beaches, waterfalls, or areas with sustained winds would moderately intense sound levels have continued for prolonged periods of time. It is interesting in this regard that ancient travellers noted that villagers who lived near the cataracts of the Nile appeared to have hearing loss.

Hearing evolved to play a role in both individual and social adaptation to the environment. By hearing, man can detect a sound-making object or event, day or night. Often man can localise the direction of an object or event and sometimes identify it by its sound alone. To increase the chances of identifying objects or events and to insure appropriate preparation for response, evolution has closely tied hearing to man's activating and arousal systems.

Hearing is also involved in social mechanisms of adaptation to the environment. With our voices and ears we can "communicate our experiences of the past and also our ideas and plans for future action." In addition, language, dialect, and manner of speech are important determiners of the actions and cohesiveness of social groups.

The close ties of hearing to arousal, muscular actions, and social relations provide the biological foundations for the mood-influencing and aesthetic properties of auditory experience. For hearing not only serves as an ever-vigilant warning system and as the avenue of speech reception, but also acts to influence man's moods, feelings of well-being, and aesthetic sensibilities. Many of these responses to sound are culturally determined and represent learned attitudes, but surely there are biological bases for development of music with its associated emotional responses along with the muscular responses of rhythmic movement and dance. Some of these biological bases stem from adaptative interrelations between the auditory system and the arousal and muscular systems. Others may be simply accidents of the evolution of the auditory system.

Thus, it is clear that sound is of great value to man. It warns him of danger and appropriately arouses and activates him. It allows him the immeasureable advantage of speech and language. It can be beautiful. It can calm or excite and it can elicit joy or sorrow. The recent discovery that five-day-old infants will work to produce a variety of sounds only reinforces our everyday observations that man enjoys hearing and making sounds.

But not all sounds is desirable. Unwanted sound is noise. The definition of noise includes a value judgment, and for a society to brand some sounds as noises requires an agreement among the members of that society. Sometimes such agreements can be achieved readily. Other times considerable analysis and debate is required before agreement can be reached.

While machines are useful and valuable, they often produce as a by-product too much sound or noise. On the other hand, since machines can be dangerous, undoubtedly they should make enough sound to warn us of their approach or of the danger from their rapidly moving, powerful parts. Also, sounds that are valuable in one location may travel to places where they may not only serve no desirable purpose, but they may interfere with and disrupt useful and desirable activities. Some sounds seem to serve no useful purpose, anywhere or anytime to anyone. These sounds are unwanted and they clearly are noises. Other sounds are noises only at certain times, in certain places, to certain people. It is these complexities that require considerable analysis and thought to enable us to reach agreement about what is noise and what is not.

2.0 AUDITORY EFFECTS.

The auditory system is exquisitely sensitive to sound. The acoustical power at the eardrum associated with a sound so loud as to produce discomfort (120 dB(A) is only about 1/10,000 of a watt. The sound power of the same sound impinging over the entire surface of the body is of the order of 1.0 watt. Furthermore, the boundary between the skin of the body and the surrounding air is such that little of the acoustical power of audible sound is actually transmitted into the body. Even for very loud sounds only a small amount of acoustical power actually reaches the body. Therefore, it is not surprising that noise has its most obvious effects on the ear and hearing since these are especially adapted to be sensitive to sound.

One set of auditory effects is noticeable after a noise has passed; these are temporary hearing loss, permanent hearing loss, and permanent injury to the inner ear. Another set of auditory effects is noticeable while a noise is present; these are masking and interference with speech communication.

2.1 Ear Damage and Hearing Loss.

Exposure to noise of sufficient intensity for long enough periods of time can produce detrimental changes in the inner ear and seriously decrease the ability to hear. Some of these changes are temporary and last for minutes, hours, or days after the termination of the noise. After recovery from the temporary effects, there may be residual permanent effects on the ear and hearing that persist throughout the remainder of life.

The changes in hearing that follow sufficiently strong exposure to noise are complicated and include distortions of the clarity and quality of auditory experience as well as losses in the ability to detect sound. These changes can range from only slight impairment to nearly total deafness.

2.1.1 Ear Damage.

The outer ear, the tympanic membrane and middle ear are almost never damaged by exposure to intense noise. The eardrum, however, can be ruptured by extremely intense noise and blasts (reference 30). The primary site of auditory injury from excessive exposure to noise is the receptor organ of the inner ear, which is known as the Organ of Corti.

Sound waves reaching the tympanic membrane are transmitted by the combined lever movement of the three ossicles, the malleus (hammer), the incus (anvil) and the stapes (stirrups), to the fluid in the internal ear. This produces a wave-like motion of the basilar membrane of the Organ of Corti and the tectorial membrane resulting in bending of the hairs of the hair cells of the Organ of Corti which are inserted into the tectorial membrane. This gives rise to nerve impulses in the auditory nerve by which they travel to the brain stem and to the auditory centres of the brain where they are interpreted as sounds. Incidentally, the Organ of Corti also acts as an amplifier as well as a transducer since it also adds energy to the sound impulses which travel to the brain. Excessive exposure to noise can result in the destruction of hair cells and collapse or total destruction of sections of the organ or Corti. Also the auditory nerve fibres may degenerate.

The loss of hearing ability depends, in a complicated way, on the extent of the injury along the Organ of Corti. Total destruction of the organ of Corti for one or two millimeters of its total 34 millimeters may or may not lead to measurable changes in hearing. Recent evidence from human cases and animal experiments suggests that the loss of sensory cells must be quite extensive in the upper part of the cochlea (that part which is important for the perception of low-frequency sounds) before this damage is reflected as a change in threshold. In the lower part of the cochlea (that part which is important for the perception of high-frequency sounds) losses of sensory cells over a few millimeters are sometimes reflected in changes in hearing (reference 3).

The mechanism by which over-exposure to noise damages the auditory receptor is not well understood. Very intense noise can mechanically damage the organ of Corti. Thus, loud impulses such as those associated with explosions and firing of weapons can result in vibrations of the organ of Corti that are so severe that some of it is simply torn apart. Other very severe exposures to noise may cause structural damage that leads to rapid "break-down" of the processes necessary to maintain the life of the cells of the organ of Corti. Such an injury is an acoustic trauma. Over-exposure to noise of lower levels for prolonged periods of time also results in the degeneration of the hair cells and accessory structures of the organ Corti. Such injuries are called noise-induced hearing loss.

Excessive exposure to noise leads to the destruction of the primary auditory receptor cells, the hair cells. There can be other injuries to the organ of Corti that can range from mild distortion of its structure to collapse or complete degeneration. The auditory neurons (nerve fibres) may also degenerate. All of these cells are highly specialised. Once these cells are destroyed, they do not regenerate and cannot be stimulated to regenerate; they are lost forever.

2.1.2 Threshold Shift

The primary measure of hearing loss is the hearing threshold level. The hearing threshold level is the level of a tone that can just be detected. The greater the hearing threshold level, the greater the degree of hearing loss or partial deafness. An increase in a hearing threshold level that results from exposure to noise is called a threshold shift.

Some threshold shifts are temporary and they diminish as the ear recovers after the termination of the noise. Frequently-repeated exposures can produce temporary threshold shifts that are chronic though recoverable when the exposures cease. When a threshold shift is a mixture of temporary and permanent components, it is a compound threshold shift. When the temporary components of a compound threshold shift have disappeared (that is, when the ear has recovered as much as it ever will), the remaining threshold shift is permanent. Permanent threshold shifts persist throughout the remainder of life.

Temporary threshold shifts can vary in magnitude from a change in hearing sensitivity of a few decibels restricted to a narrow region of frequencies (pitches) to shifts of such extent and magnitude that the ear is temporarily, for all practical purposes, deaf. After cessation of an exposure, the time for hearing sensitivity to return to near-normal values can vary from a few hours to two or three weeks.

In spite of efforts in many laboratories, the laws of temporary threshold shifts, have not yet been completely determined. There are large numbers of variables that need to be explored. Also, there are probably several different underlying processes that influence the measured threshold shifts.

Nonetheless, certain generalisations seem to be correct (reference 32). Noises with energy concentrations between about 2000 and 6000 Hz probably produce greater temporary threshold shifts than noises concentrated elsewhere in the audible range. In general, sound levels must exceed 60-80 dB(a) before a typical person will experience temporary threshold shifts even for exposures that last as long as 8 to 16 hours. All other things being equal, the greater the intensity level above 60-80 dB(A) and the longer the time in noise, the greater the temporary threshold shift. However, exposure durations beyond 8 to 16 hours may not produce further increase in the magnitude of the shift (reference 17 and 18). It is also an interesting property of temporary threshold shifts that such shifts are usually greatest for test tones and a half to one octave above the frequency region in which the noise that produces the shift has its greatest concentration of energy. Finally, there is less temporary shift when an exposure has frequent interruptions than when an exposure is continuous.

People differ in their susceptibility to temporary threshold shifts. Unfortunately, these differences in susceptibility are not uniform across the audible range of frequencies. Indeed, one person may be especially susceptible to noises of low pitch, another to noises of medium pitch, and another to noises of high pitch. In general, women appear to be less susceptible to temporary threshold shifts from low-frequency noises than are men, and this relation is reversed for high-frequency noises.

The more intense the noise, the more rapidly threshold shifts accumulate as the time in noise is extended. When the noise is only 65 dB(A), a typical person has to be exposed for several hours before any significant threshold shift can be detected. However, when the noise is very intense, say 130 dB(A), a typical person exposed for only five minutes reaches dangerous levels of threshold shift. The combinations of intensity level and duration that produce threshold shifts greater than about 40 dB are said to be in the region of possible acoustic trauma. In this region, for some people, the normal processes of the ear may "break down" and permanent threshold shifts - hearing loss - may result from even a single exposure to noise.

Recovery from threshold shifts after the cessation of an exposure to noise depends on a variety of factors and is not completely understood. Sometimes recovery from a threshold shift is complete in 50 or 100 minutes. Such rapid recovery from a threshold shift has been observed when the threshold shift is small, less than 40 dB, and the duration of the exposure is short, less than 8 hours (reference 31).

The slow recovery from noise-induced threshold shifts probably holds whenever the exposure is severe either in terms of the total duration or in terms of the amount of threshold shift present a few minutes after the termination of the noise. Recovery from temporary threshold shift appears to be very slow when the initial threshold shift exceeds 35-45 dB, when the exposure lasts as long as about 12 hours, or after some long but intermittent exposure to noise. For example, it has been shown that exposure to a noise of about 80 dB(A) for two days results

in small temporary threshold shifts that do not completely disappear for several days.

Very severe exposures to noise can produce compound threshold shifts from which complete recovery is impossible. After recovery from the temporary component of a compound threshold shift, there remains a permanent threshold shift. The ear's recovery from compound threshold shifts is often quite slow and this recovery probably represents a "healing" process. There can be no additional recovery (healing) beyond two to twelve weeks after an exposure.

This well noted variability of recovery from temporary threshold shift may well be due to the effects of the equal energy principle.

Noise-induced permanent threshold shift. Noise-induced permanent threshold shifts accumulate as exposures are repeated on a near-daily basis over a period of many years. As the exposures are repeated year after year, the ear becomes less and less able to recover from the temporary threshold shift present at the end of each day and the temporary threshold shift becomes permanent or nearly so. (References 20 and 28). Within a group of similarly exposed people some will exhibit very large temporary threshold shifts, while others will exhibit only small shifts. Some of the differences are due to differences in susceptibility to noise induced hearing loss and some are due to actual differences in the noise levels encountered. In an industrial situation all workers do not necessarily receive the same exposure.

Threshold shifts from impulsive noise. Intense impulsive noise can be particularly hazardous to hearing. The reason is that in addition to the processes involved in noise-induced threshold shifts there is the added risk of a "breakdown" in the inner ear. Permanent threshold shift due to acoustic trauma may result. Since on acoustical impulse may contain only a small amount of total energy because of its limited duration, the predicated threshold shift might be small. At the same time, a single impulse because of its high amplitude might rip or tear a crucial tissue barrier and a considerable degeneration of the organ of Corti may result. Therefore, it is unlikely that description of impulsive noise in terms of equivalent spectrum and energy of "steady sounds" will be successful in predicting the enormous variability in response to impulses with high peak levels. With these impulses, occasional cases of sudden severe hearing loss are observed and these can be explained in terms of direct mechanical injury. It may be possible that expressing impulses in terms of equivalent spectrum and energy with steady sounds may be successful in predicting median trends. (Reference 15).

1.1.3 Interpretation of noise-induced hearing loss.

There has been, and continues to be, considerable debate about the implications and significance of small amounts of ear damage and hearing loss. The Standards Association of Australia Draft Australian Standard Code of Practice for Hearing Conservation (DR 72084) sets out that hearing impairment is related to ability to perceive speech under every day conditions, including moderate amounts of background noise and distortion of the speech signal, and is considered to begin when the hearing threshold equals or exceeds any of the following values.

Audiometric Test Frequency (Hz)	500	1000	2000	3000	4000
Hearing Threshold (dB) above the Standard Auditory Response	25	20	25	30	40

Individuals having threshold hearing levels equivalent to those above are not considered to have normal hearing. Individuals considered to have normal hearing will having hearing threshold levels corresponding with the standard auditory response.

By these definitions, any injury to the ear or any change in a hearing threshold level that places it outside of the normal range constitutes a hearing impairment. Whether a particular impairment constitutes a hearing handicap or a hearing disability can only be judged in relation to an individual's life pattern or occupation.

Some individuals with hearing impairment above 2000 Hz may experience considerable difficulty in understanding speech in moderate levels of background noise even though their average hearing threshold levels at 500, 1000, and 200 Hz do not exceed 25 decibels (reference 19). Also, persons with hearing loss primarily above 2000 Hz may not be able to distinguish the sounds of certain consonants. Individuals will react differently to a hearing loss. One may be particularly upset by his inability to understand his children; another may feel handicapped by his inability to participate in rapid verbal patter; and others may miss the sounds of music or those of nature.

1.1.4 Hearing aids and noise-induced hearing loss.

People with partial deafness from exposure to noise do not live in an auditory world that is simply "muffled". Even those sounds that are heard may be distorted in loudness, pitch, apparent location, or clarity. While a hearing aid sometimes can be useful to a person with noise-induced hearing loss, the result is not always satisfactory. The modern hearing aid can amplify sound and make it audible, but it cannot correct for the distortions that often accompany injury to the organ of Corti.

1.1.5 Presbyacusis and environmental noise.

With age, people almost uniformly experience increasing difficulty in understanding speech. Undoubtedly, some of this loss is due to the degeneration of neurons in the brain which generally accompanies advancing age. Some of this loss is due to changes in the middle or inner ear. Some of the changes in the inner ear are due to normal ageing processes; some are undoubtedly due to toxic drugs; some are due to disease processes; and some are due to incidental, recreational, and occupations exposures to noise. Clear evidence is available that noises above 80 dB(A) can contribute to inner ear damage and eventual hearing handicap if such noises are frequently and regularly encountered. Beyond this, the evidence does not warrant stronger statements about the role of noise in progressive hearing loss with age. Theoretical grounds do suggest that frequent exposures of sufficient duration to noises greater than 70-80 dB(A) could contribute to the "normal loss of hearing with age".

At least some aspects of hearing loss with age seem to add to hearing loss from noise exposure (reference 12). This means that a small loss of hearing from exposure to noise may be insignificant when one is middle-aged, but might, when combined with other losses due to age, become significant as one reaches an advanced age.

1.1.6 Prevention of Ear Damage and Hearing Loss from Noise.

Hearing loss and ear damage due to noise can be eliminated if exposures to noise are:

(1) held to sufficiently low levels;

(2) held to sufficiently short durations; or

(3) allowed to occur only rarely.

The regulation of the acoustic environment in such a way that hearing loss and ear damage from noise are eliminated poses several problems. For example, the chances that a person will develop a hearing impairment due to noise depends on the pattern of exposure from all sources of noise that he happens to encounter. Some of these exposures from particular sources may be innocuous in isolation. But these same noises, which are innocuous by themselves, may combine with noises from other sources to form a total sequence of noises sufficient to produce hearing impairment. While it may be possible to control the total exposure in an occupational setting during a day's work, it is nearly impossible to control an individual's activities and exposure to noise while he is away from work. Thus, one must turn to the regulation of sources of noise.

In general, any source of 70-80 dB(A) has the potential to contribute to a pattern of exposure that might produce temporary threshold shifts and this could lead to permanent hearing impairment. Therefore, it seems desirable to have as few sources as possible that expose people to sound levels in excess of 70-80 dB(A). But people can tolerate many brief exposures in excess of 70-80 dB(A) if they are widely spaced in time. For example, a shower bath may have a sound level of about 74 dB(A), but one would have to shower for over an hour before a temporary threshold shift would appear. Clearly, regulation must not eliminate all sources of noise with sound levels in excess of 70-80 dB(A). On the other hand, if such sources are allowed to proliferate without bound, then vast numbers of persons will suffer chronic threshold shifts.

Sources with sound levels in excess of 80 dB(A) have the potential to contribute to the incidence of hearing handicap. The argument about regulation of such sources runs exactly parallel to that of the previous paragraph.

Finally, from studies of hearing loss from occupational exposures to noise, one can identify exposures that, in and of themselves, increase the incidence of hearing loss. (Reference 15 and 22). Sources that provide exposures as severe as these should be avoided, eliminated, or controlled.

Another approach to the protection of hearing from noise is the use of ear plugs and earmuffs when hazardous noises are encountered. Effective devices are available for this purpose, but they must be carefully selected and properly used. In spite of the effectiveness of earplugs and earmuffs, people will often refuse or neglect to use them for reasons of appearance, discomfort, and bother.

2.2 MASKING AND INTERFERENCE WITH SPEECH COMMUNICATION.

Man has a formidable ability to hear one particular sound from a background of other sounds. For example, often one can hear the doorbell over a background of music and conversation. But there are very definite limits to this ability to "hear out" a signal. Unwanted sounds (noises) can interfere with the perception of wanted sound signals. This is called masking. By masking, an auditory signal can be made inaudible or the signal can be changed in quality, apparent location, or distinctiveness.

While it is important for everyday life to be able to understand generally the perceptibility of auditory signals, most people would agree that the understanding specifically of the problem of speech perception has great significance for the quality of human life. If speech is totally drowned out by a masker, the speech is said to be inaudible or below the threshold of detectability. If the presence of the speech can be detected, but it is indistinct or difficult to understand, the speech is said to be above the threshold of detectablility and to have poor intelligibility or discriminability. Intelligibility or discriminability refers to the clarity or distinctness with which speech can be heard over a background noise and it is usually measured in the percentage of messages that a listener can understand.

2.2.1 Speech and Understanding Speech.

A talker generates a complicated series of sound waves. This series is called the speech stream. It is not possible to assign a particular acoustic pattern to each of the "sounds" of the English language in a one-to-one fashion. Rather, the "speech stream" carries the cues for the sounds of English and the listener decodes the "speech stream" by a complicated, synthetic process that not only relies on the acoustic cues carried by the "speech stream", but also relies on the listener's knowledge of the language and the facts of the situation. Not all of the cues carried by the "speech stream" are known. Also, the synthetic processes by which the "speech stream" is decoded and "heard as speech" are not fully understood. Nonetheless, much is known about which regions of the audible range of frequencies carry the cues for the intelligibility of speech.

Cues in the speech stream can be found at frequencies as low as about 100 Hz to as high as about 8000 Hz. Most of the acoustical energy of the speech stream is concentrated between 100 and 6000 Hz. But, the most important cue-bearing energy falls between aboug 500 and 2000 Hz. The speech stream carries much extra information which is redundant. Therefore, speech can be heard with high intelligibility even when some of the cues have been removed.

There are many variables that influence the accuracy of speech communication from talker to listener. The characteristics of the talker; the transmission path from talker to listener; the background noise; the spatial locations of the talker, noise source, and listener; and the integrity of the listener's auditory system all can be important. Also important are the quality of the naturalness of speech, recognition of the talker, or recognition of the personality or psychological state of the talker.

It can clearly be seen that the more intense the speech in relation to the noise the greater the percentage of messages correctly understood. Also, the fewer the number of alterative messages the greater the percentage of correctly understood messages. It is important to realise that the absolute percentage of correct messages transmitted for each speech-to-noise ratio will depend on the talker, the exact nature of the noise, its spectrum and intensity.

2.2.2 The Major Effects of Noise on Speech Communication.

The usual talker unconsciously raises his voice level when he is surrounded by noise. If the background noise is about 74 dB(A) for a listener and the talker is 20 feet away, it is clear that communication would be difficult even if the talker were to shout.

But, if the talker were to move within one foot of the listener, communication would be practical even when a normal voice is used. It can be seen that at 15-20 feet, distances not uncommon to many living rooms or classrooms, the background noise levels must be below 50 dB(A) if speech communication is to be nearly normal.

People vary their voice levels and distances not only in accordance with the level of background noise and physical convenience, but also in accordance with cultural standards. Distances less than about 4-1/2 feet are reserved for confidential or personal exchanges usually with a lowered voice. Distances greater than about 5 feet are usually associated with a slightly raised voice and reserved for messages that others are welcome to hear. Thus, levels of background noise that require the talker and listener to move within less than 4 feet will be upsetting to persons who do not normally have an intimate association. Even for close friends there may be some embarrassment if the message would not normally require such nearness. When the content of the message is personal, there will be reluctance to raise the voice level even if the background noise demands it for intelligibility.

In one-to-one personal conversations, the distance from talker to listener is usually of the order of 5 feet and nearly normal speech communication can proceed in noise levels as high as 66 dB(A). Many conversations involve groups and for this situation distances of 5-12 feet are common and the intensity level of the background noise should be less than 50-60 dB(A). At public meetings or outdoors in yards, parks, or playgrounds distances between talker and listener are often of the order of 12-30 feet and the background noise must be kept below 45-55 dB(A) if nearly normal speech communication is to be possible.

Effects of Characteristics of People on Speech Interference. Lower noise levels are required if the talker and the listener speak different dialects. Children have less precise speech than do adults and also their knowledge of language often makes them less able to "hear" speech when some of the cues in the speech are lost. Thus, adequate speech communication with children under about 13 years of age probably requires lower noise levels than are required for adults. One's ability to understand partially masked or distorted speech seems to begin to deteriorate at about age 30 and declines steadily thereafter. Generally, the older the listener, the lower the background noise must be for nearly normal communication. It is well known that persons with hearing losses require more favorable speech-to-noise ratios than do those with normal hearing. This group again requires lower noise levels for adequate speech communication than do young adults with normal hearing.

Effects of Situational Factors on Speech Interference. Adequate communication in higher noise levels can occur if the possible messages are predictable. This factor accounts for the success of communication in many industrial situations with high levels of noise. Success may give way to failure, however, when an important but unpredictable message must be communicated. For example, firemen in a high-level noise may have little difficulty with standard communications about the use of equipment, but may encounter grave difficulty communicating about unexpected events that occur at the scene of the fire. The opportunity to lipread or use facial or bodily gestures in support of hearing will improve the success of communication in background noise. Almost everyone has some small amount of lipreading skill which they often use without awareness of its contribution to intelligibility.

Spatial variables also may facilitate speech communication in noise. If the source of noise is clearly localized in a position different from that of the talker, speech communication may be possible under noise conditions less favourable than normal. On the other hand, spatial factors can sometimes reduce the intelligibility of speech. If a space produces many reflections of sound it is said to be reverberant. Noise interferes with speech communication more in a very reverberant space than in one that is not.

Sometimes unusual acoustic conditions can make our voices clearly audible at great distances. If one raises his voice to talk to a near-by person over the sound of a power lawn mower or outboard motor, he can sometimes be heard more clearly by a distant accidental spectator than by the nearby friend.

2.2.3 Implications of Masking and Interference with Speech Communication.

Masking of auditory signals. Many auditory signals serve important functions in our lives and these functions may be lost in noise. While the masking of a doorbell because of noise may only be a source of inconvenience and annoyance, the masking of signals can interfere with the performance of tasks. In some cases, the masking of a signal such as that of an approaching vehicle can lead to property damage, personal injury, or even death.

Interference with speech communication. The implications of reduced opportunity for nearly normal speech communication are considerable. Those who must work in high levels of background noise claim that they "get used to it." There is evidence, however, that they adopt a "non-communicating life style" and increase their use of non-verbal communication through gestures, posture, and facial expression. Even though non-verbal communication is important, it is unlikely that it is nearly as important as verbal communication. Many suctleties of life are lost when verbal communication is restricted.

Among adults, free and easy speech communication is probably essential for full development of social relations and self. For very young children, there may be an additional problem. They gradually induce their knowledge of language and its subtleties from the speech to which they are exposed. Also, as previously stated, because their knowledge of language is still developing, children probably have more difficulty understanding speech in noise than do adults. Because noise can reduce the amount of speech used at home, in the yard, or on the playground and because noise can make speech difficult to understand, it is possible, though unproven, that the language development of early childhood might be adversely affected. From this, difficulty in learning language and learning to read may ensue. One can only guess at how severe the noise must be to produce such effects; nearly continuous sound levels in excess of 70 dB(A) might be required. Such conditions do exist at some residences in urban areas near freeways. When contemplating possible increases in general levels of community noise, one should give consideration to these possible effects on the linquistic development of children. Later, school-age children probably encounter more difficulty in noisy classrooms, than, for example, do sailors in noisy enginerooms who exchange a limited number of prescribed technical messages. With regard to the impact of noise on formal education, the Jamaica Bay Environmental Study Group of American National Academy of Sciences summarised their findings as follows:

> "Within the present impacted area (near airports) there are 220 schools attended by 280,000 pupils. With normal school-room

usage, this implies about an hour's interruption of classroom teaching each day and the development by the teachers of the "jet pause" teaching technique to accommodate the impossibility of communicating with the pupils as an aircraft passes overhead. The noise interference goes beyond the periods of enforced non-communication, for it destroys the spontaneity of the educational process and subjects it to the rhythm of the aeronautical control system."

Any casual observer of intimate family life is aware of the irritation and confusion that can arise when simple, everyday messages need frequent repetition in order to be understood. Noise does not cause all of these occurrences, but it causes some. The enjoyment of retirement and later life can be hampered by masking noises. It is well known that speech reception abilities deteriorate with age and clinical observations clearly indicate that older persons are more susceptible to the masking of speech by noise than are young adults. It is likely that one must somehow "work harder" to maintain speech reception in noise than in quiet. Thus, successful speech communication in noise probably has its cost. If the cost is too high, the number of verbal exchanges probably declines.

In a highly intellectual, technical society speech communication plays an extremely important role. Background noise can influence the accuracy, frequency, and quality of verbal exchange. In excessive background noise, formal education in schools, occupational efficiency, family life styles and the quality of relaxation can all be adversely affected.

3.0 GENERAL PSYCHOLOGICAL AND SOCIOLOGICAL EFFECTS OF NOISE.

3.1 INTERFERENCE WITH SLEEP.

Sleep begins with a stage of drowsiness when one is still awake. This is followed by a progression, with occasional reversals, to the deeper stages of sleep. After about 90 minutes of sleep there is a stage of Rapid Eye Movement which corresponds with a return to the earlier light stage of sleep. Dreaming and mental activity can take place in all the stages of sleep but most dreams occur during the Rapid Eye Movement stage. A 90 minute cycle from one Rapid Eye Movement stage to another tends to occur throughout the period of sleep.

Sensory Responses to Stimulation During Sleep. The sense organs are just as sensitive to their appropriate physical stimuli during sleep as they are during wakefulness and information from the sense organs does reach the highest centres of the brain even during deepest sleep.

The apparent indifference to stimulation during sleep is not a simple "shutting out" of the neural messages at or near the periphery of the nervous system close to the sense organ. Rather, this apparent indifference to external stimulation is due to a complicated re-organisation of brain processes during sleeping as opposed to waking states.

Arousal. Sensory messages reach the highest centres of the brain, but whether or not they influence the sleeper will depend on a complicated set of circumstances. Many theorists believe that mechanisms in the brain busily carry out "sleep work" throughout the sleeping period.

These mechanisms assess the significance of incoming sensory messages and adjust the state of the brain in accordance with the sensory messages and the whole situational complex. This view is supported by everyday experience as well as by scientific investigation.

Effects of Brief Noises. Laboratory experiments have shown that subjects can awake to sounds that are about 30-40 dB above the level at which they can be detected when subjects are conscious, alert and attentive. While in deep sleep the stimulus may have to be 50-80 dB above the level at which they can be detected by conscious, alert, attentive subjects before they will awaken the sleeping subject.

Motivation to Awake and Intensity Level of the Noise. There is clear evidence that motivation to awake can influence the probability of awakening to noise. The effects of motivation, however, depend on the stage of sleep and the intensity level of the noise. For weak stimuli, motivation may have a strong influence on arousal only during light sleep. For moderately strong stimuli, motivation to awake may have a powerful effect on the probability of an upward shift in sleep stage (probably awakening also) from all depths of sleep. With very intense stimuli it is likely that motivation would have little influence; for example, brief noises with sound levels of 100-120 dB(A) awaken nearly everyone from any stage of sleep.

Fluctuating Noise Levels. The results of a very careful study carried out in France strongly suggest that fluctuations in the noise levels and the degree of fluctuation are important factors in determining sleep disturbance by sound.

Steady and Rhythmic Sounds. One investigation of complaints about noise produce by air-conditioning and heating equipment may be relevant to the effects of steady noise on sleep. It was found that people especially objected to noises that included "tones" and "throbbing" or "beats". Blazier summarised the frequency of complaints in relation to A-weighted sound levels of noises in sleeping quarters as follows: below about 33 dB(A), no complaints; 33-38 dB(A), occasional complaints; 38-48 dB(A), frequent complaints; and over about 48 dB(A), unlimited complaints. While it is not known whether these complaints are due to sleep disturbance or other factors, these results do appear to be in remarkable agreement with the trends for sleep disturbance by brief noises.

Sound Quality and Sleep Disturbance. There are no data available as yet on this question but it seems reasonable to assume that such variables which influence perceived noisiness would influence sleep disturbance.

Sleep Deprivation and Sleep Disturbance. Subjects who have been deprived of sleep require more intense noises for awakening than do normally rested subjects.

Age and Sleep Disturbance. There is clear evidence that persons over about 60 years of age are much more easily awakened or shifted towards lighter sleep than are middle-aged adults or children. This effect is large and dramatic. More specifically, simulated sonic booms that awaken middle-aged adults and 7 and 8 year-old children on less than 5% of their occurrences will awaken 69 to 72 year old adults on nearly 70% of their occurrences. These dramatic differences hold over all stages of sleep. Also, once awakened, an older person has more difficulty in returning to sleep than does a middle-aged adult or a child.

There is no evidence that children are especially sensitive to sleep disturbance by noise. On the contrary it has been found that 7 and 8 year old children are slightly less sensitive to noise during sleep than are middle-aged adults. However, since general sleep disturbance in children (enuresis, somnabulism, night terrors and nightmares) seems to peak between 4 and 6 years of age it seems that sleep disturbance by noise may have a special impact on children in this age range. It is well known, for instance, that thunderstorms can waken and frighten children of these ages. Children in the age group of 4-6 years seem to be particularly disturbed by sudden arousal from deep sleep.

Sleep stage and accumulated sleep. Sleep is more easily disturbed in the lighter than the deeper stages, but a person can be aroused from sleep more easily the longer he has slept no matter what the stage of sleep.

Stimulus meaning and familiarity. There is considerable evidence that sleepers can discriminate between stimuli if the differences are learned and discrimination is established while they were awake. "Familiar" sounds change sleep stages less frequently than "unfamiliar" sounds.

Adaption to sleep disturbance by noise. There is as yet no convincing evidence concerning adaptation to noise. The adaptation that seems apparent from everyday experience may be the result of (1) changes in the motivation to awake and (2) amnesia for awakening.

There is clear evidence for adaptation to the total sleeping environment. Sleep researchers talk of the "first night" effect. Normal sleep is rarely if ever observed during the first night in the laboratory. It is likely then that some of the disturbance reported by the rural person trying to sleep in an urban area and the urban person trying to sleep in a rural area is but the "first night" effect. It is commonplace that when we cannot sleep, for whatever reasons, we "hear" many sounds.

It seems probable that persons with disorders which result in light, restless sleep or frequent awakenings will be more frequently aroused by sounds than will normal person or persons with disorders that produce unusually deep and prolonged sleep. Also, it has been demonstrated that sleep deprivation has more adverse effects on "poor" than on "good" sleepers.

Noise, Sleep Disturbance, Health and Quality of Life. Brief sounds of sufficient intensity and fluctuating noise levels definitely can alter the normal sleep pattern. These changes in sleep pattern are in the direction of lighter sleep.

Whether such sleep disturbance constitutes a health hazard is debatable. While good sleep is necessary for physical and mental health, normal persons who lose sleep compensate by spending more time in deep sleep, by becoming less responsibe to external stimuli, and by napping. Present knowledge tends to show that sleep disturbance by excessive noise will reduce one's feeling of well-being and when the noise levels are high enough to disturb sleep on a regular recurring basis, then the disturbance may constitute a hazard to mental and possibly to physical health.

3.2 LOUDNESS, PERCEIVED NOISINESS AND UNACCEPTABILITY.

People are commonly annoyed, irritated, distracted or disturbed by sounds and often these reactions can be traced to particular situational factors. If the noise of a motor cycle awakens one, the annoyance felt is often due to the disturbance of sleep rather than the noise itself. The noise of a sonic boom may produce fear or another noise may interrupt a conversation. A great many instances of annoyance by sound may be due to masking effects, to a particular reaction to the sound or to physiological responses to the sound. In spite of the wide variations in intensity of reactions to various disturbing sounds there are relations between the physical characteristics of noises and the reaction to that noise.

Loudness is an attribute of auditory experience and depends upon the frequency, complexity and intensity of the sound.

Perceived Noisiness, according to Kryter, is the subjective impression of the unwantedness of a not unexpected, non-pain or fear-provoking sound as part of one's environment and is probably the same as unacceptability. Kryter sets out five measurable physical aspects of a sound that are most likely to control its perceived noisiness as (1) spectrum content and level; (2) spectrum complexity (concentration of energy in pure-tone or narrow frequency band within a broad band spectrum); (3) duration of the total sound; duration of the increase in level prior to the maximum-level of non-impulsive sounds; and (5) the increase in level, within an interval of 0.5 sec., of impulsive sounds.

There is still great debate among students of loudness and noisiness concerning (1) whether these two attributes are the same or different; (2) the relative noisiness; and (3) the relative merits of various schemes for predicting loudness and noisiness from physical measurements of sound.

3.2.1 Verbal Descriptions of Sound and Auditory Experience.

The present situation in this regard is summed up best in "Effects of Noise on People" (reference 29) and I quote:

> "Auditory experience has a richness and variety that far exceeds those aspects represented by loudness or noisiness. Even sustained pure tones have the attributes of loudness, pitch and volume. Tones appear to be of low or high loudness, low or high pitch, and of small or large volume (Stevens and Davis, 1938). Volume refers to the fact that some tones seem to be large and diffuse, while other tones seem to be thin and compact. Complex tones, being mixtures of pure tones, vary in quality or timbre and seem to have at least three qualities in addition to loudness, pitch and volume. These are brightness, roughness, and fullness (Lichte, 1940). Everyday sounds and music grow in dimensionality and variety as they are extended in time. The full richness of sound only emerges when sounds form a sequence spread over time. While an extremely rich visual scene can be "taken in" at a glance, the auditory scene must be "taken in" over a period of time. Psychologists have only begun to study the richness and variety of auditory experience. A few studies (Solomon, 1958, 1959a, 1959b) have been done. Even though only limited sets of sounds have been used,

the results suggest that people can meaningfully evaluate sounds on a magnitude dimension (heavy-light); on a esthetic-evaluative dimension (good-bad, beautiful-ugly); a clarity dimension (clear-hazy); a security dimension (gentle-violent, safe-dangerous); a relaxation dimension (relaxed-tense); a familiarity dimension (familiar-strange); and a mood dimension (colourful-colourless). These dimensions relate to the overall spectral patterns of the sounds, their temporal pattern of spectral changes, and their rhythmic structure. These examples of possible dimensions are not meant to be taken as the dimensions of auditory experience. Rather, these results are mentioned only to suggest the diversity of auditory experience and its description.

An approach to the verbal description of objects, events and perception has been developed by Charles E. Osgood of the University of Illinois (Osgood, 1952). Subjects are allowed to rate objects, events, or stimuli along many dimensions as defined by pairs of adjectives in opposition. After statistical treatment, it is found that many of these dimensions are highly correlated. In general, an intensity dimension (weak-strong), activity dimension (active-inactive), and an evaluative dimension (good-bad) emerge whether people are judging pictures, sounds, political ideals, or whatever. In addition, several special dimensions are usually isolated that are specific to the situation and the set of stimuli being judged.

Loudness and perceived noisiness are similar, but probably distinct, attributes of auditory experience. These dimensions in turn are correlated with many adverse effects of excess and unwanted sound. Indeed, loudness and noisiness are probably the most important dimensions of auditory experience in this regard. Other variables will undoubtedly be uncovered that are also of importance - the apparent extent in space may be an example.

But if we are to reach a stage where we wish to speak of an optimal acoustical environment, as opposed to a damaging or intolerable environment, we shall have to learn much more about the dimensions of auditory experience. Perhaps the techniques of Osgood and Solomon will lead to a better understanding of auditory experience and allow improved acoustical design. For example, it may be possible to design a vacuum cleaner that sounds 'busy' and 'active' without excessive loudness."

3.3. ANNOYANCE AND COMMUNITY RESPONSE.

Annoyance by noise is a response to auditory experience and has its base in the unpleasant nature of some sounds, in the activities that are disturbed or disrupted by noise, in the physiological reactions to noise, and in the responses to the meaning or "messages" carried by the noise.

The degree of annoyance and whether that annoyance leads to complaints, product rejection, or action against an existing or anticipated noise source are dependent upon many factors. Responses to aircraft noise have received the greatest attention. There is less information available concerning responses to other noises, such as those of surface transportation and industry and those from recreational activities.

Annoyance from sound depends, in part, on the properties of the acoustical environment which include the intensity level and frequency content of the noise, the concentrations of energy in narrow regions of frequency (pitch), the duration of a noise, the period of initial rising intensity level, and the presence of impulses (such as those associated with gunfire, automobile backfires, hammering, and so on).

Other variables become obvious where attention is usually focused on one kind of noise such as aircraft noise, and other noises are considered as part of the background noise. It is interesting that when the "background noise" is great, then the annoyance attributed to a particular "intruding noise" may be less than when the same intruding noise appears against a lesser background noise. Field studies of annoyance and community responses to particular types of noises must include, therefore, direct or indirect measures of the number of repetitions of the "intruding noise", the level of the "background noise" from all other sources, and in one way or another the variability in the noise exposure from the combination of "intruding noises" and "background noises". The acoustical properties of an individual's immediate environment are also important. In the exposed person's immediate environment, it is the intensity level of the background noise and the reverberant characteristics of the space that are important. However, measurements from monitoring points have been successful in predicting <u>average</u> levels of annoyance and disturbance among persons located near the point where the measurements are made.

Other variables that must be considered are, for example, the type of neighbourhood, the time of day or night and even the season of the year. In summer people remain out of doors longer and are more likely to have the windows open than in winter. When measuring noises that are said to cause annoyance, various factors must be considered such as identification of a single intruding noise, intensity levels and duration of such a noise, the number of times it occurs, the intensity level of the background noise, variability of the intensity levels of the noises and the perceived noisiness of the intruding noise.

Annoyance, as I have said, is a response to noise and obviously measurement of it is most difficult. Annoyance may be calculated by considering the number of activities disturbed and the degree to which they are disturbed by the noise. Further, the assessment of annoyance varies with the attitude of the complainant. There are his general attitude towards noise; his attitude towards the source of the noise, e.g. is the noise producing activity important for his social or economic well-being or not; what he believes to be the attitude of the person responsible for the noise, e.g. is that person concerned for the exposed population's welfare or not; and particular factors related to the noise, e.g. fear of aircraft crashes or will the sonic boom damage his property. There is little evidence to suggest that annoyance due to community noise decreases with continued exposure. Further, it is very difficult to forecast the number or forcefulness of any complaints that may arise in a particular noisy situation. Whether complaints or some concerted action will develop depends upon such social and political attitudes as the presence of anti-noise leadership, attitudes towards the source of the noise and so on.

3.4 PSYCHOLOGICAL AND SOCIOLOGICAL EFFECTS OF NOISE.

<u>Noise and Performance</u>. The action of noise on the performance of tasks has been studied extensively in the laboratory and in the actual work

situation. When a task requires the use of auditory signals, speech or non-speech, then noise at any intensity level sufficient to mask or interfere with the perception of these signals will interfere with the performance of the task. When tasks do not require auditory signals, the effects of noise on their performance have been difficult to assess. Nevertheless, some general conclusions have been reached.

(1) Steady noises without special meaning do not seem to interfere with human performance unless noise level exceeds about 90dB(A).
(2) Irregular bursts of noise are more disruptive than steady noises. Even when the sound levels of irregular bursts are below 90 dB(A), they may sometimes interfere with performance of a task.
(3) High-frequency components of noise, above about 1000-2000Hz, may produce more interference with performance than low-frequency components of noise.
(4) Noise does not seem to influence the overall rate of work, but high levels of noise may increase the variability of the rate of work. There may be "noise pauses" followed by compensating increases in work rate.
(5) Noise is more likely to reduce the accuracy of work than to reduce the total quantity of work.
(6) Complex tasks are more likely to be adversely influenced by noise than are simple tasks.

The ideal acoustical environment is one that does not disturb human performance either because of the properties of the noise itself or because of irrelevant messages carried by the noise.

3.4.2 Acoustical Privacy.

Without opportunity for privacy, either everyone must conform strictly to an elaborate social code, or everyone must adopt highly permissive attitudes. Opportunity for privacy avoids the necessity for either extreme. In particular, without opportunity for acoustical privacy one may experience all of the effects of noise previously described and, in addition, one is constrained because his own activities may disturb others. There is a need for standardised acoustical ratings to be developed for dwellings of all types and these ratings should include measures of acoustical privacy as well as other measures of acoustical quality.

Time Judgements. Steady noise with a sound level up to about 90 dB(A) seems to expand the subjective time scales; that is, less time has been judged to pass than actually has (reference 13). Steady noise more intense than about 90 dB(A) seems to contract subjective time; that is, more time is judged to pass than actually has.

Effects on Other Senses. A variety of effects of auditory stimulation on other senses (intersensory effects) have been reported. At very high noise levels dramatic intersensory effects, such as disturbance of equilibrium at levels of 130 to 150 dB, may occur. Such effects would not occur in response to present levels of community noise.

Mental Disorders. There is no definite evidence that noise can induce either neurotic or psychotic illness.

Anxiety and Distress. Nausea, headaches, instability, argumentativeness, sexual impotency, changes in general mood, general anxiety, and other effects have all been associated with exposure to noise. These effects are difficult to assess because intense noises are often associated with situations that in and of themselves, even without noise, might

involve fear and stress. Whether the noise, purely as noise, contributes significantly to the stress of life it is difficult to assess at this time. But the factors discussed above support the contention that noises can act as a source of psychological distress.

3.4.1 Transient and Possible Persistent Physiological Responses to Noise.

It has been proposed that frequent repetition of the responses mentioned above might lead to persistent pathological changes in non-auditory bodily functions. Also, it has been proposed that frequent repetition of these transient physiological responses might aggravate known disease conditions. These proposals have not been verified, but evidence consistent with them has been gathered. While these claims of noise-induced pathology of non-auditory bodily function merit further research and investigation, they are unproven.

While physiological arousal in response to sound can be of great benefit in the maintenance of response to possibly dangerous events, unnecessary arousal of irrelevant sounds can provide a basis for annoyance and for interference with performance of tasks. Chronic arousal from noises of sufficiently high levels or from noises that are sufficiently varied, may although it is unproven, contribute to the incidence of non-auditory disease. However, the evidence does suggest that, if noise control sufficient to protect persons from ear damage and hearing loss were instituted, then it is unlikely that the noise of lower level and duration resulting from this effort could directly induce non-auditory disease. Nevertheless, it is conceivable, though unlikely, that certain patterns of exposures to irregular, brief sounds could produce non-auditory pathology of greater significance than the noise-induced pathology of the inner ear.

4.0 HEARING CONSERVATION PROGRAMMES

The various procedures which may be followed by Industrial Management when faced with a problem of excessive noise exposure of employees are collectively embraced in a Hearing Conservation Programme. Ideally the aim is to ensure that no individual's hearing is affected during his work life to an extent greater than that which normally occurs with age, and to provide a working environment in which the productivity of workers is unaffected by adverse psychological effects of noise. The major objectives of a Hearing Conservation Programme may be stated as:-

1. To conserve hearing;
2. To prevent hearing loss amongst industrial workers and the impairment of their performance and morale.
3. To prevent economic loss to employers and employee as a result of hearing loss, and the possible loss of a skilled worker; and
4. To gather scientific information to facilitate the accomplishment of these objectives.

There are some indications which serve to alert management to the need to consider whether the noise exposure within its premises is of such a level that a risk of hearing damage is present. These indications are:-

1. Difficulty in communicating by speech whilst in a noisy area, or

2. Head noises or ringing in the ears after working in the noise for several hours; or

3. A temporary loss of hearing that has the effect of muffling speech and certain other sounds after several hours of exposure to the noise.

Some other conditions, although less obvious and dramatic, may also indicate effects of excessive noise exposure. If workers in a noisy area suffer a high accident rate for which there is no other obvious explanation, if there is reduced efficiency, increased errors or breakages, or even an above average level of absenteeism, then the possibility of contribution by the noisy environment to these uneconomic occurrences should be investigated.

The first step is to confirm that there is a hazard, by evaluating the magnitude and characteristics of the noise exposure by accurate measurement. This is usually termed a "noise survey", and should be carried out by qualified acoustic consultants. By such an assessment an accurate evaluation of the hazard can be made, leading to determination of the most practical and efficient remedy. The assessment will show whether treatment lies in engineering modifications - to machines, buildings, enclosures, etc. - or in the provision of some form of ear protection for exposed workers.

The noise survey should form the basis for consultation between management and engineers with expert knowledge of acoustical treatment, when the engineering and economic feasibility of noise attenuation methods may be determined. The importance of engineering noise control cannot be over-emphasised; it is obviously better to control excessive noise at its source or to attenuate the transmission of the noise from source to operator than to rely entirely on the personal protection of workers.

4.1 PERSONAL EAR PROTECTION.

When all that can be done by engineering control has been decided and carried out, there may remain some employees exposed to excessive noise. It is then necessary to provide personal ear protection. The noise survey should indicate clearly the noise levels to which various employees are exposed, both in terms of time and intensity. It will define those employees requiring protection. Reference to the noise protection properties of the different types of ear protector available will aid in deciding which employees require ear muffs or ear plugs to receive adequate protection. Management should be guided here by its medical and engineering advisers. Such factors as costs, labour turnover, micro-climate and individual employee requirements should be considered in conjunction with the attenuation properties of protectors. It is important when introducing hearing protection to ensure that both management, employees and their representatives have a full and thorough understanding of the aims of and the need for the programme. If hasty decisions are made or if the programme is presented to employees without adequately preparing them for participation, co-operation is difficult to achieve. Experience has shown that insufficient efforts to educate employees will lead to misunderstanding of the employer's motives and objectives, to discontent and to rejection of the protection. When introducing the programme, it is helpful to arrange meetings to be attended by small groups of employees to be addressed by a medical practitioner on the effects of noise and the need for the use of ear

protectors. The types of protectors chosen can be demonstrated, and the procedures to be followed for fitting and care, hearing testing and continued supervision of the programme can be explained. Following the talk, free discussion is encouraged, with a question and answer session, so that any doubts, misconceptions or objections may be expressed openly, and answered satisfactorily. The services of a medical practitioner, or a consultant otologist, may be obtained for this purpose.

4.2 AUDIOMETRY.

The measurement of the hearing levels of each employee likely to be exposed to excessive noise is an essential part of a hearing conservation programme. These tests should be carried out by or under the close supervision of a doctor who will be able to interpret the results in conjunction with a medical history of each individual and a knowledge of that individual's work environment.

Audiometric tests are made at the commencement of the programme, repeated in three months from the commencement, and thence every six months for a period of two to three years depending on the noise environment, and then annually. In this way the success of the programme can be measured, by demonstrating that no further loss of hearing is occurring in any exposed workman. These periodic tests also detect the occasional employee who is more susceptible to noise than the average person, or the employee who is receiving inadequate protection due to poor fitting plugs or muffs, or failing to use the protection supplied.

Tests should be made also on each new employee as part of a preplacement examination at the time of engagement. Pre-existing ear disease or deafness may make it desirable to place a new employee in a less noisy environment for his own sake and for the sake of safety to others. Preplacement examination and testing also provides opportunity to educate the new employee in the hazards associated with excessive noise exposure and to provide him with ear protectors if necessary.

4.3 RESPONSIBILITY.

For the successful conservation of hearing and avoidance of other undesirable effects, the programme must be continuous. It is important that the responsibility for each aspect of the programme is clearly defined and placed in the hands of executives with sufficient authority to ensure that the programme is faithfully carried out at all times. This applies equally to both engineering noise control and to hearing protection.

All plans for industrial development should be passed to the executive in charge of engineering noise control so that he may study the possible effects on the total noise environment. Noise specifications should be laid down when ordering new machinery and designing new buildings. If possible the medical practitioner should have the responsibility for the hearing protection programme, and employees should be allowed direct access to him to discuss complaints or problems associated with the use of ear protectors. Hearing conservation programmes will not be successful unless soundly based on adequate planning and delegation of responsibility. All levels of management and all participating employees should be convinced of the need for the prevention of hearing damage.

To complete the picture I add composite audiograms compiled from the testing of 104 miners whom I have examined for workman's compensation.

They have been divided into eight groups according to the number of years of exposure to the noises of employment underground and consist of those men whose audiograms I believe to be accurate and whose hearing loss is due to exposure to excessive noise at work.

The composite audiograms have been obtained firstly by averaging the audiograms of the two ears of each man and secondly by grouping together the number of patients in each exposure group and averaging these. The numbers in each group bear no true relation to the number of men employed in the industry as each of these patients has presented as a claimant for compensation, However, I consider that the figures are large enough to give a good indication of the hearing damage which is occurring in this particular industry and most probably would be paralleled by figures from many other industries were they available. There were no patients in the 0-4 year exposure group. The one case in the 5-9 year exposure group is retained purely as an example of a relatively early damage audiogram. The composite audiograms of the next three groups show that the greatest amount of damage to hearing occurs during the first ten years of exposure and that the rate of damage falls off very considerable afterwards (Chart 1).

The composite audiograms of the next four exposure groups show little change the one from the other. However, they do show a continuing damage particularly in the higher tones (Chart 2).

The whole picture of the damage caused by exposure to high intensity noise is illustrated simply by the third chart in which the results of 10-24 years of exposure and of 25-44 years of exposure are grouped and contrasted with the one case of less than 10 years exposure (Chart 3).

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CHART 1

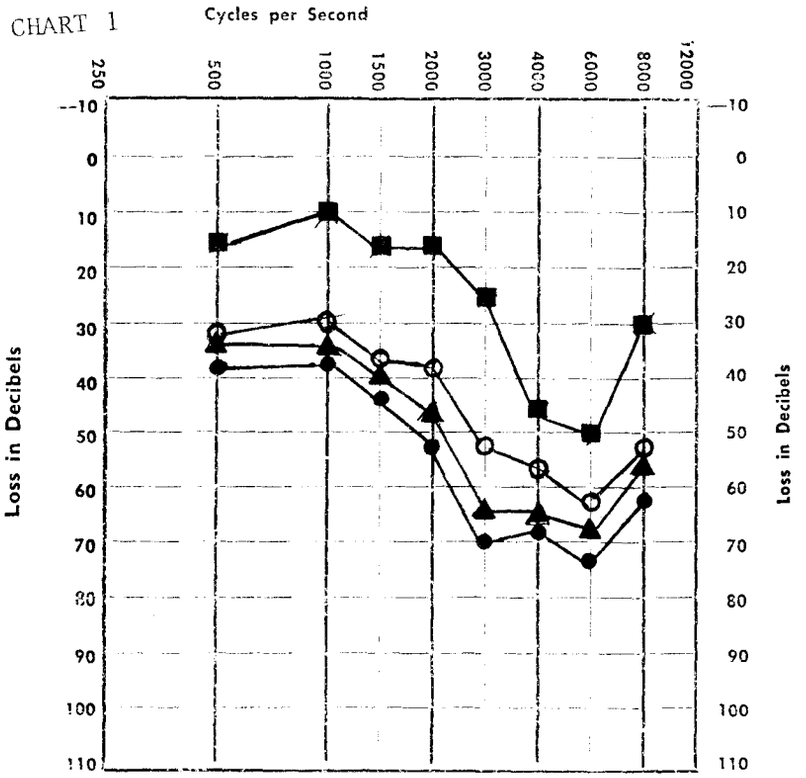

CHART 1

Year of Exposure	Number of Cases	Symbol
5-9	1	■
10-14	8	○
15-19	19	▲
20-24	26	●

CHART 2

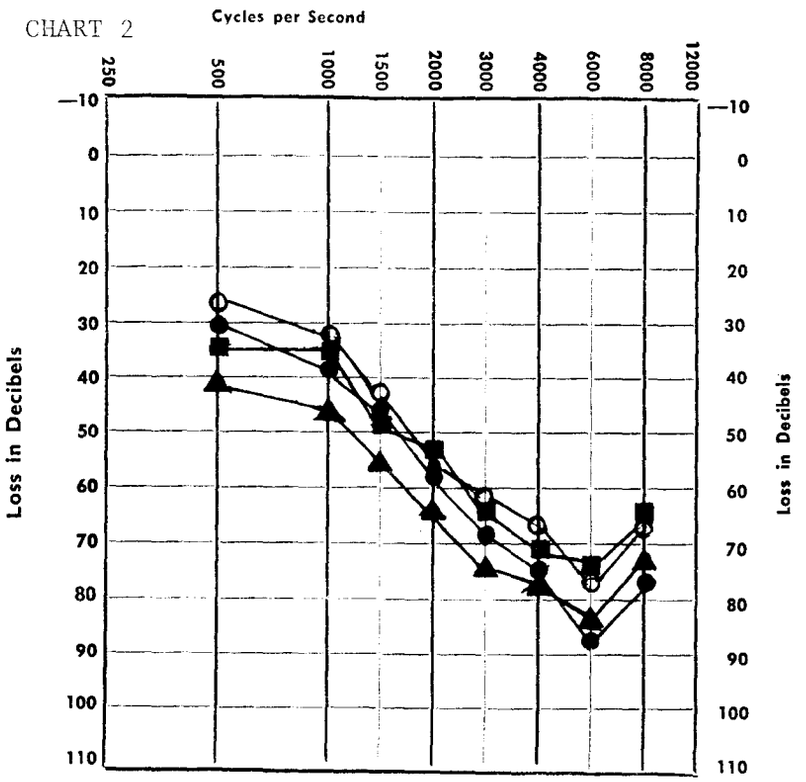

CHART 2

Year of Exposure	Number of Cases	Symbol
25-29	10	■
30-34	25	○
35-39	7	▲
40-44	8	●

CHART 3

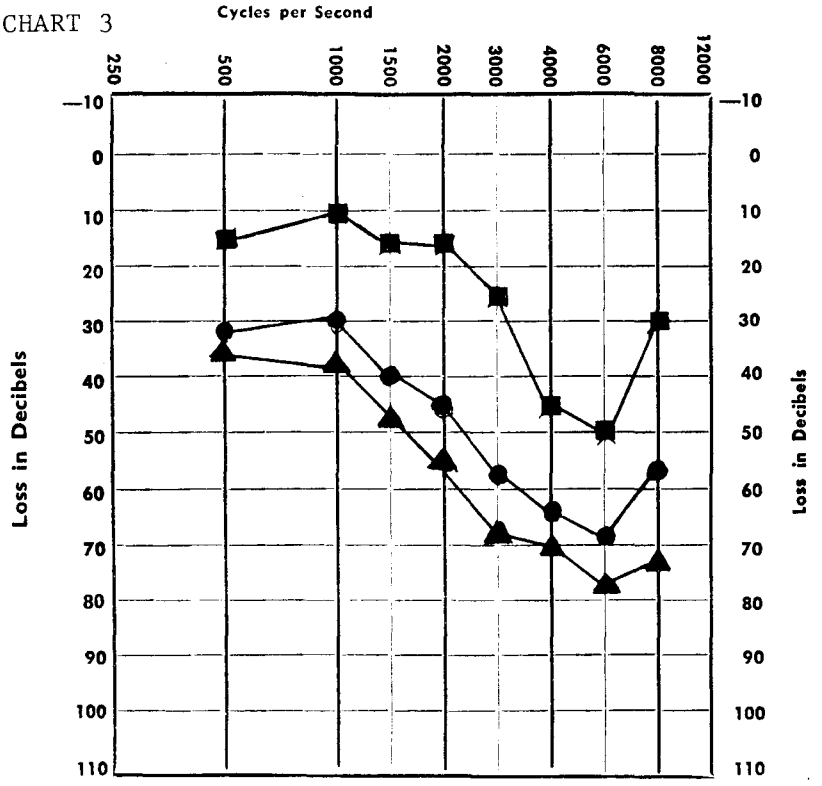

CHART 3

Year of Exposure	Number of Cases	Symbol
5-9	1	■
10-24	53	●
25-44	50	▲

NOYS AND NOISE ANNOYANCE (AND OTHER NOISE UNITS).

by

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1.0 INTRODUCTION.

Noise measurements must bear some relationship to the way in which humans respond to that noise. Because of the basic complexity of human response to sound, a great diversity of noise units have been developed during the last few years. The intention of this paper is to describe some of the more important of these units and to explain why and how they were formulated and hence to indicate the circumstances under which a particular unit should be used.

The characteristics of a sound which affect the response of humans to that sound are:

(1) How "loud" the sound is. The ear has to respond to a great range of sound intensities and unfortunately it also responds differently at various levels of intensity.

(2) The frequency content of the sound. The sensitivity of the ear varies with frequency and also with the frequency content of the sound to which it is subjected.

(3) The masking effect. The presence of a sound at a particular frequency inhibits the detection of another sound at a slightly higher frequency.

(4) The duration or time varying characteristics of the sound.

In the following sections, the way in which these factors are accounted for in the various noise units will be discussed.

2.0 NOISE UNITS.

The problem of accommodating the very large range of sound pressures experienced by the ear is overcome by defining a logarithmic unit, the decibel (dB). This is now a familiar unit and its definition will not be given here. The justification for such a unit is that, from the threshold of hearing to the threshold of pain (where the sound is so loud it produces sensations of pain and fright), the acoustic pressure fluctuations vary by a relative magnitude of about 3×10^{6}. The decibel reduces this large range to a variation from 0db to 130dB, which is much more manageable.

2.1 VARIATION WITH FREQUENCY

Having determined the unit to be used to describe the magnitude of the sound, the frequency characteristics of human acoustic response must be investigated. These characteristics can only be determined by experiments directly involving people to determine subjective response. This produces a complication because it transpires that the frequency response depends not only on the type of sound to which you subject the person during the experiment, but also on how you ask him or her to assess that sound. A further complication is that the results must be the average of the response of a large number of people.

2.1.1. Equal Loudness Curves for Discrete Frequencies.

Early work to determine frequency response was reported by Fletcher

and Munson (Reference 1) who played discrete frequencies (i.e. pure tones) to a group of subjects. They were asked to assess the relative loudness of a pure tone at a particular frequency compared to a reference tone at 1000 Hz. This produced the frequency response curves shown in Figure 1. The lines on this figure indicate the pure tone sound pressure levels which have equal loudness, in units of phons. The phon value of a curve is the sound pressure level of an equally loud 1000 Hz tone. Phons are therefore units of loudness.

It will be noticed that at low sound pressure levels (near the threshold of hearing) the phon curves are nowhere near flat, but become more nearly so at higher levels. Because of this marked variation in frequency response with sound pressure level, it was decided to incorporate three frequency correction or weighting networks into sound level meters in the hope that this would enable a correct subjective assessment of various sounds to be made. These were called the A, B and C weighting networks and sound levels obtained using them have units of dB(A), dB(B) and dB(C). The A and B networks correspond with the 40 phon and 70 phon curves and were intended for use in measuring sounds in the low and medium sound pressure level ranges respectively, while the C network is nearly flat and was intended for high intensity sounds. (See Figure 2).

2.1.2 Equal Loudness Curves for Octave Bands of Noise.

Over a period of years, it became obvious that the use of the three weighting networks as outlined above did not produce results which agreed with the subjective assessment of the loudness of sounds. The work of Fletcher and Munson was therefore repeated with the difference that the subjects were asked to compare the loudness of an octave band of noise to the loudness of a 1000 Hz reference tone. The equal loudness curves (again in units of phons) obtained by Robinson and Whittle (Reference 2) for these conditions are shown in Figure 3. Compared with Fletcher and Munson's results, these curves do not change nearly so much in shape as the sound pressure level increases. Their shape corresponds reasonably well to that of the A weighting network. This explains why the dB(A) is used so extensively if a single, readily obtainable number is required to indicate the loudness of a broad-band sound, no matter whether it is of low or high sound level.

2.1.3 The Phon and the Sone.

The A weighted sound level indicates the "loudness" of sound, but it does not tell us how much louder one sound is compared to another on a subjective basis. The decibel unit will, under certain circumstances, indicate the relative energy in a sound field (it doubles for each 3 dB increase in level). However, if an "average" person was asked to adjust one sound until it is "twice as loud" as another sound, then the first would end up 10 dB higher than the second. A unit called the sone was therefore developed so that the relative subjective loudness of two sounds can be assessed. It is mathematically related to the phon and this relationship is shown graphically in Figure 4. The reference level of one sone equal to 40 phons was chosen purely for convenience by the originators of the concept. Using it, the relative subjective loudness of two sounds is given by the ratio of their sone values.

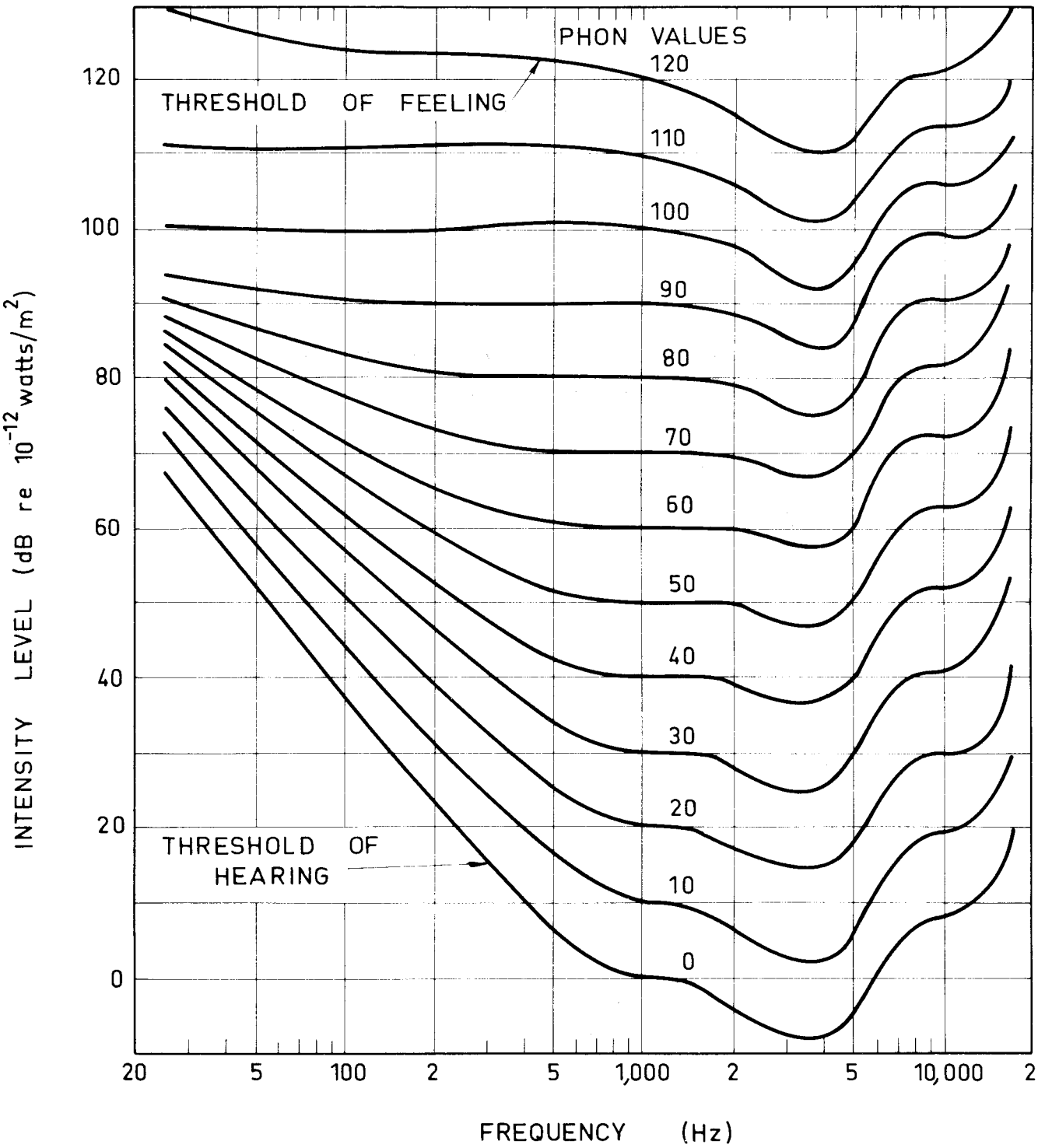

FIG. 1. CURVES OF EQUAL LOUDNESS FOR PURE TONES

(AFTER FLETCHER & MUNSON)

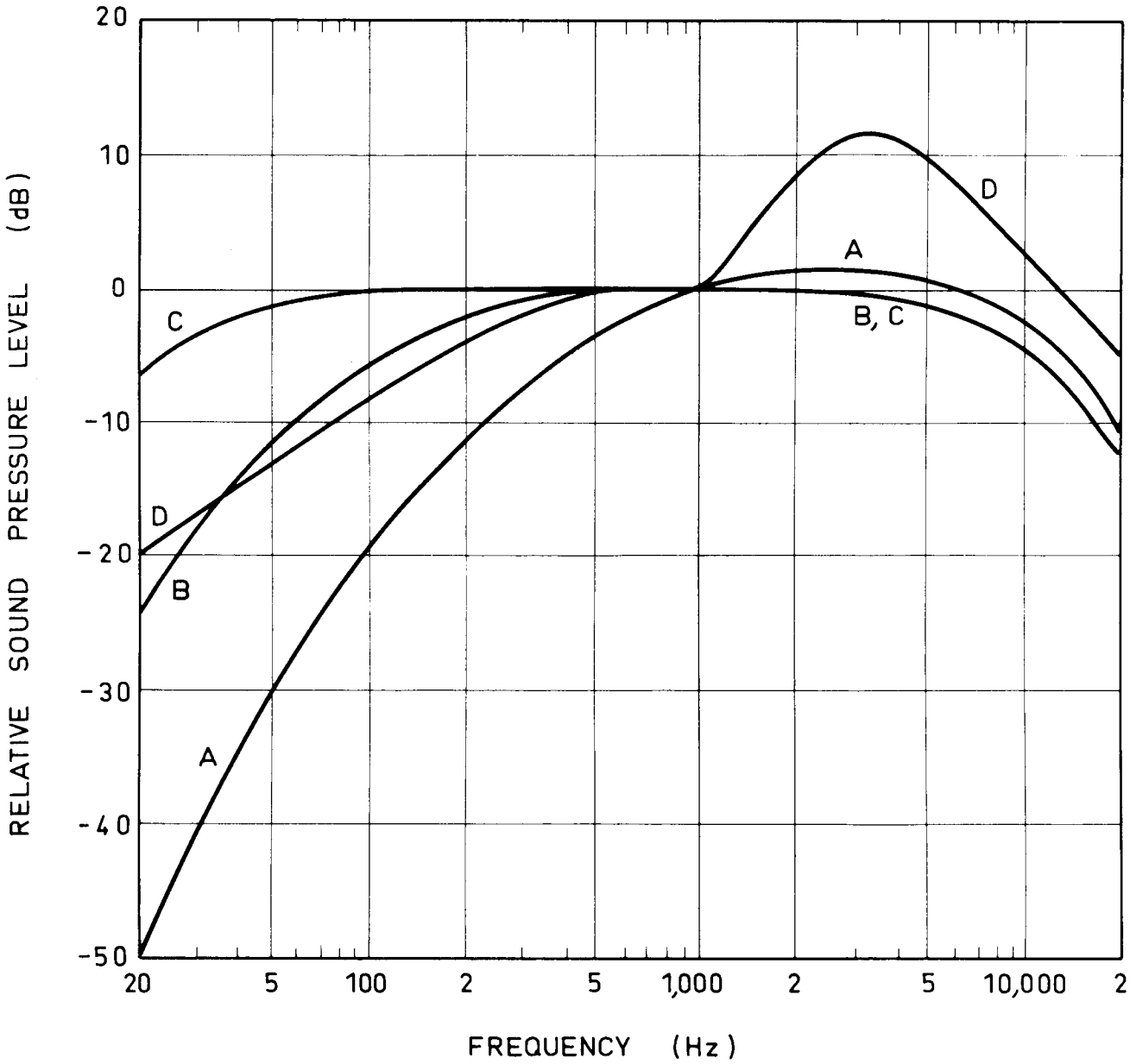

FIG. 2. THE A, B, C AND D WEIGHTING NETWORK CURVES

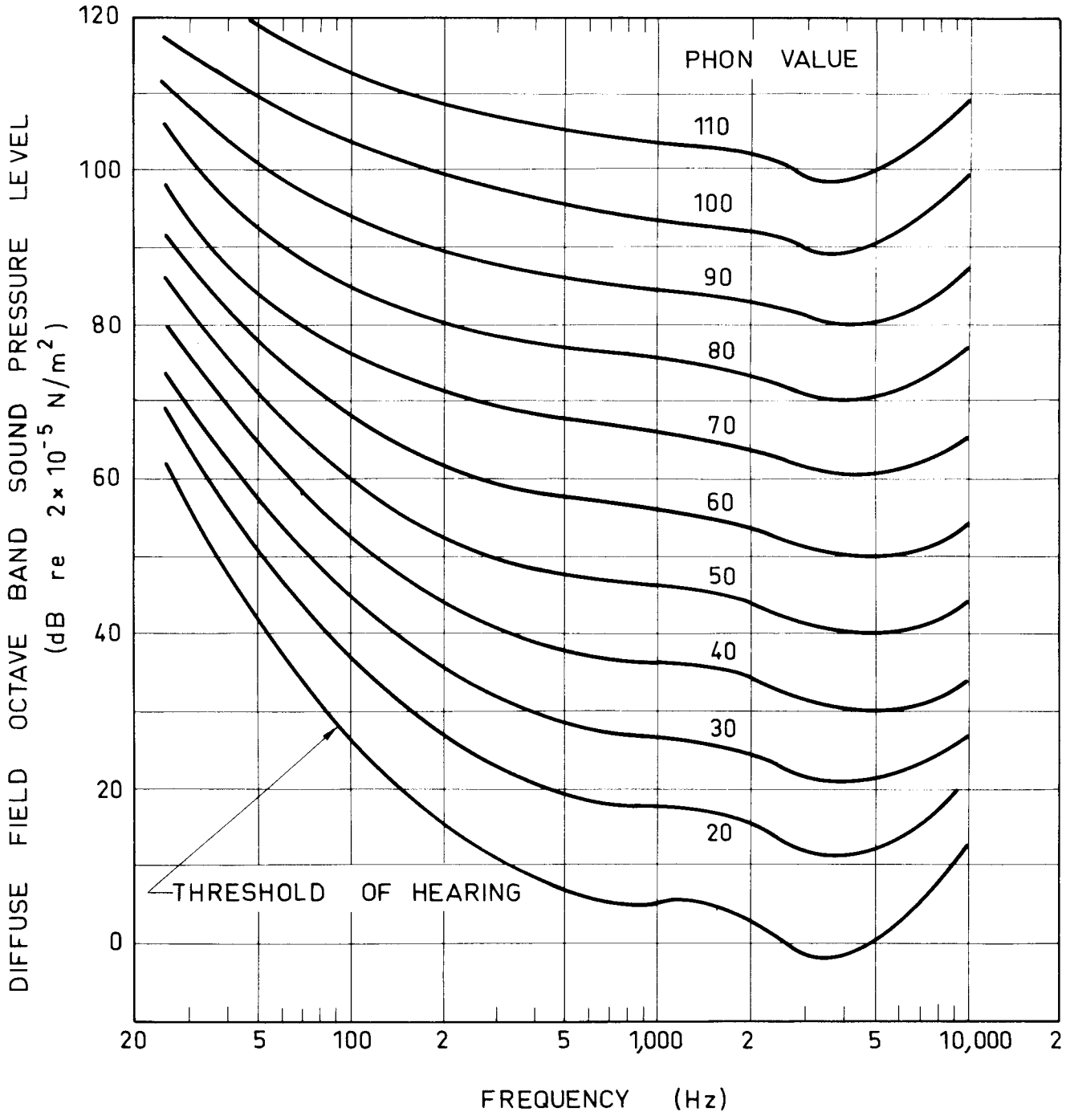

FIG. 3. CURVES OF EQUAL LOUDNESS FOR OCTAVE BANDS OF NOISE *(AFTER ROBINSON & WHITTLE)*

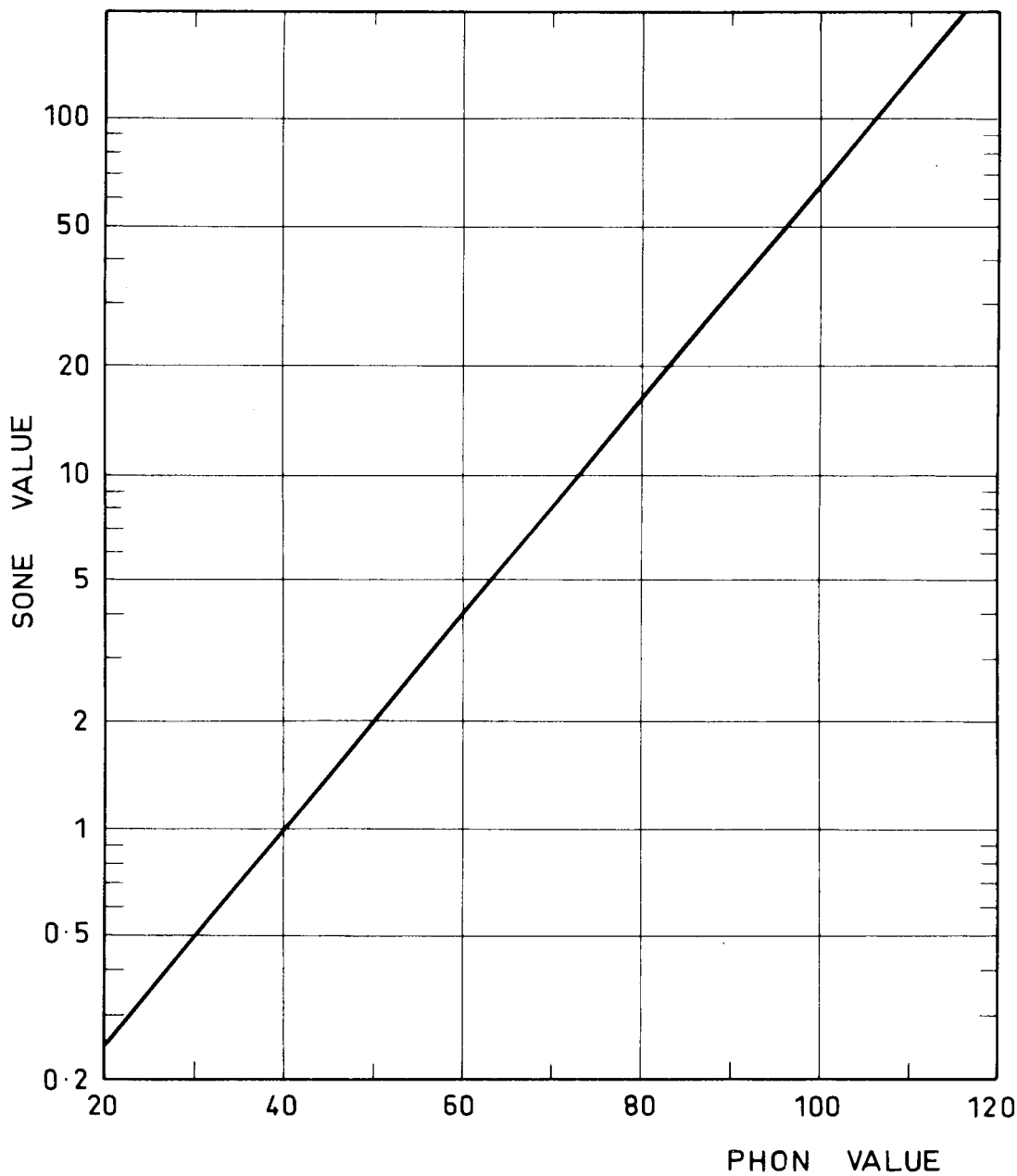

FIG. 4. PHON - SONE CONVERSION CHART

2.1.4 Equal Annoyance Curves.

The preceding sections have discussed loudness. However, with the advent of jet engined airplanes, it was felt that loudness was not necessarily the correct basis on which to judge sounds, but that it was the annoyance caused by a sound that was important. In the U.S.A., Kryter and Pearsons (References 3 and 4) conducted experiments to produce curves of equal annoyance for octave band and one third octave bands of noise. These are shown in Figure 5. The unit of annoyance is the noy (hence the title of this paper) and the curves in Figure 5 are so labelled. The noy is a subjective unit, bearing the same relationship to annoyance as sones bear to loudness. Thus, if one sound has twice the noy value of another, then the first is subjectively twice as annoying as the second. The noy curves do not change shape greatly as the sound level increases, but they differ from the shape of the 40 phon curve (or A weighting network). In particular they have a much larger "dip" in the frequency range above 1000 Hz. The shape of the noy curve is reproduced in the D weighting network (see Figure 2) now available on some sound level meters. Its chief use is in measuring aircraft noise annoyance. A method of using the noy curves to determine the annoyance of a broadband noise will be given in the next section.

2.2 CALCULATION OF LOUDNESS AND ANNOYANCE.

The frequency response characteristics described above must be incorporated into methods of calculating loudness or annoyance levels of broad-band sounds. In this section, three different methods will be described.

The first is a method of assessing loudness due to Zwicker (Reference 5). He performed some detailed experiments and showed that there are certain frequency bands, called critical bands, within which the human ear is insensitive to the detailed distribution of sound within the band, but rather responds just to the sound pressure level in the band as a whole. He defined twenty four such bands of varying widths spread over the important part of the audio frequency range. Zwicker also investigated the masking effect (mentioned in the introduction), and combined this information with his critical band concept and the human frequency response characteristics to produce a method of determining loudness. It is a semi-graphical method and allows for the differnces between diffuse sound fields and free field conditions. The graphs used in the analysis and details of the procedure are given in Reference 6. The result is phon and sone values for the sound being investigated. This method is probably the most precise one that is available for calculating how loud a sound is.

Another method of calculating loudness is due to Stevens (Reference 7). He has produced a simpler method than that due to Zwicker, but it is applicable primarily to diffuse sound fields with fairly smooth sound level spectra without prominent pure tone components. The method is based on a set of equal loudness contours of a similar form to those produced by Robinson and Whittle (Figure 3) except that they take the form of a series of straight lines rather than smooth curves. Each contour has a "Loudness Index" (a subjective unit) associated with it.

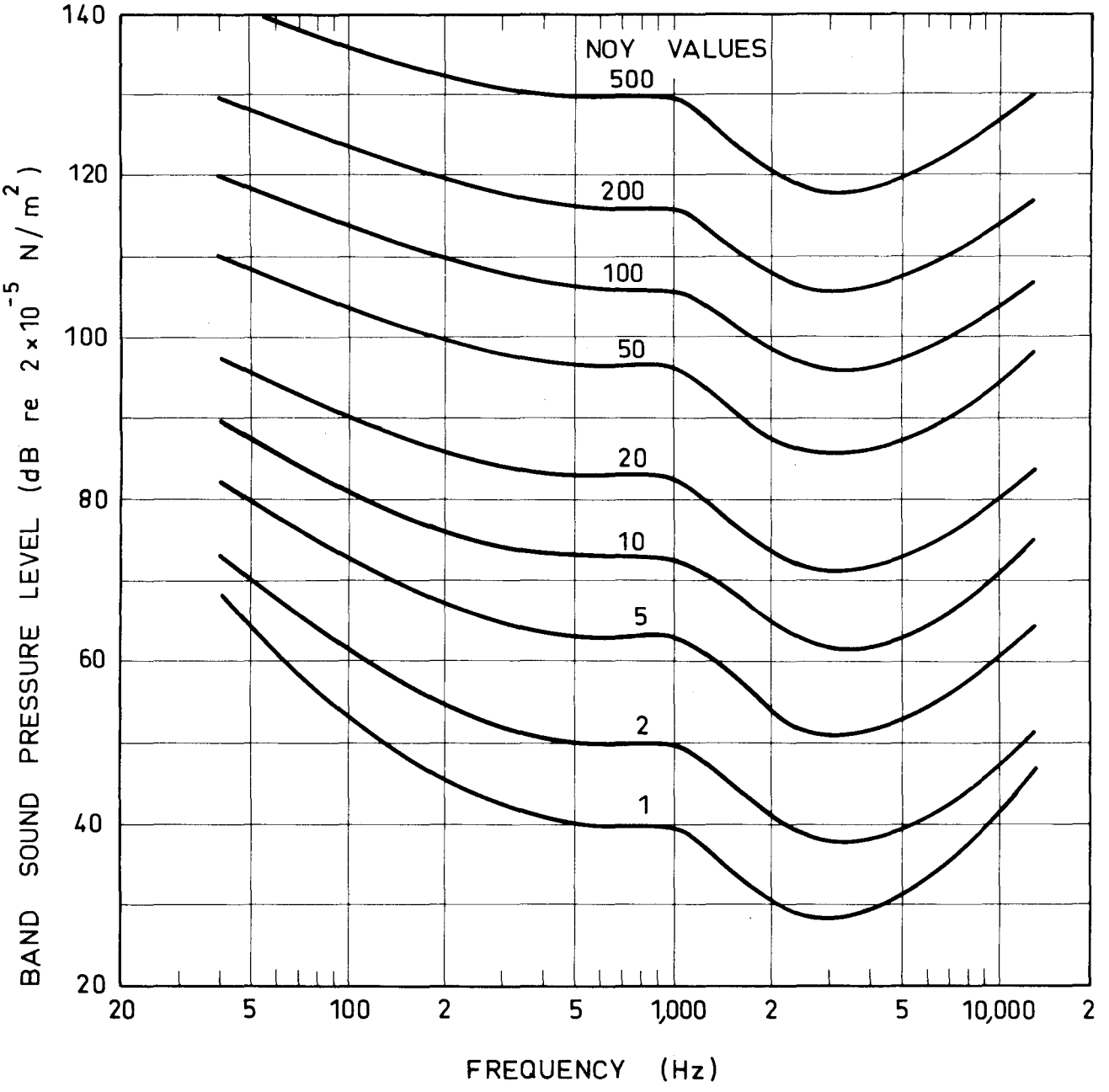

FIG. 5. CURVES OF EQUAL ANNOYANCE FOR BANDS OF NOISE *(AFTER KRYTER & PEARSONS)*

The sound under investigation is analysed in octave, one third octave or half octave bandwidths. The loudness indices for each band are then determined from the equal loudness contours and combined in a special manner to obtain a combined sone value. This can then be converted to a phon value as described previously.

The third method is based on Kryter's equal annoyance curves and uses a calculation procedure almost idential to that of Stevens. In this method the octave, one third octave or one tenth octave bandwidth spectrum levels are measured and converted to noy values (N) using the equal annoyance curves (Figure 5) or their equivalent tabulated values (Reference 4). A combined noy value ($\underline{N}$) is then obtained from

$$\underline{N} = N_{max} + k\,(\Sigma N - N_{max})$$

where N_{max} is the maximum band noy value and k is 0.3, 0.15 or 0.07 depending on whether octave, one third octave or one tenth octave band analysis was used. The combined noy value, $\underline{N}$, is then converted to an annoyance unit called the "Perceived Noise Level" having units of perceived noise decibels (PNdB). The conversion is exactly the same as that between sones and phons (with noys replacing sones and PNdB replacing phons) or the noy values at 1000 Hz in Figure 5 can be used.

These three methods of determining loudness or annoyance of a sound are all very firmly based on experiments performed with human subjects and represent some sort of average response of the population. Unfortunately, they all produce different results when they are applied to the same sound, although under many instances the differences are small or consistently different. It should also be pointed out that five ways of calculating loudness sones and phons have been mentioned. Some of the methods are only applicable under specific conditions, but it does emphasise the fact that the method used to obtain a particular result must be clearly stated if there is any possibility of confusion.

The methods described in this section produce a single numerical quantity to describe a steady noise (or the noise occurring at an instant of time). In the next section, methods of assessing the "noisiness" of time varying or repeated sounds will be given. However, before turning to this, three other methods of assessing steady noises will be mentioned, although they do not strictly fall within the scope indicated by the heading of this section.

The principle use of the first two of these is to indicate the effect of a background noise on speech communication. One of these is the "Speech Interference Level" (SIL) suggested by Beranek (Reference 8) who found that the arithmetic average of the sound pressure levels in the (now defunct) octave bands centres on 850 Hz, 1700 Hz and 3400 Hz, could be related to the distance over which a conversation could be heard. Nowadays the SIL is taken as the average of the sound levels in the 500 Hz, 1000 Hz and 2000 Hz octave bands. At a later date the "Articulation Index" was introduced by Kryter (Reference 9). It performs a similar task to SIL but uses the octave bands from 500 Hz to 4000 Hz inclusive. It requires not only an analysis of the background noise which is inhibiting the speech communication but also of the speech itself. The difference between the speech and noise octave band levels is then used to calculate the articulation index which can in turn be interpreted to give the percentage intelligibility of the speech.

Finally, the Noise Rating curves must be mentioned (see Kosten and van Os, Reference 10). The noise rating (NR), and the similar noise criterion (NC) curves, are methods of specifying an upper limit to the octave band spectrum of a noise. They allow for the poorer sensitivity of humans to low frequency sounds by permitting progressively higher octave band levels in the lower octave bands. Alternatively, the NR (or NC) value associated with a sound spectrum can be found by plotting that spectrum on special graph paper on which the NR (or NC) curves are plotted. The NR (or NC) value of the noise is then given by the lowest curve which just touches the top of the octave band spectrum. The method does not perhaps have quite such a firm theoretical basis as some of the units described above (if a choice is available it is probably better to use dB(A)) but it is in fairly wide use in the air-conditioning industry, for example, and is sometimes used for specifying acceptable background noise levels in buildings or in the community at large.

2.3 THE MEASUREMENT OF TIME VARYING NOISES.

The preceding discussion has shown that it is not a simple job just to measure a steady noise and that many potential methods are available from which to choose. When it comes to considering more complex noises which vary with time; which consist of a repetition of a particular noise or which have a long duration, then there are again several methods to choose from. Again such noise units have generally been developed only after extensive experiments to assess people's reaction to the noise. This is, in fact, an area in which much research is at present being concentrated, and the situation is by no means resolved. The research has tended to concentrate on a particular type of noise, such as aircraft or road transportation noise, and noise units developed specifically for such noise types. These units generally incorporate one or several of the following:

- A time integration of the sound. This can either be a continuous integration or an integration over a typical noise event plus an allowance for the number of such events.
- An allowance for the variability of the sound. A noise tends to be much more intrusive and hence more disturbing if it fluctuates rather than remains steady.
- A measure of the peak noise level.

In this section the noise units developed for various specific noises will be briefly described before concluding with a mention of one recent attempt to combine some of them in a single unit.

2.3.1 The Measurement of Aircraft Noise:

The measurement of aircraft noise around airports has received a great deal of attention and the noise unit developed from the work has varied with the country in which the work was done. In Great Britain, the initial studies were made in conjunction with the so-called "Wilson Committee" which studied the problem of noise in the early 1960's. Their final report (Reference 11) introduced the Noise and Number Index (NNI), defined as -

$$NNI = (\text{average peak perceived noise level}) + 15 \log N - 80$$

This unit was produced as the result of a social survey in which people were asked to indicate the annoyance caused by aircraft noise. The analysis of the data showed that if the number of aircraft increased by a factor of four, then the average peak perceived noise level had to decrease by 9PNdB to maintain the same annoyance rating (hence the factor 15 logN in the above expression). The constant 80 was introduced because there was found to be no annoyance at about 80 PNdB. Hence if the NNI exceeds zero, some annoyance will probably exist.

The unit developed in the U.S.A. is the Noise Exposure Forecast (NEF, often abbreviated now to Noise Exposure (NE), see Reference 11). Like the NNI, the NEF is based on the perceived noise level although at that point the similarity ends. The NEF is a time integration of the tone corrected perceived noise level, which is a perceived noise level to which corrections are added to allow for any discrete frequency components (such as the whine produced by the compressor of a jet engine) that may be present. This is done because pure tones are subjectively more annoying than a broad-band noise of the same level. A reference duration of 10 seconds is used in the integration (because this is typical of the duration of the noise produced by an aircraft fly past). The resultant noise value when applied to a single fly past is called the Effective Perceived Noise Level (EPNdB). It is pertinent to remark at this point that there is no real reason why the use of tone corrected PNdB or EPNdB units should be limited to aircraft noise. They could be applied to any annoying noise.

In calculating NEF values from the individual aircraft EPNdB levels, several factors are taken into account. First it is recognised that noise is much more disturbing at night than during the daytime. A day is therefore divided into a daytime period from 7 a.m. to 10 p.m. during which a total of twenty aircraft movements are taken as reference in calculating NEF. The nightime period is the remaining nine hours of the day, during which it is assumed that, if there are the same number of average hourly aircraft movements (each producing the same EPNdB level) as during the day, then the NEF value should be ten units greater. Finally, a correction factor of 75 units is applied so that zero NEF corresponds approximately to no annoyance. The NEF is therefore obtained from a relationship of the form -

$$NEF = (\text{average EPNdB per aircraft}) + 10 \log (Nd + 16.67Nn) - 88$$

where Nd and Nn are the number of daytime and nightime aircraft movements respectively and the effect of the reference number of twenty aircraft during the daytime has been added to the correction factor of 75 to produce the constant 88.

One unfortunate aspect of the NEF value is the amount of work involved in computing the effective perceived noise level. If done manually, it is a very time consuming operation, and, if automated, then a digital computer and other electronic equipment is required. In an attempt to overcome these disadvantages and to make it easier and cheaper to produce continuous aircraft noise monitoring equipment, the State of California has written noise legislation (Reference 13) based on a unit similar to the NEF, but using the dB(A) instead of PNdB as its basis. No correction is made for discrete frequencies. They produce a time integrated noise unit for a single aircraft fly past called The Single Event Noise Exposure Level (SENEL) to corres-

pond to the EPNdB. It also differs from the latter in having a one second reference duration rather than 10 seconds (in the hope that such a unit may be more readily applicable to noises other than aircraft noises). The equivalent of the NEF produced from SENEL is the Community Noise Equivalent Level (CNEL). It differs from the NEF in that it divides the day into three periods, daytime (7 a.m. to 7 p.m.), evening (7 p.m. to 10 p.m.) and night-time (10 p.m. to 7a .m.), with an intermediate weighting applied to the evening period, and does not apply a correction factor to make zero CNEL correspond to zero annoyance.

To conclude this section, it should be pointed out that a major difference between the United States and British units is in the allowance made for the number of aircraft movements. Thus the NNI changes by 15 log (N), (N being the number of movements) whereas NEF and CNEL change by 10 log (N). The factor ten implies that annoyance increases in direct proportion to the effective sound energy reaching a point, whereas a factor of 15 implies it changes at a greater rate. The factor of 15 is firmly based on experimental evidence and it is interesting to note that workers in Continental Europe have recently suggested that the factor should be 13.5 rather than 10.

2.3.2 The Measurement of Traffic Noise.

In this section, one measure of traffic noise will be mentioned. It is of interest because it is apparently very different in form to any unit discussed previously. It requires that the A-weighted sound level of the traffic noise be recorded and the level which is exceeded for 90% of the time (L_{90}) and the level exceeded only 10% of the time (L_{10}) be found. The so-called Traffic Noise Index (TNI) is then defined (from Reference 14) as

$$TNI = 4\ (L_{10} - L_{90}) + L_{90} - 30.$$

The constant 30 is included to bring the numerical values of TNI down to more "reasonable" levels. This unit has been shown to correlate very well with the dissatisfaction felt by people experiencing traffic noise.

2.3.3 Industrial Noise and Noise Induced Deafness.

In reference (15), Burns and Robinson report the results of an extensive audiometric test programme in which industrial noise induced deafness was investigated. They were able to compare the noise exposure over an extended period of time (T) to the frequency dependent hearing loss found as a result of that exposure. The noise unit is called the Noise Immission Level (NIL) defined as

$$NIL = L_A + 10 \log\ (T/T_o)$$

where L_A is the A-weighted sound pressure level (which should be reasonably constant over a working day. Alternatively the level exceeded 2% of the time can be be used) and T_o is a reference duration (normally a year or a month). This unit can be used to estimate the deafness that would be produced by an industrial noise environment.

2.3.4 The Noise Pollution Level.

With the exception of the noise immission level, the above noise units have attempted to relate some sort of dissatisfaction with a specific type of noise. The units are apparently very different in form from one another. In practice a noise environment may be due to a mixture of noise sources such as aircraft, vehicles and electrical or mechanical equipment, for example. It is therefore desirable to find a noise unit which could satisfactorily describe this mixed acoustic environment and also, if possible, unify or at least not conflict with, the noise units mentioned previously. Robinson (Reference 16) has attempted to do just this and has defined a unit called the Noise Pollution Level (NPL), where

$$NPL = L + 2.56s$$

where L is a mean sound level which can be expressed in any suitable unit such as dB(A) or PNdB, and s is the standard deviation of the sound level (a quantity which describes the size of the sound level variations). Although the NPL appears to be very different from the NNI (section 2.3.1) and TNI (section 2.3.2), Robinson was able to show that there are similarities and that there was a reasonable probability that the NPL could be use to characterise traffic and aircraft noise with approximately the same degree of precision as that provided by TNI and NNI respectively. It is interesting to note with reference to the discussion at the end of section 2.3.1, that the NPL yields a variable logarithmic correction factor to allow for the number of repetitions of a specific noise event. Robinson also used the NPL to analyse the data collected by Kryter and Pearsons in connection with their equal annoyance curves and show that again it produced results which were in reasonable agreement with theirs.

This unit could therefore be an extremely important unit since it appears to be useful in describing a wide range of noises. Consequently it is receiving a great deal of critical attention at the present time.

3.0 CONCLUSIONS.

This paper has unfortunately taken the form of a list of noise units. One conclusion to be drawn from the multiplicity of such units is that human response to noise is very complex and that research workers are still tackling the task of understanding that response. This latter fact is emphasised by the dates of the publications listed in the reference section of this paper. (Only one paper was published before 1960.) This indicates that the whole field of noise units and noise measurement is far from being finalised and it is possible that significant changes could occur in the next few years.

It is also possible that mentioning so many units has created more confusion that clarification in the mind of the reader. The glib (but probably reasonable) response to this complaint would be - if in doubt, use dB(A) and understand that a 3dB increase in sound level implies a 23% increase in loudness, not a 100% increase.

Finally, even if the perfect noise unit is eventually produced, it must be remembered that it will only correlate well with the response of the mythical average person and so could never be used to say with certainty what the response of a particular individual will be.

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COMMUNITY NOISE COMPLAINTS, THEIR CAUSE AND ASSESSMENT.

by

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1.0 INTRODUCTION.

> In seeking the objective of protection of the environment in respect to noise, in which we all have a responsibility, it is necessary to know the causes of complaints and the types of noise likely to annoy. Subjective assessment is often useful and is appropriate with some nuisances where immediate action by a responsible person is required. Scientific methods of assessment are a most useful tool; however, such methods must include consideration of many factors and, in part, a subjective evaluation by the observer. On the other hand measurement of machine noise under specified conditions is precise and, as prevention is better than cure, such measurement is important in achieving the objective.

Community noise is a major environmental problem which in civilised countries probably affects more people than any other single form of pollution. Theodore R. Kupferman, former New York Congressman, once said that noise detracts from the quality of our lives and in the long term our handling of the problem will reflect how civilised we have a right to call ourselves.

It is probable that the behavioural effects of noise as a health problem are often exaggerated and exaggeration tends to weaken the argument. Nevertheless, it is a serious intrusion of the privacy, comfort and amenities of the home which the community should not have to suffer.

Frequently there is no difficulty in assessing a situation, but there is at times inconsideration for the neighbours, sometimes when the noise is obvious. At times there is no effort by an offending industry to have a responsible person survey the matter at the relevant place and time; a community noise problem cannot be evaluated from the inside of an engineer's office. People making noise will usually co-operate in an effort to eliminate the cause when they know that the complaints are valid, but co-operation will be greatly improved if the alternative is some form of enforcement.

Irrespective of any legal implications and difficulties which might arise in deciding whether, or not, the best practical means have been used, from the experiences of the author, where it would appear that an industry has taken reasonable precautions to control a noise, the neighbouring community is more tolerant than if no obvious attempt has been made. Wise management will realise that a good public relations policy will reduce the risk of complaints.

The aim is to reduce and ultimately eliminate noise which will cause annoyance to reasonable people. In striving to meet this objective a realistic approach will produce more effective results in the long term. It is necessary, not only to protect individuals from the intrusion of annoying noises, but also to protect an individual or undertaking engaged in a resonable activity from unjustified complaints from a neighbour who is unhappy with most things around him.

In seeking more effective means for the control of noise there is need for reliable standards and methods of assessment. This will require

not only subjective and acoustic assessments, standards and scientific criteria, but must also take into account many other factors including adaptation, economic, sociological and political considerations so that the ultimate solution may be a compromise.

Present day techniques can measure sound pressure level and frequency content, but exposure to noise along with environmental stimuli results in variable subjective responses. No single method of measurement accurately describes environmental cause and effect relationship on a basis of which simple criteria can be established. Such methods are not simple, criteria are not yet clearly defined and if treated as such they will surely fail. An incorrect interpretation of results may well increase the problem.

However, measurement techniques, standards and criteria which have been evolved provide a very useful tool in the progress towards a better environment in respect to noise when used by experienced people.

In order to make any type of assessment, whether subjective or objective, it is most essential to have an understanding of the likely causes of complaints and the types of noises which are most likely to annoy most people as well as being aware of one's own hearing acuity. This applies to all concerned, particularly engineers and others who may be responsible for the origin of the noise.

2.0 REASON FOR COMPLAINTS.

Existing Industries

Investigation of complaints from an old established factory, will invariably show that there is a new noise which is prominent, or of an irritating character. This may arise owing to a number of reasons which are frequently overlooked by management as follows:

(a) Industrial

- Lack of Maintenance, particularly gear, bearing and shaft alignment.
- Introduction of a new machine.
- Relocation of equipment to an area more exposed to residents.
- Extension of exhaust ducts and cyclone dust collecting equipment.
- Substitution of equipment, such as oil burners which may produce a low frequency drumming noise.
- Extension of hours of operation.
- An increase in the number of employees' vehicles.
- Increased handling of materials in the yard, loading and unloading operations have been frequently associated with many sudden noises with irritating characteristics.
- A low frequency tone, particularly from a tall exhaust stack may be prominent at some distance from a factory,

because of a greater attenuation of the general steady type factory noises and a consequent reduction of broad band masking.

- Management's lack of concern for irregularities in machines and processes which have no affect on operations or production but which propagate noise to the neighbourhood.

  Unfortunately many managements are complacent on the above matters and do not accept their responsibilities.

(b) Residential Development or Change

- A person unaccustomed to noise, may move to the area. In some cases if the noise is not irritating in character he may adapt to it.
- Residential development may take place near the industry, resulting in the movement of new homes closer to the noise. Such situations are varied and may be complicated with difficulties for both parties. However, well-informed management will be aware if the adjacent land is of a residential classification and, if wise, will take precautions to avoid the propagation of new noise. This situation can arise also from change of zoning or bad planning. Each situation must be considered on its merits, but generally, if the principle of looking for and eliminating annoying characteristics is applied, the problem can be overcome. It is not sufficient to ask who was there first?

(c) Changing Personal Conditions

- Ill health may reduce a person's tolerance to noise.
- Deterioration in hearing may cause a person to be more irritated by an intruding noise than a person with good hearing, e.g. a person with a high frequency deafness may react strongly to a low frequency noise.
- Psychological differences or differences in past experiences.

Psychiatric studies have led to two conclusions, viz.,

(1) There are no grounds for supposing that noise produces neurosis;

(2) An individual who dislikes noise is not necessarily neurotic.

It is possible, under certain conditions, for persons to become adapted to some noises. Habituation may occur if the noise is free from any irritating characteristics, if it is of a "smooth" spectrum character so as to blend in with the background and if there is no unpleasantness. Industrial management should understand the importance of good public relations in this regard.

On the other hand if a noise is irritating in character, an emotional reaction, once established, will not die away with repetition and may likely increase, so that the ultimate solution may require reduction

to a lower level than would have been required if adequate precautions had been taken in the design stage. Good management will recognise the problem and take early action to avoid the build up of resentment.

New Industries

Complaints will arise if a new industry introduces a new noise which is prominent above the existing background, which is out of character with the existing environment or which contains annoying characteristics which are clearly audible in neighbourhood residential areas. There is sufficient technical information available to avoid such a problem.

Construction and Demolition

These operations are inherently noisy and include equipment and processes such as pneumatic hammers, pneumatic drills, air compressors, bulldozers, loaders, mechanical shovels, mixers, vibrators, elevators, etc. These activities are of importance because of interference with communications in offices, work situations, places of learning, etc. and of disturbance in places near hospitals and homes. Some contractors show no consideration for their neighbours, when much can be done by better maintenance, use of suitable mufflers, judicious selection, placement and enclosure of equipment, and attention to the hours of operation.

Motor Vehicle Noise

Noise arising from the vehicle and the manner in which it is driven is a major problem throughout the world. It is not proposed to include it in this paper other than to mention that in the opinion of the author this problem must initially be controlled at the source. Standard methods of measurement are a first requirement, followed by limits and their progressive reduction with time. For such measurements suitable equipment and measuring locations will be required.

At this stage, attempts to control by measurement of noise from vehicles on the road would be unreliable, of doubtful value, and may well hinder rather than assist in achieving the objective.

Non-Industrial Noise

Valid complaints arise from many sources including home air-conditioning, power saws, lawn mowers, advertising, parties, amplified music, animals and birds in captivity, milk vendors, council garbage collectors, dances, concerts, hotels, clubs, model aircraft, boats and cars, carnivals, circuses, sporting events, swimming pools and many others.

These may be broadly classified into:-

(a) Mechanical noise such as lawn mowers, air conditioners.

(b) Nuisances which are intermittent such as private parties, highly amplified music, etc.

(c) Annoyance by noise which is of a routine, continuous or semi-continuous nature. This may apply to noise from public halls, hotels, clubs, sporting events, animal kennels, etc.

2.1 ARE THERE LIMITS OF TOLERANCE?

Whilst there are no clearly defined limits of tolerance and there are wide differences between individuals, there are many noises which the majority of people do not like. Objective methods referred to later are based on this fact and not on health implications.

The Liability of a Noise to Provoke Complaints will Depend on:-

(1) The relationship with the pre-existing background.
(2) The presence of clearly audible annoying characteristics.
(3) Whether, or not, it is a situation which will permit conditioning (habituation). This must not be overlooked in considering noise problems.
(4) Interference with any human activity.
(5) A number of additional contributing factors such as fears of damage or reduced property values, environmental factors, whether or not the noise conveys meaning, is necessary or appropriate to one's own activities. There are noises which a particular individual may dislike for certain valid reasons.

Annoyance and Characteristics of Noise.

In addition to loudness the following characteristics contribute considerably to annoyance. In making an assessment of a noise situation their presence, if audible, is usually more important than a measured level.

- High frequency, to which the mind is psychologically very alive, such as belt slip, metal to metal friction, screeching tyres, etc. Fortunately this type of noise is more readily controlled by barriers than is one of a lower frequency.
- Suddenness.
- Low frequencies (in vicinity of 100 Hz) which, for a long time were overlooked, are now considered to be very important. They are not readily attentuated and are responsible for many complaints. Low frequency noise may be produced by fans, oil-fired boilers, air compressors, etc.
- Modulation in intensity and frequency.
- Pure Tone or Narrow Band noise as produced by fans, rotary pumps, transformers.
- Warbling or beating tone from two or more rotating machines.
- Cyclic, e.g. air compressors, diesels.
- Incidental, or intermittent noises which cannot be measured, such as hammering and yelling, are usually very important, particularly at night time and should not be overlooked.

3.0 MEASUREMENT OF AIRBORNE SOUND EMITTED BY MACHINES.

Prevention is better than cure and any attempt to abate noise must include reduction at source as a logical first step, if practical. The author considers that it should be compulsory for manufacturers, or suppliers of many machines to determine the noise rating of the

machine under standard test conditions and to display such ratings on the appropriate nameplate or specification sheet. Whilst the stage has not yet been reached where it is realistic to expect manufacturers, in many cases, to meet clearly defined "acceptable" limits, it is realistic for manufacturers, or suppliers, to determine the noise levels of many machines such as, earth moving equipment, tractors, lawnmowers, etc. Apart from the incentive value, such a requirement is necessary if manufacturers of machines are to design for noise reduction. The information will be of considerable benefit to users in choosing quieter equipment and in suitably locating and designing for it's use. It is the author's firm opinion that, at this stage, such a step will achieve considerable reduction in many aspects of the noise problem, and that with many machines it would form a foundation for the successful introduction of limits which could be progressively reduced with time.

Such a noise rating would be a precise measurement, as distinct from an assessment of a noise environment where many varying circumstances must be taken into consideration. Australian Standard AS1217-1972 sets out clearly defined test conditions and a method of measurement of noise emitted by machines. The method is not yet applicable to machines where it is not practical to maintain a fixed operational condition. A condition of such a measurement is that no interference or error is introduced by ambient noise, the all encompassing noise associated with that environment, being usually a composite of sounds from many sources near and far. For accuracy the measurements with the machine on test should exceed those due to ambient noise alone by at least 10 dB.

High levels of the ambient sounds, perhaps from near sources, are of importance. The ambient noise level referred to here is different from the background sound level (mean minimum) which is referred to later as a criterion when assessing an intruding noise in a community environment. The two levels must not be confused.

4.0 ASSESSMENT OF NOISE IN THE COMMUNITY IN RESPECT TO ANNOYANCE.

Frequently subjective observations can be made on the basis of the factors already mentioned, particularly the audible relation to the existing background level and the character of the noise. Offending industries can certainly carry out such observations and should do so often. A reasonable assessment can be made in this way and if quantitative proof is required in borderline cases this can then be done by an experienced acoustician.

Situations may arise where there is little or no relationship between the measured level and the annoyance such as:-

- In a factory which had been operating for years, a broad band noise successfully masked an irritating noise, so that the closing of part of the factory and the actual reducing of the sound level caused complaints. This could be assessed by the presence of an audible unmasked irritant.
- Sound conditioning may, by raising the sound level, mask an irritating noise.

- Natural noises which are acceptable may produce a higher level of noise than the irritant, e.g., birds, crickets. The difference can be shown by frequency analysis.
- The trend to relate an assessment to values at a boundary is perhaps most practical, but there is need for caution. This position will not always determine equitable values, it does not take into account many variable factors such as the relative distance between the measuring point, the source and the listener.
- With the trend to dB(A) "for simplicity" it must not be overlooked that noises of very different spectra may show identical dBA readings.
- Whilst economic factors and the practicability of a solution may not be part of an assessment of a noise, such factors may well have some bearing on the total solution which may be a compromise.

4.1 INDUSTRIAL NOISE - OBJECTIVE METHODS.

Many objective methods have been proposed over a number of years for assessing noise in respect to annoyance, particularly noise propagated from industrial or commercial undertakings. Such methods are not precise, there are various contributing, or related factors to be taken into account. The appropriate adjustment factors depend on an individual opinion which must be an educated one. However, experienced sound engineers, and acoustic experts working independently on the same problem have usually been in reasonable agreement.

Common features in most objective methods are as follows:-

(a) An allowance for old established factories, for conditioning, but not for new noises.

(b) The use of the pre-existing background level as a criterion for the environment.

(c) Adjustment factors for characteristics known to annoy.

(d) Emphasis on new factories, new installations or extensions.

Objective methods can be used as follows:-

(1) To determine if complaints are valid.

(2) To help in achieving an understanding between parties. They are particularly useful in convincing offenders that there is, in fact, a valid reason for a complaint.

(3) To detect the source of irritation and to provide information for control. As the ultimate solution with existing industries may be a compromise between the ideal and what is practical, information to decide the practicability of control is most useful.

(4) To determine if treatment has been effective.

(5) To plan to avoid the risk of complaints from new installations, etc.

A draft Australian Standard method for the assessment of industrial noise in residential areas involves Sound Level 'A' measurements but,

because entirely different noise spectra will give the same dB(A) figure, this draft provides for a frequency analysis in difficult cases. Frequency analysis is essential if corrective measures are to be evaluated. The measured levels are adjusted for the character of theparticular noise (See Appendix, Table A) and the adjusted figures are then compared with a criterion.

The criterion may be determined by two methods:-

(a) By measurement of the background sound level. This is the lowest sound level (mean minimum) measured at the relevant place and time in the absence of the noise which is alleged to be offending. It is the level being exceeded 90% of the relevant time. When using a background sound level as a criterion to determine the relationship with the irritant, the significant factor is that it is a level above which there is no effective masking of a noise intruding into a particular environment.

The background sound level referred to here and the ambient noise level referred to earlier (measurement of machine noise) are distinctly different levels which unfortunately are frequently confused.

(b) If (a) is not practical, or if necessary to avoid a "creeping background", then the Basic Criterion which has been suggested is adjusted for the type of environment, time of day, etc. (See Appendix, Table B).

In some cases offenders, in an attempt to raise the criteria and to justify their noise, compare the levels of noise propagating from their particular industry with peak levels from extraneous noises such as passing vehicles. It may be true that such noise at high levels is an additional neighbourhood irritant and that it may lower the residential status of a particular environment but such varying noises will not effectively mask the presence of an irritating noise.

The figures shown in the Appendix, which are based on the above draft standards, have been found to provide reasonable guidelines for the assessment of community noise in respect to annoyance but attention should be given to the notes.

Adjustment factors for duration of the noise have not been shown because this is more complex. Often a noise which occurs intermittently is more annoying than a continuous noise of the same noise level.

4.2 ESTIMATE PUBLIC REACTION.

Estimated public reaction is shown in the Appendix, Table C.

Differences of 5 dBA or less are marginal. In general, in a community situation if a new noise does not exceed the background level by more than 5 dB(A), or preferably 5 dB in any octave band, and if there are no annoying characteristics present, complaints would not be expected. However, if it is economically practical a figure of 3 dB would be desirable. Although there may be no likelihood of complaints, action

may be desirable in some cases to prevent a "creeping background".

With differences of 10 dBA or more complaints would certainly be expected, but there may be exceptions with a "smooth noise" (broad band) which allows habituation.

When the excess is between the marginal 5 dBA and 10 dBA the likelihood of complaints will depend on the type of noise and various related factors.

There is need for realism in seeking an ultimate solution to this problem. Criteria low enough to completely eliminate risk of annoyance may unduly penalise industry. On the other hand permissive levels would give potential offenders a false sense of security and would not assist at all in the ultimate solution. Socio-economic implications cannot be overlooked and the ultimate solution may be a compromise.

Construction and Demolition.

Owing to the nature of such activities and the fact that they are usually temporary, people show considerable tolerance. Reduction to the ideallevel would not usually be practical; however, it is reasonable to expect a contractor to carry out an environmental noise impact study and to show that he has taken action to reduce the effects to a minimum. The appropriate criteria should be related to the existing usage and circumstances.

Non-Industrial Noises.

(a) Mechanical Noise.

As in the case of most machines, prevention is better than cure and attention must be given to reduction at source.

It is the author's opinion that the appropriate ultimate assessment and control should be by compulsory determination of noise levels under standard test conditions with subsequent limits and progressive reduction with time. If the noise is continuous, such as an air conditioner, an on-site acoustic assessment would be appropriate to determine control measures.

(b) Noise nuisances which are intermittent such as amplified music, voices, etc.

It would seem that certain activities could be defined as nuisances. In this type of problem where there is a variety of circumstances there is a need for responsible persons to have authority to personally judge the situation immediately, to order offenders to cease if necessary and to take appropriate action for the offence if they do not comply. Acoustic measurements might provide support in difficult cases.

(c) Noise nuisances which are of a routine or semi-continuous nature such as hotels, large animal hospitals or kennels, etc.

Action as above would seem appropriate in many cases. However, acoustic measurements will not only assist an objective assessment as described earlier, but will provide most useful information regarding the amount of reduction required for determining

effective treatment.

In many such cases the ultimate solution is not in assessing and stopping immediately but in determining a permanent method of control.

5.0 PROTECTION OF THE ENVIRONMENT IN RESPECT TO INDUSTRIAL NOISE.

What can industry do?

5.1 EXISTING INDUSTRIES.

Good maintenance is important for obvious reasons, apart from noise.

- A periodic noise check at, or beyond, the appropriate boundaries of residential areas, by a competent and responsible person, should be an essential part of a preventative scheme. Whether, this survey is subjective or objective will depend on the circumstances and the nature of the industry. If there is complaint potential, then measurements are suggested. Good engineers and managers keep a routine check on all aspects of plant in relation to production. Surely it is reasonable to make a routine check on noise to preserve neighbourhood amenities.
- When there is a complaint, management should investigate to find out why the people are concerned. Immediate action in this regard will assist considerably in maintaining good public relations.
- If there is a potential environmental noise risk it should be a duty of the shift supervisor to record in his log book any irregularlity which might contribute to the problem.
- Avoid, particularly at night, incidental noises such as hammering, yelling, banging doors, etc.

5.2 NEW INDUSTRIES, PROCESSES, MACHINES, ETC.

If proposing a new factory, or additions to an existing one, industrial management should take precautions to prevent the introduction of a new noise which is out of character with the pre-existing background, or which contains annoying characteristics. Councils must also be aware of the necessity for such precautions.

- Make a survey beforehand to determine the background sound level for the area concerned and check this with the appropriate basic criterion for the locality.
- Ask manufacturers to supply noise level measurements under standard conditions for major items of machinery and buy the quietest equipment practical.
- With a knowledge of likely noise, design the building and the layout of the plant so as to avoid a noise problem.
- Wise industrial managements will plan to avoid noise problems and, until a thorough examination of the situation has been made, they will not try to convince themselves and councils that there will be no noise. If there is a noise nuisance,

not only will there be irate neighbours, but it will be much more expensive to eliminate than it would have been with the correct design initially.

6.0 CONCLUSIONS.

Individuals and industry have responsibilities to avoid annoyance to their neighbours.

There are many valid reasons for complaints and usually there is no excuse for lack of action by the offender because an initial observation at the relevant place and time will indicate the problem.

The concept that assessment by measurement is simple has in some cases hindered rather than assisted progress.

Individuals react differently to noise but there are available techniques which provide a yardstick to determine if a particular noise is likely to cause justifiable complaints, to determine the degree of reduction required and to determine the effect of action taken.

There is no excuse for an environmental noise problem from new industries, processes, equipment or extensions. Before submitting proposals for development, extensions, etc. industry must investigate the likely noise, its impact on the existing environment and design the project to ensure that there will be no noise problem later.

Owing to the nature and varying circumstances of many intermittent noise nuisances a personal subjective assessment by a responsible person is appropriate.

Prevention is better than cure and, where practical, emphasis must be placed on reduction of machine noise at source. Such noise can be measured precisely. With many machines this can be ensured initially by compulsory noise rating tests using a standard method, followed by noise level limits with progressive reduction with time.

Finally, L. Urwick a well know authority on administration techniques once concluded a book with the words, "if in their practical application any of these instructions are repugnant to reason and commonsense, let reason and commonsense prevail". This must surely apply in the field of "quantitative measurement of noise". There is no doubt that definite techniques in respect to annoyance by noise are emerging and there is a reasonable agreement among experienced sound engineers. However, there are still gaps which must be filled in by subjective judgment and in their application reason and commonsense must prevail.

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APPENDIX

ASSESSMENT OF NOISE IN RESPECT TO ANNOYANCE

TABLE A. Suggested Adjustments to the Measured Sound Level in dB(A).

Influencing Factor	Possible Conditions	Corrections dBA
Peak Factor	Impulsive (e.g. hammering) Note 1: The impulse correction can be omitted when an impulse sound level meter is used. Note 2: In some cases these values may not be sufficient and more detailed analysis may be required.	+ 5
Noise Spectrum Character	Audible Tone components (e.g. whine)	+ 5
	Beats and amplitude modulated and frequency modulated signals (if applicable)	+ 5

Note: There may be exceptions to the values given in the above table.

TABLE B. Proposed Basic Criterion = 40 dB(A)

Suggested Adjustments to Basic Criterion for:

(1) Differences in Time of Day	
Time of Day	Correction to Basic Criteria dBA
Day time (Monday to Friday) (7 a.m. to 6 p.m.)	0
Evening (6 p.m. to 10 p.m.)	- 5
Night time (after 10 p.m.)	- 10
Day time at week ends and public holidays (7 a.m. to 6 p.m.)	- 5

Note: Time periods and levels may be varied to suit local conditions.

(2) Types of District		
Class	Type of District	Adjustment to base level dBA.
R1	Rural and outer suburban areas, Infrequent transport noise	0
R2	General suburban areas, Infrequent transport noise	+ 5
R3	General suburban areas away from Main transport noise	+ 10
R4	Suburban areas with some commerce or light industry or near Main Transport routes	+ 15
R5	City area, Business, Trade, Administration also Industrial Area bordering Residential	+ 20
R6	Predominantly industrial area	+ 25
Note 1:	There may not always be a clear differentiation between the types of districts shown above. It may be necessary to measure the background noise levels to decide the appropriate correction factors.	

Note: (a) The background level includes appropriate influences of the local site, the season and the time of day, providing it is measured under the same conditions as the noise, and no adjustment is required.

(b) Adjustment factors are based on an individual opinion requiring a sound knowledge and experience. They are suggested as a guide and are not necessarily clearly defined.

TABLE C. Public Reaction.

Amount by which adjusted rating exceeds suggested adjusted criterion.	Estimated Public Reaction
0 - 5	None
5 - 10	Little. Sporadic complaints.
10 - 15	Medium. Sporadic to widespread
15 - 20	Strong. Widespread.
20 - 25	Very Strong. Vigorous community action.
Over 25	Extreme. Immediate direct community and personal action.

SOME COMMENTS ON DR 72084: DRAFT AUSTRALIAN CODE OF PRACTICE FOR HEARING CONSERVATION

by

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James Hardie and Co. Pty. Ltd. *

* The views expressed in this paper are those of the author and not necessarily the views of James Hardie and Co. Pty. Ltd.

This paper will discuss some aspects of the Draft Standard Code of Practice for Hearing Conservation recently circulated for comment by the Standards Association of Australia. I don't propose to deal with the nitty gritty of its detail - indeed, I would be overreaching my competence were I to try. I shall concern myself with the essential philosophy adopted by the authors and underlying the proposals of the Draft Standard as it is set out in the Preface, Additional Comments and, to a lesser extent, in the Foreword, in such a way as puts it, I think, within the competence of all of us to consider.

Whatever meaning one gives to the word "adequate" I cannot accept the statement in the Foreword that, "The Minimum Requirements Recommended relate to the ability to understand one's native speech. For this purpose adequate hearing acuity in the frequency range from 500 Hz to 4,000 Hz is important." Much less can I accept the statement in the Additional Comments that hearing to and, indeed, above 4,000 Hz is necessary "for the understanding of all speech in quiet involving frequencies in excess of 4,000 Hz"; unless, of course, one adds the rider that scarcely any speech does substantially involve frequencies above 4,000 Hz, in which case the whole thing becomes pretty meaningless. Likewise, there are grave objections to accepting the suggestion of the authors that loss of high frequency hearing will materially hamper the task of restraining workers for new jobs as new technologies evolve. The creators of any new technology will, indeed, have to exercise the greatest phonetic skill in evolving the associated jargon if this is to come about.

One naturally wonders on what these claims are based. In the Additional Comments the authors of the Draft Standard speak of "authenticated clinical researches" and of the "research findings" of the Commonwealth Acoustic Laboratories, they mention the "recently published work of Robinson and Burns" which, they claim, support their view that for the comprehension of one's native speech hearing to and even above 4,000 Hz is necessary. However, despite the apparent wealth of the evidence supporting their view, much of which surely must be readily and locally available, they give only one precise reference, and that to a Draft Proposal published in Holland, that would enable one to consult the evidence on which their position is based.

On the other hand, the evidence which, in my view, defeats the position adopted by the authors of the Draft Standard is readily available. In one simple form it is all too readily available. A P.M.G. telephone transmits no frequencies above 3,000 Hz and yet speech on the telephone is readily comprehensible, one can readily identify the voices of those whom one knows and one has no difficulty in judging that one's wife was displeased when one has rung up at half past six to say one will not be home for dinner.

To gain further evidence to support my contention, I propose at this point in the presentation to give a demonstration of the effect of filtering out the higher frequency components in my voice. This will indicate that, when you can hear nothing above 4,000 Hz, you scarcely notice any difference in comprehension; that it does not make much difference when you can hear nothing above 3,000 Hz, and that only when everything above 2,000 Hz is filtered out, does comprehension become a little difficult. In the final demonstration everything above 1,000 Hz will be removed and I hope to show that even under these circumstances it is sometimes possible to understand what is being said.

This demonstration will, I trust, show why I cannot accept that unimpaired hearing to 4,000 Hz, let alone to higher frequencies, is essential for the

understanding of speech. Were the Standards Association to grant the weight of its authority to this view, a grave disservice would be done in the community. Such an action would invite the inference by the legislatures that occupationally noise induced losses to 4,000 Hz, or even higher should be compensated. Workers, having once discovered the utterly trifling consequences of high frequency loss would very understandably seek such a loss that they might receive compensation - indeed the authors of the Draft Standard seem almost to invite this in declaring that, "Stress should be laid on the voluntary accepting of hearing protection procedures...." I therefore conclude that, initially, the aim should be to preserve hearing to 2,000 Hz to ensure that speech comprehension is preserved.

ACKNOWLEDGEMENTS.

I am, unfortunately, not able to attend the Conference in person. My paper has therefore been recorded for presentation at the Conference.

I would like to acknowledge the assistance of the Commonwealth Acoustic Laboratory, Sydney, in the preparation of this recording. I must also thank Mr. R.B. King of King, Sawley and Associates Pty. Ltd. who has agreed to answer any questions on the topic of this paper that may arise during the subsequent discussion.

WORKERS' COMPENSATION FOR INDUSTRIAL DEAFNESS.

by

His Honour Judge J.S. Ferrari
Workers' Compensation Commission of New South Wales.

The Workers' Compensation Acts and Ordinances of Australia and Papua New Guinea provide lump sum compensation for total or partial deafness from employment according to scales which at 1st June, 1972 stood as follows:

	Loss of Hearing	Complete deafness of one ear.
New South Wales	$5,500	$2,600
Victoria	$8,880	$2,740
Queensland	$5,330	$2,310
South Australia	$9,000	-
Western Australia	$7,065	$2,355
Tasmania	$5,842	$2,637
Australian Capital Territory	$9,450	$2,700
Northern Territory and Papua-New Guinea	$8,400	$2,400
Compensation (Commonwealth Employees) Act 1971	$9,450	-
(Commonwealth) Seamen's Compensation Act	$9,450	$2,700

While there is some general similarity in the various enactments, there are also considerable differences in detail and this paper does not attempt to make a general statement as to the common effect of all the enactments but is confined to setting out the position under the New South Wales Act as at September 1972.

Under the New South Wales Workers' Compensation Act compensation is payable in respect of personal injury which may arise from force, strain or other trauma or from disease. Injuries received on journeys to and from work and on certain other journeys may be compensable, but in general for compensation to be payable the worker must have received injury which arises "out of" his employment or which arises "in the course of" his employment; and it is the particular employer (or his insurer) under whom the injury was received who is alone liable to pay the compensation, and it is against him (in default of agreement) that legal proceedings must be brought and his liability established. There is an exception, however, in the case of injury from an occupational disease, that is to say, a disease which is of such a nature as to be contracted by a gradual process and which moreover is, within the words of the Act, a disease "due to the nature of" a particular employment. The contraction of such a disease may be insidious and may be spread over many years worked under different employers so that it is impossible for the worker to prove whether or in what proportions his work under particular employers contributed to his injury and eventual incapacity. In such a case, Section 7 (4) of the Act authorises the worker to recover the whole compensation for his injury from whoever at the time of the injury was his employer, or last employer, in the employment "to the nature of which the disease was due", and Section 7(5) deems the injury to have happened at the time of the worker's incapacity in order to permit identification of the employer to be held liable.

An injury arises "out of" an employment if it is caused by, or contributed to by, the employment. It arises "in the course of" an employment if it

occurs during the time the worker is either engaged in the performance of the duties of his employment or else, say, is resting during a crib break or is doing any of those things which, in the circumstances of the particular case, including practices current at the time, are to be regarded as reasonably incidental to his employment. Thus a worker is entitled to compensation if his hearing is suddenly damaged by a blast of noise from an explosion caused by something occurring in manufacturing processes upon which he is employed, or which occurs without any connection with his employment other than that he is at his work at the time. Injuries of this kind are rare.

The common work cause of injury to hearing is not from sudden accidental explosion, but from long continued exposure to loud and repetitive industrial noise. This produces the condition of perceptive or neurosensory deafness which is typically exemplified by a boilermaker's deafness, and the term "boilermaker's deafness" has come to be applied generally to nerve deafness arising from any form of continued exposure to loud, repetitive noise in industry. References in this paper to a boilermaker may be taken to extend to any other worker in noisy industry. Compensation for boilermaker's deafness is currently being paid in New South Wales at a rising rate which presently is in excess of $1.5m. per annum. The Tables at the end of the this paper show some particulars of workers' compensation paid in New South Wales in recent years and give an indication of the kinds of industry concerned. This compensation is paid under provisions which, by a series of amendments over a period of years, were specially inserted in the Act to apply to boilermaker's deafness the procedures established for occupational diseases. The best way to explain the nature and present operation of these provisions is to recount how they came to be brought into being.

Boilermaker's deafness does not as a rule lead to incapacity for work. It may unhappily even serve as some sort of assurance that a boilermaker has been well grounded in his trade. Leaving aside payment of hospital and medical expenses, compensation normally takes the form either of a weekly payment under Sections 9 or 11 during incapacity or (in the case of certain specified disabilities) of a lump sum payment under Section 16 of the Act as compensation for the physical injury. Until 1951 Section 16 contained the condition "when the injury results in total or partial incapacity" so that neither a weekly payment under Sections 9 or 11 nor a lump sum under Section 16 became payable unless and until there was some incapacity resulting from the injury. The "incapacity" referred to in Section 16 was upon some opinion taken to mean that no lump sum was payable under that Section unless the worker had suffered some loss of wages or wage-earning capacity as a result of the injury. It was eventually decided by the Supreme Court on appeal in December, 1951 that the incapacity mentioned in Section 16 referred only to physical incapacity and was consistent with the worker having in fact continued to receive full wages. In the meantime, however, earlier in 1951 the reference to incapacity had been deleted from Section 16 and the bar to prevent a boilermaker or other worker who was not incapacitated by his injury from receiving lump sum compensation for it under Section 16 was removed from the Act.

The disabilities for which lump sum compensation is payable under Section 16 are in a Table to that section. The specified injuries have always included loss or partial loss of hearing. In 1953 a boilermaker named Milne claimed a lump sum under Section 16 for partial loss of hearing. The medical evidence made clear that boilermaker's deafness results from the cumulative effect of a very large number of minute traumata, each affecting the nerves

upon which hearing depends. The Judge took the view that, being the result of trauma, it was not a disease at all. If it were a disease, contrary to his own thinking, he accepted that it fell within the description of the occupational diseases provided for by Section 7(4) of the Act as being "of such a nature as to be contracted by a gradual process". The Judge's ruling meant that Milne could not rely upon the special provisions for occupational diseases in Section 7(4) to recover compensation for all his deafness from his last employer but on the contrary could only recover from him under the general provisions of the Act for such deafness as he might be able to prove had actually been caused under his last employer, and, indeed, caused since 1951, because the Judge held that the amendment to Section 16 in 1951 was not retrospective in its effect. He considered that on the evidence Mr. Milne had in any case already "contracted" all his deafness before he became employed in 1950 by the employer against whom he claimed compensation, and consequently before the amendment to Section 16 in 1951 which deleted the reference to incapacity. Even if he had become deafer after 1951, there was no evidence upon which any monetary measurement of any loss subsequent to 1951 could be made. As the amendment to Section 16 in 1951 had not been made retroactive, the Judge held that consequently the worker's rights were to be determined as at the time he received injury and in accordance with the law then existing. He concluded that, if the case did not fall within Section 16, that section still applied to the injury in its unaltered form before its amendment and Milne could not recover compensation under it as he had not been incapacitated by the injury, even in the physical sense as opposed to the economic sense. So Milne got no compensation.

Boilermaker's deafness, it was clear, was not a pathological entity at all in the sense of there being some underlying entity which, once activated, progresses of its own accord. In 1957 the Act was amended specifically for the purpose of getting over some of the difficulties in Milne's case. A new subsection, subsection (4B), was inserted in Section 7 as follows:-

> "(4B) The condition known as boilermaker's deafness, and any deafness of like origin, shall for the purposes of subsection four of this section be deemed to be a disease and to be of such a nature as to be contracted by a gradual process".

Another boilermaker, a man named Coates employed in the Railways, brought proceedings in 1958 but it was held on appeal in 1960 that the 1957 amendmen was ineffective because it failed to have regard to the provision mentioned earlier in Section 7(5) whereby, in the case of any disease of such a nature as to be contracted by a gradual process, the injury is deemed to have happened at the time of the worker's incapacity. As Coates had not so far been incapacitated at all, he had to be treated as not having yet been injured! However, he had spent his working life in the Railways so that no other employer was concerned, and on the facts of his particular case the appeal Court thought it was open to him to recover compensation from the Railways under the general provisions of the Act upon the basis that the whole of his deafness resulted from injury arising out of and in the course of his employment the Railway Department.

The Act was again amended in 1960 to insert a new subsection (1A) in Section 16. This provided that boilermaker's deafness, and other specified disease disabilities of gradual onset, which had not resulted in incapacity should, for the purpose of determining a worker's right to the lump sum compensation in Section 16, be deemed to have happened at

the time when the worker makes his claim for compensation. The effectiveness of this provision in Section 16(1A) to give compensation for industrial deafness was established by the High Court's decision in Bain's case in 1965, the Court accepting this time that what the legislature wanted to do by the 1960 amendment was to get rid of the difficulties and complications which had arisen in relation to claims for lump sum compensation under Section 16. On the worker making a claim upon an employer who is then employing him in an employment to the nature of which boilermaker's deafness is due (or, if he is not then employed in such a noisy industry, upon his making the claim upon the last employer who did employ him in such a noisy industry), the whole of his loss of hearing over the years from industrial employment is to be treated as having happened suddenly, as it were at one blow, at the time he makes the claim, and he is entitled to recover from the one employer compensation for the whole condition of deafness due to industrial noise.

This provision certainly embodies a most remarkable legislative fiction, the product doubtless of legislative frustration over nearly a decade. It has the remarkable effect that not only is it left to the worker to choose when he wants to crystallize his claim for his gradually accrued deafness, but within some limits his power of choice extends to the particular employer in noisy industry (or his insurer) who is to pay it. He can work for thirty years in one boilermaker's shop without claiming compensation, and then take another position in another shop and claim for the whole of his deafness from his new employer after working for him a few days or weeks. The gradually accumulating compensation entitlement (of recent years periodically and retrospectively updated in value to counter inflation) has a portability undreamt of by the most optimistic superannuation scheme planners. And the Act expresses no bar to the receipt of compensation under the New South Wales Act for deafness accumulated in industry in another State or in a foreign country and imported into New South Wales, nor for that matter does the Act provide any machinery to prevent a deafness entitlement to compensation which has been satisfied in some other State or country from being cashed all over again in New South Wales.

One of the arguments against Bain's claim in the High Court was that the 1960 amendment was not intended to have a retroactive effect. It was said, however, by the Chief Justice that it was in the actual language of the amendment that the expression of the legislature's intention was to be found. No doubt Bain's condition at the time of his claim was a product of past events but by the express words of the amendment it was to be treated as having occurred at the date of his application, that is, at a time subsequent to the making of the amendment. That did give him a right to compensation for the present result of the progressive deterioration of his hearing caused during many prior years of boilermaking.

Further amendment to the Act was made in 1966 by insertion of a new provision, Section 16(5A), with respect to loss of function from occupational diseases. By this amendment second and later claims for compensation for further deafness from industrial noise are to be deemed further injuries, and the compensation is to be for the difference between the total percentage of loss of hearing at the time of the preceding claim. The ordinary provision for calculating compensation for a first compensable hearing loss, as with other loss of function, remains based upon the percentage diminution in whatever hearing (good or bad) the worker previously had. There is nothing in Section 16 that requires or permits regard to be had, when assessing the loss of hearing or the lump sum compensation for it, to any

relevance or usefulness of hearing, or range or acuity of hearing, to the occupation or pursuits of the individual worker, whether he is young or old, skilled or labourer, boilermaker or musician. The percentage diminution to be assessed is, however, of the individual worker's prior hearing, before the work injury was received, whether that prior hearing was normal or abnormal.

The question of loss of hearing by reason of age changes arose in the case of Sadler which was before the Courts from 1967 to 1969. The medical evidence showed that the worker, who was 60 years of age, had boilermaker's deafness. As qualitatively hearing loss from presbycusis and other boilermaker's deafness are indistinguishable, both being a neurosensory deafness, it was not possible to detect from examination whether the worker had suffered loss of hearing from presbycusis, but medical literature pointed to a likelihood of a general statistical average loss in humans of half a decibel for each year over 50 years of age. It was held by the High Court that this could not afford material on which any part of the measured loss of hearing of a worker suffering from boilermaker's deafness could be found to be due in fact to presbycusis and not to boilermaker's deafness. The particular application of the decision to presbycusis was reversed by legislative amendment in 1970 when a new Section 16(5B) was inserted in the Act to require (except in the case of a total loss of hearing of either ear) in ascertaining the percentage of diminution of hearing in respect of boilermaker's deafness (or any deafness of the like origin) that there is conclusively presumed that the worker's loss of hearing is to be attributed to presbycusis to the extent of half a decibel for each year over fifty. The legal logic of the decision remains on the relationship of the general to the particular, and in respect of the observations of the Chief Justice that, once the existence of boilermaker's deafness is established, the onus is upon an employer to prove (and not upon a worker applying for lump sum compensation under Section 16 to negative) that the worker already had an impairment of hearing due to causes other than his industrial occupation. The differentiation from boilermaker's deafness of other forms of neurosensory deafness, as from mumps or the like, is normally dependent upon the patient's medical history.

The option a boilermaker has under Section 16(1A) to exact compensation for his deafness from a present employer, or wait to impose the burden upon another employer in noisy industry, is to be looked at nevertheless against a general background of arbitrariness in imposing the compensation liability for occupational diseases. In the case of sudden accidents, it is natural to make liable a present employer, if anyone is to be liable at all. With an imperceptibly progressing occupational disease, legislatures have long taken the view that, once the worker breaks down into incapacity, his employer then should be held liable and the workman not sent from pillar to post in an impracticable attempt to establish and in some way apportion liability upon successive employers. The burden has been looked at as falling upon the industry generally, with the roughness to be smoothed out by employers insuring against liability. Sometimes there is provision for the last employer to claim contribution against earlier like employers This is restricted in New South Wales to employers within twelve months preceding in the worker's incapacity. It is little availed of, and in any case is not applicable to boilermaker's deafness where there is no incapacity.

The difference in the incidence of liability and in procedures makes important the distinction between injury from an occupational disease (including Boilermaker's deafness) and an injury actually caused by or

arising in the course of the employment of a particular employer. The essential factor for the application of the occupational disease provisions of the Act is that the disease, or its aggravation, is due not simply to something in fact occurring in employment by a particular employer, but to the nature of the class of employment that has been followed by the worker over the years, perhaps in the service of many successive employers. This is something quite distinct from the disease being caused, contributed to or aggravated by something that is not at all characteristic of the class of employment but merely happened to occur without there being any characteristic or distinctive feature of the employment, or anything in its nature which, more than any other employment, tends to cause, or exposes the worker to special risk of, such an injury.

In some compensation legislation, in order to facilitate proof, the course has been followed of specifying certain employments (for example, employment upon processes involving the use of arsenic or any of its preparations or compounds) as employments to the nature of which certain occupational diseases (for example, arsenical poisoning) are to be deemed to have been due. A somewhat equivalent provision is embodied in a Tasmanian amendment passed in 1970 that, where a worker is found to be suffering from hydatids and he has been engaged in a class of employment that involved his handling dogs, the hydatid disease is to be deemed to have come from the last employment of that class in which he was engaged. The New South Wales Act does not particularise any causal relationship between processes and diseases but relies upon the general words of Section 7(4). It is accordingly necessary, in default of agreement, that it be established in each case that the worker's disease or some aggravation if it has probably been due to the nature of some class of employment in which he has engaged by virtue of the very tendencies, incidents or characteristics of that employment. That means that the disease resulted from service in that employment under some one or more of the worker's employers, but it is immaterial which. If it happens that the worker has served under the one employer only in that employment, a finding that the disease was due to the nature of that employment would at the same time be also a finding that it actually arose out of the employment under that employer, so that alternative grounds of liability would exist.

The occupational disease provisions of the Act are not confined to cases of contact with industrial materials or of organic injury, as is illustrated by a case under the Commonwealth Employees' Compensation Act in 1964. Certain employees in the postal department were suspected of dishonest practices in removing records of trunk line calls made by starting price bookmakers. Another employee, a woman who turned out to be suffering from latent paranoia, was allotted the special job of spying upon these employees under the subterfuge of pretending to work on other records nearby. The strain of her new job was sufficient within little more than a week to precipitate this woman into a severe mental disturbance which incapacitated her from work. It was found that it was not merely that her employment happened to bring about this change, but that her employment was attended in its very nature by the danger to latent paranoids of a psychotic onset, the medical evidence being that one could hardly have chosen a job more likely than this one to stir up a paranoic person. The mental condition into which she was precipitated was found due to the nature of the employment in which she was engaged.

It follows accordingly that the case a worker has to make out in a claim for compensation for boilermaker's deafness under the disease provisions

of the Act is that his employment with the employer sued was one characterised by continued exposure to loud industrial noise of the sort that causes boilermaker's deafness. He need not show that his deafness was, in fact, increased under the employer sued or that the extent of his own subjection to noise under the employer was such as either to make it probable that his hearing was in fact damaged or even to make it likely that there was an actual risk of damage to his hearing. Provided the employment is shown to be one that subjects the worker to the class of noisy conditions that causes the disease of boiler-maker's deafness, the worker is entitled to recover without proof that he individually was at risk. Upon this basis the scope for noise tests of the worker's surroundings is somewhat limited. So long as the employment is one that contains the necessary exposure to loud industrial noise, precise enquiry as to the levels of noise and the duration of exposure or positive proof that the worker or some other person either had his hearing impaired or specifically on some occasion ran a risk of it is immaterial in proceedings for workers' compensation as distinct from an action for damages for negligence. The position may be illustrated by reference to a case of arsenical poisoning. If the worker was last employed by the employer sued in an employment involving the use of arsenic or of arsenical preparations or compounds, and that class of employment is shown to be an employment to the nature of which arsenical poisoning is due, it is beside the point for the employer to call detailed evidence to show that the worker's disease was not in fact contracted in his employment or that tests show that his precautions against the risk of poisoning were very good and such as to make it unlikely that the worker was in fact exposed personally to the risk of poisoning. The only apt defence in such circumstances is not that the poisoning was not contracted while in the defendant's employment, but that the poisoning was not contracted in any employment at all involving the handling of arsenic but rather, say from drinking weed-killer by mistake at home in the man's own garden.

TABLE 1: WORKERS' COMPENSATION FOR INDUSTRIAL DEAFNESS IN NEW SOUTH WALES

Year ended 30th June

	1969		1970		1971	
	No.	$	No.	$	No.	$
Awarded by Workers' Compensation Commission	877	519,453	1160	750,070	1598	997,171
Legal Costs		85,226		135,443		178,438
Payments without Awards	1473	346,047	1946	315,088	2031	272,476
Total Number and Amount	2350	950,726	3106	1,200,601	3629	1,448,085
New cases reported			2036		2201	

TABLE 2: INDUSTRY CLASSIFICATION OF NEW CASES REPORTED IN YEAR ENDED 30TH JUNE, 1971.

Agricultural, Horticultural and other Rural	4
Building	40
Clothing, Textiles, Upholstery Manufacturing	18
Construction, Maintenance etc.	135
Food & Drink Manufacturing	8
Leather Manufacturing	1
Metals, Machinery Manufacturing, Repairing, Metal Working	1437
Mining and Mines Treatment, Quarrying	419
Miscellaneous Manufacturing	26
Paper, Printing etc.	15
Professional (including Clerical and Administrative)	16
Stone, Clay etc. Manufacturing	39
Transport (Air, Land, Water)	18
Wholesale, Retail and Bond Stores	14
Woodworking	11
	2201

IDEALISED NOISE LEGISLATION

OR

AN ANARCHISTIC APPROACH TO DEALING WITH NOISE

by

R.J. Satory

Satory Acoustic Services, Lower Hutt,
New Zealand.

As a scientist I recognise that any article is easier to read if one knows the prejudice of the author. I therefore tell you that in writing on law I write from the prejudice of the statement of Tom Paine's "The Government that governs least, governs best".

As a philosopher it appears to me that laws are written when the people "polarise" on two sides of an issue and one group imposes its thinking on the other. This appears to hold true in the case of what is now called murder, through to the case of at least one law which reads that a motor vehicle must be preceded by a man with a red flag.

Let us look at some of the differences of opinion I have heard on some noise situations.

1. a. Factories shall be required to reduce the noise in them to a minimum.
   b. Employees know how much noise there is in a factory and can either 'lump it' or leave.
2. a. Factories shall be required to reduce external noise to a minimum.
   b. Factories are in an industrial area and therefore have a right to make a noise.
3. a. Airlines shall take every means practical to reduce their annoyance to a minimum.
   b. Airlines are synonymous with "progress" and therefore sacrosanct.
4. a. New motor vehicles shall meet a noise standard before they are authorised for sale.
   b. Such a law is too difficult because such silencing measures may even cause such things as vehicles to overheat.
5. a. Motor vehicles should be required to meet a noise test as part of the warrant of fitness.
   b. Accurate noise measurements of motor vehicles are too difficult to make.
6. a. Party music is not to be classed as noise.
   b. The "modern sound" is noise, and should be classed along with privately owned sirens for legislation.

There seems to be a lot of forces, not the least of which are those from people with an interest in acoustics, trying to "polarise" the people with an interest in these noise issues, to where legislation is necessary. As I suggested previously, I believe that our efforts should be towards non-polarisation, and the solution found in edicts which I will call "non-legislation".

An example of what I mean by "non-legislation" is the recent revisions of the N.Z. Factories Act (see Appendix I). On first reading, this Factories Act amendment has all the appearances of real legislation which is designed to put teeth into protection of the worker from the employer. I suggest that it offers nothing new, and offer the following restatement of it as confirmation. "No employer shall ask an employee to work in a (noise) hazard area without protection from

the hazard. If any employer should do so, and any employee working in such an area suffers effects that could be attributed to the hazard the employer shall be deemed responsible, and pay just compensation." It becomes obvious that this is not new law, and has been accepted as just by the employer in the cases of eye accidents, lead damage, etc. Note: This particular 'non legislation' is in fact quite similar to English common law in that learned judges have found it to be an amiable and equitable decision for hearing loss cases when there was no specific written guide.

Of course it was the previous factory act upon which these learned judges gave their award. Other decisions on noise have been made under the Police Offences Act, 1927 (see Appendix II); Traffic Regulations 1956 limiting the use of warning devices and Regulation 66, (see Appendix III); Section 34A of the Town Planning Act 1953, which deals with noise as an objectionable element in the use of land; and Regulation 190A, Civil Aviation Regulations 1953; which requires that engines removed from aircraft should be silenced for testing. It is interesting to note that this Civil Aviation Regulation specifically allows certain noises to be made (see Appendix IV).

Under civil law (i.e. rights between citizens) we have laws related to nuisance and negligence. These laws range widely, but are succinctly summarised in the textbook "Law of Torts", by Fleming, 4th ed. P348 (see Appendix V). It is pertinent that New Zealand judges have accepted for submission the English law with regard to the pertinence of sound levels as a "reasonable document".

It is appropriate to point out that New Zealand law on noise may see some drastic changes in the near future as the Board of Health has called together a "Committee on Noise". The sixteen people on the Committee are calling various other specialists to help deal with their terms of reference "To consider the adequacy of existing measures to control noise and to make such recommendations as it considers appropriate bearing in mind present legislation and future needs".

I propose that we can meet the future needs with what I have defined as "non-legislation". I offer a review of my contacts with the results of the changed factories act in support of this claim.

It has reminded the employer of his responsibility to the place whereabouts he takes action. It is true that most of them think of their new interest as taking action to protect themselves from the law rather than the protection of the workers. None the less I have talked to more than 1,000 people representing management who were reacting to this law, as compared to some 50 people taking such an interest in the eight years previous to the passing of this law. Other activities that I have noticed because of this law include an interest in audiometric tests, and in having plant noise studies conducted.

In relation to the subject of hearing loss I offer a few facts which you may find of use in judging the importance of legislation. Nearly 20% of our population at large, sustain a hearing loss of 30 decibels by the age of 55. (Soft sounds require more than 3,000 times as much energy in order to be heard. The International standards level considered a "significant loss of speech communiction".) Almost 90% of our heavy industry population [those working a 40 hr. week in 100 dB(A)] suffer such damage. Strict compliance with the present law could reduce those with such a loss in the heavy industry down to 50%.*

ISO/TC46. Recommendation 1999. Assessment of Occupational Noise Exposure for Hearing Conservation Purposes, Table 5.4.

If the medical officer used 80dBA rather than 90dBA as the guide point for the legislation this risk percentage would be reduced to 27%. Because all people do not comply with 'non-legislation' we cannot expect to reduce the hearing loss in all of these cases. It may make it easier to understand why we do not get compliance with this type of legislation when it is pointed out that less than 10% of those who do have a claim go through the procedure of claiming.

For those of you who would ask what would I call real legislation, I offer - "Any employer who allows a worker to enter a hazard area shall be fined $X, for every occurrence established. Any employer who requests an employee to enter a hazard area shall be fined $X, plus $Y per day thereafter until the hazard area is fixed."

I recognise that the enforcement of real legislation could reduce the heavy industry hearing loss to close to the 20% of the normal run of population, but I support 'non-legislation' as a slower but better solution because it does not cause "polarization" within our society. However, this philosophy of governing least and best, does require education of all concerned towards what are their common interests, and how these can be obtained by co-operation.

I offer my comments towards writing 'non-legislation' for the previously mentioned cases.

1. Has been answered by the Factories Act Amendment 1971.

2. (Under zoning laws) No heavy industry shall be allowed to introduce equipment which will cause a sound level of more than 45 dBA at a residential boundary, or 55 dBA at a light industry boundary, or 65 dBA at a medium industry boundary. This would also require similar laws for medium and light industry.

   (Under general) Any industry which receives a complaint in relation to a noise that it produces shall take all practical steps to reduce this noise to a minimum.

3. As I understand the aircraft legal situation no laws are liable to be written owing to the lop-sided strength of those interested, but it seems that various pressures could be put to bear towards such considerations as choosing turbo-prop aircraft in preference to jets.

4. The new motor vehicle laws should be written to follow the laws written for England with 2 to 3 years delay to the English time sequence.

5. The present warrant of fitness law in New Zealand allows the inspector a good deal of leeway, and complete decision making on whether he authorises a warrant of fitness, and on many aspects of testing he has less guidance than he would receive from a sound level meter when testing the mufflers of cars. I therefore recommend that warrant of fitness inspectors be empowered to refuse the warrant to noisy vehicles.

6. Sounds originating at a residence must obey the same regulations at the property boundary lines that industry is required to obey. Particularly to the aspect of taking all practical steps to reduce any sounds complained of. Special consideration should be assigned to the hours 11 p.m. to 7 a.m.

APPENDIX I

THE NOVEMBER, 1971 AMENDMENT TO THE FACTORY ACT

5. Protection from harmful noise - The principal Act is hereby further amended by inserting, after section 67, the following section:

67A. (1) If, in the opinion of the Medical Officer of Health, any noise arising from any process or activity carried out in any factory is likely to cause impairment to the hearing of the persons employed therein the occupier shall take all such steps as may be practicable to prevent those persons from being exposed to that noise.

(2) If, in the opinion of the Inspector, it is not practicable to prevent exposure to the noise by reducing the noise level of the process or activity, or by isolating or insulating the process or activity, the occupier shall cause all persons exposed to the noise to be provided with a personal ear protection device of a type approved by the Medical Officer of Health.

6. Duties of persons employed - (1) Section 74 of the Principal Act is hereby amended -

(a) By omitting from subsection (1) the word "wilfully", and substituting the words "without reasonable cause", and

(b) By omitting from subsection (1) the words "in pursuance of this Act".

(c) By omitting from subsection (1) the words "under this Act".

(d) By omitting from subsection (2) the words "wilfully and".

(2) The said section 74 is hereby further amended by adding the following subsection:

(3) Every person who acts in contravention of or fails to comply with the provisions of this section commits an offence against this Act.

7. Regulations - Section 79 of the Principal Act is hereby amended by omitting from subsection (1) the words "health of" and substituting the words "health or impairment of the hearing of".

APPENDIX II.

POLICE OFFENCES ACT 1927.

Section 3 (x) provides that every person is liable to a fine not exceeding $50.00 who "wantonly or maliciously disturbs any inhabitant by ringing any doorbell, knocking on any door, blowing any horn, beating any drum, using any other noisy instrument in any public place or ringing any fire bell".

Section 3(cc) provides that the same penalty is applicable to any person who "sets off any fireworks or explosive material in or on any public place or so near thereto as to endanger, annoy or frighten the passer-by".

Section 3(dd) provides for the same penalty in respect of any person who "disturbs any public meeting or any meeting or any lecture, concert or entertainment or any audience at any theatre whether money is charged or not from such lecture, concert, entertainment or theatre".

APPENDIX III.

Regulation 43 of the Traffic Regulations 1956 provides that except for an efficient warning device, no person shall operate a motor vehicle if it is equipped with a bell, siren or whistle and no person shall at any time use a warning device otherwise than as a reasonable traffic warning or make any unnecessary or unreasonably loud, harsh or shrill sound by means of a warning device.

Regulation 66 of the Traffic Regulations 1956 provides "no person shall operate a motorcycle unless it is fitted with a silencer which is effective and in good working order and is so constructed or adapted that it is impossible to interfere readily with the operation or effectiveness of the silencer at any time".

APPENDIX IV

Regulation 190A Civil Aviation Regulations 1953 provides that noise and vibration may be caused by aircraft at any licensed aerodrome or authorised place so long as - (a) the aircraft is taking off or landing, or (b) the aircraft is manoeuvring on the ground or water or sea, the engines are being operated in the aircraft (1) for the purposes of pre-take off run up, or (2) for the purpose of ensuring their satisfactory performance, or (3) for the purpose of ensuring that the instruments, accessories or other components are in satisfactory condition.

APPENDIX V

TEXT BOOKS ON THE LAW OF TORTS

by Fleming 4th ed. p 348

"In order to be an actionable nuisance, there must be an inconvenience materially interfering with the ordinary comfort physically of human existence not merely according to elegant and dainty habits of living but according to plain and sober notions among our people. There is a vast difference between noxious vapours from the stacks of alkali works and an occasional whiff of unpleasant smoke from a household incinerator or domestic chimney, between the shrill and relentless noise of circular saws, of a speedway track or jet engines and the sounds coming from a nursery, music room or even residential accommodation used by students in a proper manner. No-one can claim the law's assistance "to cut a swathe of silence around him" and object to the singing of a religious congregation at reasonable hours, but the blare of Salvation Army bands from early morning to late at night on Sundays or the persistent and early ringing of street bells may well exceed the bounds of tolerance".

"The character of the neighbourhood has an important bearing on the standard of comfort to which the Plaintiff is entitled. Certain districts, by reason of random growths or conscious planning, have come to be devoted primarily to industrial, others to residential or agricultural purposes. The more exclusively an area is given to one type of enterprise, the more likely that a different activity is unsuited to it. Social friction is therefore most effectively minimised by compelling new-comers to accommodate themselves to the prevailing conditions of the neighbourhood. The man who makes his home in an industrial area which is inevitably noisy and smoke-producing cannot expect the same standards of immunity from pollution as a person living in a residential district, although even he must not be subjected to an unreasonable increase in the amount of discomfort. Likewise, an industrialist setting up a factory must select a site suitable for such a project. This often poses for him a difficult problem which sometimes can be resolved only by securing statutory authority. Unaided by legislation, the Courts are faced with this task of "judicial zoning" by rightly giving more weight to the demands of stable, as distinct from a changing, society."

OVERSEAS NOISE LEGISLATION - WHAT CAN WE LEARN FROM IT?

by

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1.0 INTRODUCTION.

Noise pollution, like air and water pollution, is largely a consequence on the man-made environment, the result of the application of technology without first considering fully the impact upon people. To the extent that it is man-made, it is not likely to go away, but will undoubtedly become more serious unless effective strategies are developed for its control.

Australia, like most other industrialised and high-density urban societies, is joining battle with excessive noise rather late. The problem has existed for a long time. Yet it is encouraging to realise that we are joining battle before the problem has reached the proportions of a crisis. We are in a position to plan our attack on the problem, to hopefully minimise the cost to our society of remedying the results of improvident use of technology, to learn, wherever possible, from others who have started before us, if not that much before, what fruitful steps they have taken to attain and ensure a continuing quality of environment.

Most technically well developed countries exhibit and have exhibited for a number of years, a degree of concern toward the problem of environmental noise. In the past decade or so an increasing number of countries have transformed their concern into concrete action, developing specific methods for controlling the problem to a sensible level. Of the arsenal of weapons at their disposal, most have chosen the legislative process as their prime method for control.

To attempt within the limits of this paper to evaluate the effectiveness of such legislation is perhaps a foolhardy task, because any proper evaluation must necessarily demand an appreciation of the manner in which different governments operate, the relationships between state, local and federal levels of government, the extent of direct control that government exerts over industry and so forth. Yet, if these factors can be overlooked in the first instance on the reasonable (?) assumption that governments are objective in their desire to control environmental pollution, it would seem possible to establish a gross picture of the effectiveness of overseas legislation. This has been attempted with respect to hearing conservation and industrial noise, and community noise annoyance as it relates specifically to people.

In this paper, we first examine the problems faced by state and local governments in legislating for noise control. Next we look at what federal governments are doing in this area and attempt to assess the success of their efforts. Finally, we summarise the lessons learnt. We conclude that, overseas, the attack on noise has been most successful when spearheaded by federal rather than state or local governments. We see a recognition on the part of governments that technology must be guided to provide a quieter environment. There is evidence that federal governments are increasingly using their very considerable purchasing and funding powers to this end. We find, however, that it is too early yet, to determine how effective such legislation has been although the prospects appear encouraging.

2.0 GOVERNMENT ACTIONS.

In many countries noise legislation seems, traditionally, to have been the province of local and state governments in the first instance. This

is, perhaps, to be expected, since people do tend to turn first to their local and state government representatives when confronted with an environmental problem. In some countries, such as the U.S.A., however, it has been due in no small measure to the fact that many federal governments have, in the past, taken the position that the matter of noise abatement is a local concern. In recent years, though, there has been a positive move on the part of many such federal governments to adopt basic responsibilities for noise abatement in those areas where state and local governments have been found wanting or unable to be properly effective. An increasing number of countries have set up or are now setting up environmental ministries which define national standards for the control of the noise of transportation vehicles, construction equipment, and machinery in particular.

It is too soon at this time to determine properly how effective such ministries are in tackling the problems of noise in a country. All that is possible, really, is to look at the matter from the other point of view, examine how well state and local governments have assumed responsibilities in the area and assess whether actions proposed by federal governments offer what may be deemed a more effective approach.

2.1 STATE AND LOCAL GOVERNMENTS.

In the past, most anti-noise legislation developed overseas at the local or state government level has been remedial rather than preventive and has tended to rely on vague words such as "unreasonable", "unusual" or "unnecessary", to describe excessive noise. In some cases, the legislation has not extended beyond nuisance laws. Only occasional standards define measureable permissible noise levels. Even then the use of the word "objective" is in question since so often, it is apparent that governments have copied legislation developed by other governments and, as is seemingly the nature of things, have either copied bad legislation or applied basically good legislation to their own situation without sufficient accommodation for differences between their situation and the one for which the legislation was originally intended. A classic example of this is to be found in the U.S.A. where the City of Chicago noise ordinances developed in the 1950's (and recently modified) have been adopted in full by cities of all shapes and sizes from rural centres to busy metropolises.

Whatever, regional governments seemingly have experienced trouble in enforcing what may be considered reasonable anti-noise legislation. In fact, the only type of anti-noise ordinance which, it would appear, has proved easily enforceable, is that which completely prohibits a certain type of noise such as horn blowing in the streets.

A number of possible reasons can be put forward as to why regional government anti-noise ordinances developed overseas seem to have been less effective than desired. If we can take the U.S.A. about which so much information is available on this score, as a microcosm of the situation, the evidence (1,2)* suggests the following:

- The state or local government is often the greatest source of noise itself. The major forms of transportation are usually owned by a public or semi-public body as are generally major items of construction equipment.
- The state or local government may be wary of imposing a significant economic burden upon companies by requiring

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* *Numbers in brackets refer to references quoted at the end of this paper.*

them to conform with anti-noise regulations, particularly if the companies are very important to the local economy.

- Such legislation usually relies for its enforcement on overworked police forces and health inspectors and the like, who rarely see noise as one of their more serious problems.
- Even if an anti-noise ordinance defines a noise standard in decibels, the fact that many sources of noise are moving or vary in time, or do not permit practical, on-the-spot evaluation under controlled conditions, makes it very difficult for a conviction to be achieved in court if the basic information has been obtained by other than an "acoustical expert".
- No single source of noise may be excessive with respect to an ordinance but the noise level in the community may be uncomfortably high if a system approach has not been adopted in the establishment of the ordinances.
- Federal governments in some countries have largely pre-empted the authority of regional governments to regulate noise in certain fields which concern closely the safety of the public or the national interest. One such field has been aircraft operations, a common source of excessive noise in many communities*.
- The community may be faced with a dominant source of noise outside of its control. An example is to be found in California where a small local government area is bounded on all sides by major freeways which totally dominate the noise environment in the area. The local governments had no say in the freeway planning and has no means presently at its disposal to force noise control measures to be implemented at the freeways.
- Most anti-noise legislation is remedial rather than preventive in nature and is applied only after significant economic interests have been vested.

Now, this is not to imply that all state and local government anti-noise legislation falls in the same mould. In fact, there are excellent examples of enforceable, precentive legislation at the state level, particularly in California in the U.S.A. and in the Land Nordrhein-Westfalen in West Germany. But in both these instances the states are theoretically in a position to exert considerable influence. They are both highly industrialised states which are, by themselves, economically comparable to many countries about them. They have both instituted preventive anti-noise legislation and encourage industries in particular to plan for noise control in the design stages of plants. However, both are still faced with federal government conflict in certain areas where the federal government has pre-empted authority. Thus it would seem that there is a lesson to be learnt in all of this; to be effective on a broad front, to avoid the introduction of unenforceable anti-noise legislation, the evidence suggests that the attack on noise should not be spearheaded by state and, or, local governments, the indication is that, to be effective, the attack on noise should be spearheaded by federal governments.

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* *It should be noted that recent policy changes have occurred in the U.S.A. which now permit state governments some influence in this area.*

The state and local governments must surely have an important part to play, but experience suggests that their respective roles should be defined within the context of a federal plan of action.

2.2 FEDERAL GOVERNMENTS

On the information available, it would seem that there are, at this time, but few countries whose federal governments have taken strong positive action to influence the control of the noise environment. To be sure, many countries have developed general policies and statements of intent which afford them or their regional governments the power to formulate laws, but in terms of objective, enforceable regulations aimed at promoting and achieving a quieter environment in a controlled manner, the number is small. This is unfortunately because what limited evidence there is (1, 2 and 3) suggests that without such regulations little will result from legislative efforts for the control and abatement of noise.

The stated policies towards noise pollution, of those countries who are coming to grips with the problem are similar in intent if somewhat variable in the intensity of feeling that they express, reflecting, it would appear, the roles that different federal governments feel their regional governments should play in the thrust towards control and abatement of noise. However, the basic concepts underlying their noise control laws and regulations, although often unstated, seem to be typified well by those stated by the Federal Republic of Germany. First, individuals must not create noise that can be avoided. Second, noise normally associated with the operation of a given type of premises or site must also be normal for the locale in which the source is located or on which it impinges. Third, a given noise source must be so designed and fabricated that its noise emissions are reduced to a level compatible with current knowledge on how to suppress emissions from that source or type of source.

A composite, as it were, of the anti-noise legislation for those countries is given below, covering in a brief overview, the approaches used to control and abate noise in the troublesome areas of industrial noise and transportation and community noise in general.

- INDUSTRIAL NOISE —— IN-PLANT.

  With some exceptions, the countries that are tackling this problem define a noise criterion equivalent to 90 dB(A) - 90 decibels on the A-weighted scale of a sound level meter - as a standard which must be met over the course of a working day if undue risk of damage to hearing is to be avoided. A notable exception is the U.S.S.R. which defines a noise criterion equivalent to 85 dB(A), the reduction in the criterion level being related as much to an awareness of the "...unfavourable influence of excessive noise on those functions that insure normal functioning of the (human) organism and its capacity to work (3)", as on the problem of hearing damage. Another exception is France, which in a decree of April 1969, stated that a level of 80 dB(A) should not be exceeded except that with existing equipment a criterion level of 95 dB(A) would be acceptable. From all accounts, it would appear that the U.S.A. will soon become an exception, too, as it is expected (4) that their basic criterion level will soon be reduced to 85 dB(A).

  All the countries in question make allowances for the duration of exposure to excessive noise and describe methodologies for determining

an equivalent working day exposure. These methodologies are somewhat similar in behaviour, allowing increases of from 3 to 5 decibels per halving of exposure time, with the exception of the U.S.S.R. system which is quite stringent, permitting no upward adjustment in the level of noise until the exposure time has been reduced to no more than $1-\frac{1}{2}$ hours in a working day of 8 hours.

Provision is generally made, too, for the effects of impulsive noise. Here, the various laws tend to differ considerably, but this, however, is an indication of the less than adequate state of knowledge in this area.

The different legislation tends to stress the need for sound protection through feasible administrative or engineering controls. The use of personal protective equipment is not encourages except as an interim measure while engineering controls are introduced, or where there is no apparent feasible means of engineering or administrative control. Audiometric programmes are required in some cases and suggested in others, if the noise exceeds a certain level.

The U.S.A. legislation adopts the position that a certain percentage of people will suffer undue hearing loss even at "safe" noise levels in terms of the basic criterion. Thus it points out that satisfaction of the 90 dB(A) noise criterion does not absolve the plant owner from responsibility if personnel still suffer demonstrable hearing damage through exposure to the plant noise environment.

Very few countries provide stiff penalties for non-compliance with the law. Certainly penalties do not seem to be framed in terms of criminal and civil punishments; rather fines (and small ones generally) are levied on the offender. Perhaps the stiffest penalties are to be found in the U.S.A. where non-compliance with the requirements of the Occupational Safety and Health Act (OSHA) can result in fines up to $10,000 and, indeed, in the worst case, in the possible forced closing down of a plant. If the plant in question falls under the auspices of the Walsh-Healey Public Contracts Act too, the company in question may be denied the right to bid on U.S. Government contracts for a period of up to three years. The legislation is largely preventive in nature. Its potential to influence the environment is enormous if for no reason other than the ability of the federal government to influence industry through the government's very considerable purchasing power.

- INDUSTRIAL NOISE —— COMMUNITY.

A number of countries have directed their attention at the federal level towards legislation aimed at preventing the intrusion into adjoining communities of excessive noise from industrial plants. Generally speaking, such legislation defines permissible property-line noise levels for different classifications of areas or zones, taking account of the period of the day and of the proximity of one type of zone to another.

There is considerable disparity between different countries on what are appropriate noise levels at a property-line. For example, for industrial areas bordering on residential areas - a poor situation

at best - the basic criterion ranges from about 40 to 55 dB(A) with generally complicated adjustment procedures to be implemented to account for the effects of time duration of the noise, characteristics of the noise, and so forth.

Many countries, including Great Britain and the U.S.A. see this problem as a local rather than a federal government responsibility. In at least one country, Great Britain, planning authorities consider the noise a plant will make in the surrounding area before deciding whether to permit introduction of the plant into the area.

- TRAFFIC NOISE.

Traffic noise constitutes one of the most important sources of noise in a community. There are two aspects of concern. First, there is the noise of the individual unit. Second, there is the noise of the highway upon which many vehicles may travel at any one time.

At this point in time, as far as it has been possible to determine, the U.S. Government is the only government which has legislation which can be used to influence highway design to lessen and hopefully control to a sensible level, the impact of highway noise on the communities through which a highway passes. This is a direct outcome of the fact that the federal government, through its federal aid highway programme, essentially controls highway funding in the U.S.A.

Perhaps surprisingly, the U.S. Government has not yet seen fit to introduce legislation governing the noise produced by individual vehicles. This, it has left, so far, to the State of California and, more recently, to the City of Chicago, whose legislation on this matter it would seem may be adopted far and wide in the U.S.A. The Chicago legislation, similar in intent to that proposed by the government in Great Britain, but more far reaching, is designed specifically to encourage manufacturers to develop quieter vehicles in accordance with a defined set of milestones. Specifically the legislation calls for a graduated step down in noise levels over the course of this decade of up to 13 dB(A) depending on the vehicle type. It forbids the sale in the city of any new vehicle which does not comply.

Other countries also have legislation governing motor vehicle noise. However, such legislation defines set noise level limits, not offering a graduated step down programme for noise abatement. In at least one case, that of Japan, the penalty for non-compliance is, first, a fine, then, possible forfeiture of driving papers for both the driver and the vehicle. In France, imprisonment can result.

- AIRCRAFT NOISE.

Without exception, federal governments pre-empt the authority of state and local governments to legislate on aircraft noise levels. In many countries aircraft noise is by far the most regulated area of environmental noise at the federal level.

Recently the U.S.A. introduced a system of type certification procedures for aircraft noise, a move which, it would seem, will be followed elsewhere. This type certification is applied to both domestic and foreign aircraft (imported into the U.S.A.) of the subsonic transport or subsonic turbojet powered category. It defines noise standards which new aircraft and existing aircraft (which undergo an "acoustical change") must be able to meet if they are to operate within the U.S.A.

It has the power to rule out SST flights in the U.S.A. In addition, the U.S. Government has formulated a noise abatement programme requiring the retrofit of existing subsonic turbofan engine powered aircraft as a condition to their further operation from a future date.

A most important part of U.S. legislation as it relates to aircraft (and airport) noise is that of airport development controls. The federal government uses its funding power to ensure that an environmental impact statement is drawn up and found acceptable before government funds are put into airport development which, in the U.S.A., is generally undertaken by State public agencies or, sometimes, by local governments. In this regard, if the project is a selection of a new airport site, if it is a non-metropolitan area, the communities in which the airport is to be located have a de facto veto power over the granting of an application to build. The project can only proceed then if it is found that there is no feasible and prudent alternative.

Such legislation does not yet exist outside the U.S.A. as far as is known.

- GENERAL COMMUNITY NOISE

Community noise intrusion with respect to industrial and transportation sources of noise has already been discussed. One important area that has not yet been touched on is construction noise.

Construction noise is controlled at the federal level in only a limited number of countries. Many governments prefer, apparently, to delegate responsibility for such noise to the local government level along with many other community noise problems of a quite general nature. However, in such cases, governments have tended to influence what happens at the local level anyway, by developing model ordinances which, regrettably, so often do not present objective standards but regulate only the hours within which construction work is permissible.

One country where construction noise is being tackled at the federal level is the Federal Republic of Germany. Here the legislation is very comprehensive. Not only does it define an assessment procedure whereby construction noise can be gauged against defined permissible noise levels for different zones, but it also provides substantial information on measures for reducing construction noise. Much the same is done in Switzerland, too, with the exception of the description of measures for control. In Japan, the law is equally as objective, but only requires that the constructor give proper notification of his intent to operate construction machinery and the methods of noise control that he proposes to use if necessary. If the constructor violates the law and ignores the advice of the local government on the matter, then he can be fined or possibly imprisoned for up to one year.

In a general sense, the federal regulations of many governments seek to influence the control of the community noise environment through careful land use planning requirements, reflected typically in their zoning ordinances which promote the separation of industrial areas from residential areas by commercial areas and the like.

The above provides only the briefest picture of overseas federal legislation in the field of noise control. To round it out, it is now pertinent to ask the question whether such legislation is effective on two counts. First, does it prevent noise problems by encouraging noise control in the planning stages of a project as well as being a remedy for existing problems? Second, does it tend to channel technology, creating incentives for a quieter technology?

Now most of the federal legislation discussed above is quite recent in origin. A clear exception is that for the U.S.S.R., much of whose legislation was formulated (with some changes since) in the 1950's. Thus one might imagine that the U.S.S.R. experiences would provide a useful insight into how well objective, enforceable standards influence the noise environment, particularly in the area of occupational noise exposure which is their strongest area of coverage, though also in other areas such as transportation noise and residential and city noise. However, the answer is a surprising no! There has been an apparent lack of enforcement despite the force of the law.

Why this should be so is not known, although technical writers on the subject (3) postulate a number of likely reasons including the following:

- Poor organisation of the administrative system responsible for enforcement, althought it is considered doubtful that things would improve even with better organisation.
- Noise pollution has a low priority compared with water and air pollution.
- Factory managers and regional officials have no incentives to encourage them to protect the environment but, rather, have many pressures on them to ignore it.
- Politically speaking it would seem that the proponents of noise abatement and control do not have the influence to get the sustained attention of top Soviet leadership, nor does their cause have the priority given to national security or increased industrial production.

If these are the reasons, then surely the western countries are potentially exposed to the same problems in their hopes for a quieter environment, too. Yet the prospects seem much more encouraging, at least in some areas, than one might expect, particularly in those relating to industrial noise and traffic noise and, to some degree, general community noise, as can be seen from the following brief examples.

Occupational Noise Exposure.

Noise regulations pursuant to the Walsh-Healey Public Contracts Act were published in the Federal Register of the U.S.A. on 20th May, 1969. These regulations required that federal government supply contractors ensure in their plants that employees not suffer noise exposure in excess of a prescribed equivalent level of 90 dB(A) in an 8 hour working day.

At least one industry in the U.S.A., the petroleum industry, has been motivated considerably by this Act to reduce in-plant noise levels. A noise reduction on the order of 5 to 10 dB(A) has been achieved in some acoustically critical types of plants, bringing them into conformance with the regulations. The designs of all new plants now incorporate noise specifications which suppliers of equipment must meet if they wish to tender. The result has been the development of practical solutions for noise control for many types of equipment and an increase in awareness on the part of many manufacturers concerning the acoustical performance of their machines, to the point where many now freely provide acoustical performance guarantees together with general equipment guarantees.

As might be expected, this has resulted in an increase in the cost of plant. The American Petroleum Institute estimates that plant noise control for its members costs somewhere between ½% and 7%

of the total plant cost depending on the complexity of the problem, and, tied in with these numbers, the proximity of the plant to a community.

Industrial Noise in the Community.

Industrial plants in Great Britain have been successfully designed to conform with the requirements of the British Standard BSS4142 relating to the community noise environment. Control is exerted at local government level in accordance with national policy.

Construction Noise.

The stimulus of anti-noise legislation in Land Nordrhein-Westfalen, Federal Republic of Germany, has resulted in significant gains being achieved in the control of the noise produced by a variety of construction equipment. Reductions on the order of 6 to 8 dB(A) have been obtained for equipment such as diesel driven compressors, hydraulic dredges, tow-rope dredgers and wheel derricks whereas nearly 20 dB(A) has been achieved for a pile driver.

General Community Noise.

The U.S. Government, Department of Housing and Urban Development (HUD) has established a policy concerning noise conditions at building sites for which Federal assistance is sought. The policy is (2) "... to foster the creation of controls and standards for community noise abatement and control by general purpose agencies of State and local governments, and to support these activities by minimum national standards by which to protect citizens against the encroachment of noise into their communities and places of residences."

Three mechanisms for noise control are used:

1) Financial planning assistance programmes require adequate consideration of noise as an integral problem in an urban environment.

2) New construction sites are not approved for financial support if the site is acoustically unacceptable as defined by the standards promulgated, and

3) Existing construction may not be rehabilitated with HUD financial support unless it comes within the standards.

By these means, HUD directly [and through its subordinate agency the Federal Housing Administration (FHA)]uses its financial strength to influence recognition of the need to consider the noise environment.

While these examples are limited in their scope and certainly do not allow general conclusions to be drawn concerning the usefulness of what is considered objective legislation in channeling technology toward a quieter noise environment, they certainly provide an indication that such can be the case. It is to be regretted, however, that the examples do not provide much insight into the respective roles that federal, state and local governments can fruitfully play beyond suggesting that the purchasing power and financial influence at the federal level can be used successfully to assist regional governments in their efforts to improve the quality of the environment. The information available, the experience reported, are just too scanty at this early stage.

3.0 CONCLUSIONS

This brief overview of overseas legislation reveals only too well the embryo stage of development of effective anti-noise legislation in the world today. It is considered sufficient, however, to show that unless the legislation has teeth and is effectively enforced, the legislation may just as well not exist. Furthermore, the evidence suggests that state and local governments are poor initiators of anti-noise legislation since they generally lack the real power required to carry it through and, in addition, are often major polluters themselves.* What does show up in the overview is that federal governments should be the architects of environmental reform. Perhaps working through state and local governments, a federal government can affect the quality of the environment in the best manner by introducing anti-noise legislation which is:

1. Preventive rather than retrospective.
2. Objective in stating noise criteria in terms of measurable numbers.
3. Realistic in terms of the current state of knowledge in noise control but such as to promote the creation of a quieter technology by delineating graduated "step down milestones" in a noise abatement programme.
4. Enforceable and enforced, whether through economic or other pressures.

The time is now. The longer we wait, the harder it will surely be. We need to get rolling down the road of environmental control.

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* *Federal governments can be just as guilty too. However, if anyone has to stop polluting first, it has to be them if an environmental control programme is to evince a strong measure of credibility.*

OVERSEAS NOISE LEGISLATION—BUILDINGS AND THEIR EQUIPMENT

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1. INTRODUCTION:

In some overseas countries buildings and construction projects are the subject of recommendations, whilst in others they are the subject of requirements for noise abatement and control. (13, 19)

In general, the recommendations and requirements on noise abatement and control in buildings apply primarily to dwellings, with particular emphasis on apartment buildings and their sound insulation needs. However occasionally noise limits for equipment such as elevators, heating and air conditioning plant, and domestic appliances are included.

Overseas attempts to reduce noise from construction projects have been more successful in those countries where the abatement and control statements are in the form of requirements rather than recommendations.

2. SOME NOISE ABATEMENT AND CONTROL RECOMMENDATIONS AND REQUIREMENTS SUMMARISED:

Note: This is a partial list of countries, and the coverage given those listed is not uniform in content. The countries not included and some that are will be covered and expanded respectively in a further paper, currently under preparation.
Although many of the following recommendations and requirements centre on International Standards Organisation (I.S.O.) publications, particularly in regard to the measurement of airborne and impact sound transmission, each country discussed has introduced special features of its own. (2, 7, 11.)

2.1 AUSTRIA (2, 12, 18)

In Austria, noise abatement and control has been covered in a number of Federal and State recommendations and requirements. For example, BGB1. No. 272 is a requirement concerning special noise abatement measures for convalescent and spa areas.

(i) **Sound Insulation and Noise Limit Recommendations for Apartment Buildings, ÖNORM B8115**

The sound insulation recommendations are in two categories:
(1) minimum and
(2) preferred.

Sound insulation of walls between flats:
(1) I.S.O. reference curve
(2) I.S.O. reference curve + 5dB

Airborne sound insulation of floors between flats:
(1) I.S.O. reference curve
(2) I.S.O. reference curve + 5dB

Impact sound insulation of floors between flats:
(1) I.S.O. reference curve —3dB
(2) I.S.O. reference curve + 7dB

Flanking transmission is covered by statements on flanking walls and floors.

The limits for noise produced by domestic equipment are:
quiet area, 25dB (A),
urban area, 35dB (A) and
industrial area, 45dB (A).

(ii) **Success of ÖNORM B8115**

Recent measurements undertaken by the Austrian Testing Laboratory for Heating and Acuostics showed that 60% of the structural elements on which the measurements were made failed to meet the recommendations of B8115 regarding sound insulation, that 30% of all elements met the recommendations of category (1) regarding minimum sound insulation, and that only 10% met the recommendations of category (2).
This high failure rate was attributed to ÖNORM B8115 not being a requirement and to the sometimes high noise levels due to indirect transmission and from plumbing installations.

(iii) **Construction Projects**

Although there are no national requirements limiting construction noise emissions, one of the main provisions in the Building Regulations is to ensure that construction work is carried out with the mimimum of noise.

Municipalities often require the use of noise treated equipment, particularly air compressors, and there is a trend for noise abatement measures to be stated in the contract between builder and client.

In 1971 Vienna drew up its own recommendation on construction noise, which was due to become a requirement in January 1972, and which limits noise from construction equipment to 100 dB(A), measured at a distance of one metre, after December 1974. Maximum permissible noise levels for residential, mixed and industrial areas are also stated for day and night, with the possibility of more stringent requirements for areas abutting schools, hospitals, churches and other noise sensitive activities.

2.2 CANADA (5)

Sound insulation requirements are contained in the National Building Code of Canada 1965, issued by the Associate Committee on the National Building Code of the National Research Council. For various occupancies, it states maximum noise levels likely to be produced and maximum extraneous noise levels acceptable, and requires walls and floors separating major occupancies to have transmission losses of "not less than the difference between the maximum level produced by one occupancy and the maximum acceptable level of extraneous noise for the adjacent occupancy."

Some examples are:

	max. airborne noise produced by occupancy, dB	max. airborne level of extraneous noise, dB
classrooms	80	40
operating and clinical rooms in hospitals	80	40
dwelling units, all rooms	80	30
offices	80	50

The code also provides examples of construction deemed to satisfy three sound transmission class categories:— Rating 1, STC $\geq$ 50; Rating 11, STC 45 to 50; and Rating 111, STC $<$ 45,

Three rating categories are also used to grade construction for insulation against impact sound transmission.

2.3 DENMARK (1, 2, 6, 18)

Although no requirements dealing specifically with noise exist in Denmark, the Building Act authorises the promulgation of requirements to prevent noise.

The first Building Act of 1960 has been followed up with national building requirements which are reviewed frequently. These requirements include statements on sound insulation between dwellings in terms of maximum permissible levels for living rooms and stairwells, and on limits for noise emitted by technical installations. In addition, the Act provides for the promulgation of requirements governing permissable noise levels from sources outside buildings. Recent research into noise problems associated with town planning has resulted in draft requirements prescribing minimum distances to buildings from various types of roads.

(i) **Sound Insulation and Noise Limit Requirements for Apartment Buildings, Building Regulation for Housing in Town and Country, 1966. Chapter 9 Sound Insulation.**

Sound insulation between rooms in different flats:

Rm (mean room insulation) = 49dB. Room insulation also specified as I.S.O. reference curve — 2dB.

Transmission loss in terraced houses between living rooms, kitchen and/or bathroom in one house and any room in adjoining house:

at least 52dB. Also specified as I.S.O. reference curve + 1dB.

Transmission loss for partitions (walls) bounding a flat:

at least 50 dB. Also specified as I.S.O. reference curve.

Transmission loss in terraced and semi-detached houses for walls between living rooms, kitchen and/or bathroom in one house and any room in adjoining house:

at least 53 dB average. Also specified as I.S.O. reference curve + 3dB.

Airborne sound transmission loss for floors and ceilings bounding a flat:
at least 52dB. Also specified as I.S.O. reference curve + 2dB.

Impact sound transmission loss for floors and ceilings bounding a flat:

Hz:	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150
dB:	65	65	65	65	63	61	59	57	53	53	51	48	45	42	39	36

Transmission loss for doors leading from flats to staircases, landings and corridors common to several flats:
at least 30dB.

Flanking transmission is covered by statements on flanking walls and floors.

Reverberation time in common staircases and landings:
$\not>$1.5 seconds above 500 Hz.

Reverberation time in common corridors:
$\not>$1.0 seconds above 500 Hz.

The limits for noise produced by domestic equipment are:

in living rooms, 30 dB(A), up to 35 dB(A) between 7.00 a.m. and 8.00p.m.; in kitchens, 35 dB(A).

The limits for noise produced by running water are:
in living rooms, 35dB(A); in kitchens, 40dB(A); in bathrooms, 40dB(A).

(ii) **Sound Insulation and Noise Limit Requirements for Buildings other than Apartment Buildings**

For hotels, hotelpensions, houses of the aged and college dormitories:
as for apartment buildings.

For schools and other educational buildings:
as above, with the exception of auditoria, where the mean room insulation should be at least 47dB (also specified in 1/3 octave bands from 100 to 3150 Hz), and the reverberation time should be between 0.6 and 1.0 secs.

For office buildings, common technical installations must not increase noise levels beyond 35dB(A).

(iii) **Construction Projects**

Although there are presently no national requirements limiting construction noise, local authorities can and do limit it, and draft requirements are currently under consideration. These requirements propose that the Ministry for Housing be given the authority to limit construction noise emissions to 70dB(A) from 6.00 a.m. to 6.00 p.m. It also proposes that the Ministry issue a circular to local authorities on methods for enforcing the requirements and on techniques for construction noise abatement.

2.4 FEDERAL REPUBLIC OF GERMANY (WEST GERMANY) (2, 11, 18)

The basic federal requirements on noise in West Germany are the Trade and Industry Code of 1869 (as amended) and the Law on Protection Against Construction Noise of 1965 (as amended), which requires the issuing of a permit for construction and/or alteration projections which may cause noise nuisance to neighbouring properties. In addition, a general administrative requirement issued in 1968 includes a statement that permission to erect new premises can only be granted when current noise protection measures are employed and when specified noise immissions are not exceeded.

(i) **Sound Insulation and Noise Limit Requirements for Apartment Buildings. DIN 4109.**

Airborne sound insulation of walls and floors between flats:
minimum, I.S.O. reference curve; recommended, I.S.O. reference curve + 3dB.

Impact sound insulation of floors between flats:
minimum, I.S.O. reference curve; recommended, I.S.O. reference curve + 10dB.

Flanking transmission is covered by statements on flanking walls and floors.

The limit for noise produced by domestic equipment: 30dB(A) (30 DIN phon).

(ii) **Success of Sound Insulation Requirements**

A recent survey of sound insulation in West Berlin, instigated by the Senator for Housing, showed considerable improvements since 1958 to 1962, when standards DIN 18165 and DIN 4109 were made requirements. For example, the mean impact sound insulation for floors constructed on "floating" screeds had improved by 6dB in the course of six years.

(iii) **Construction Projects**

The Law for Protection Against Construction Noise, mentioned above, applies to the immissions and emissions of construction machinery used at a construction site for

erection, alteration, maintenance and demolition of structures. If the machinery causes a predetermined ("evaluational") level for a given zone to be exceeded by more than 5dB(A), then corrective measures must be taken. The "evaluational" level is determined from the measured level, with adjustments for the average daily operational duration of the machinery.

Included in this Law are recommendations and requirements regarding site layout, location and operation of machinery, noise propagation characteristics, noise screens, damping devices, and means of replacing internal combustion engines with electric or suction motors.

The present Noise Construction Law (1968) states immissions that are permissible into various zones as well as emissions permissible from machinery. The immission limits can be as high as 70dB(A) if adjacent land is industrial, and as low as 35dB(A) if adjacent to a hospital zone at night.

2.5 FRANCE (2, 14, 18)

As of early 1971, there was still no comprehensive, national requirement regarding noise. Building noise is regulated by Decree 69-596 of June 1969. Article 4 of this Decree requires compliance with sound reduction statements, set by the Ministry of Logistics and Housing and the Ministry of Social Affairs, of 30 to 50 dB(A). Houses under construction receiving Government aid must comply with the sound insulation requirements of December 1963.

(i) **Sound Insulation and Noise Limit Requirements for Apartment Buildings**

Airborne sound insulation of walls and floors between flats:
100 — 320Hz, Dn = 36dB; 400 — 1250Hz, Dn = 48dB; and 1600 — 3200Hz, Dn = 54dB.

Impact sound insulation of floors between flats:
100 — 320Hz, Ln = 66dB; 400 — 1250Hz, Ln = 62dB; and 1600 — 3200Hz, Ln = 51dB.

The limits for noise produced by domestic equipment are:
in bedrooms, 30dB(A); in living rooms, 35dB(A).

(ii) **Construction Projects**

Decree number 69-380 of April 1969 gives local authorities the power to requir that, if construction noise is likely to be a nuisance, noise emissions must be reduce below a pre-determined nuisance level. However this Decree contains no detaile statements on noise abatement design or construction procedures.

2.6 GERMAN DEMOCRATIC REPUBLIC (East Germany). (2, 18)

Standard TGL 10687 "Measures for Preserving Public Health" (January 1965), based on recommendations of the Soviet-bloc Council for Mutual Economic Assistance (COMECC is a comprehensive document which includes statements on permissible noise levels in outside buildings, on sound-proofing, on city planning, and on structural design.

(i) **Sound Insulation and Noise Limit Recommendations/Requirements for Apart Buildings. TGL 10687**

Airborne sound insulation of walls and floors between flats:

1.S.O. reference curve — 1dB.

Impact sound insulation of floors between flats: 1.S.O. reference curve.

Flanking transmission is covered by statements on flanking walls and floors.

The limits for noise produced by domestic equipment are:
7.00 a.m. to 10.00 p.m., 30dB(A);
10.00 p.m. to 7.00 a.m., 25dB(A).

(ii) **Construction Projects**
The Instruction Relating to Issuance of Licenses of February 1963 requires builders to describe the manner in which they will protect surrounding areas against noise.

2.7 GREAT BRITAIN (3, 4, 21, 22).

The Noise Abatement Act, 1960, is the only act of Parliament designed specifically for the control of noise.

(i) **Sound Insulation and Noise Limit Requirements for Apartment Buildings and Houses.**

(a) **England and Wales**

Part G of the Building Regulations, 1965, incorporates statements on sound insulation based on standards formulated by the Building Research Station. No definite performance requirements are stated and the separating element, wall or floor, is only required to have "adequate" sound insulation. However the intention of these Regulations is understood to be that all separating walls in dwellings should have sound insulation equal to the B.R.S. House Party Wall Grade, and that all separating floors in dwellings should have sound insulation of at least Grade 1.

The Regulations also provide examples of construction deemed to satisfy the requirement of "adequate" sound insulation.

(b) **Scotland**

The Building Standards (Scotland) Regulations 1963 incorporate the standards on sound insulation formulated by the B.R.S. and require all new buildings to have airborne and impact sound transmission losses of not less than these standards, as follows:

airborne sound—for separating walls of houses other than flats, House Party Wall Grade; for walls and floors of flats, Grade 1.
Impact sound—for floors of flats, Grade 1.

(ii) **Construction Projects**

In practice, the Noise Abatement Act (1960) has not been satisfactory in reducing noise from construction projects, and many local governments have invoked their own requirements. For example, some localities have requirements governing noise from mobile air compressors based on recommendations issued by the National Federation of Building Trades Employers.

A circular issued by the Ministry of Public Buildings and Works, "Noise Control on Building Sites", describes procedures for limiting construction noise and recommends maximum boundary emission levels from construction sites of 70dB(A) for rural and suburban areas without heavy industry, and of 75dB(A) for areas with heavy traffic or industry. In addition, a recent report by the Noise Advisory Council, "Neighbourhood Noise", recommends that the tendering contractor should be advised on maximum permissible construction emissions by the local authority, and that if these limits are not met suspension of the works should be ordered by a magistrate.

2.8 HOLLAND (2, 11, 18)

(i) **Sound Insulation and Noise Limit Recommendations/Requirements for Apartment Buildings. NEN 1070**

Airborne sound insulation of walls and floors between flats:
insulation index for protecting a sensitive room—quality moderate, 0dB; quality good, + 3dB.

insulation index between two sensitive rooms—quality moderate, -3dB; quality good, 0dB.

Octave band values—Hz	250	500	1000	2000
dB	38.5	48.8	55.3	56.8

Impact sound insulation of floors between flats:
insulation index for protecting a sensitive room — quality moderate, 0dB; quality good, + 3dB.octave band values — Hz 250 500 1000 2000
dB 72 70 67 58

Flanking transmission is covered by statements on flanking walls and floors, with examples for normal, > normal and < normal flanking transmission.

(ii) **Construction Project**

One reference states that the provisions of the Model Building Regulations concerning noise are given by the national government to local authorities with the right to enact modified local requirements. A different reference claims that any local requirements promulgated must conform in content to the Model Building Regulations.

2.9 ISRAEL (2)

Israel's only requirement dealing specifically with noise is that of the Ministries of Health and of the Interior, passed in 1966. It deals with noise in residential quarters and is at present under review.

The Planning and Building Law of 1965 might also be used in building noise abatement and control. It states that "schemes to be made at different levels should include provisions for insuring appropriate conditions in respect to health, sanitation, cleanliness, and for abating nuisances." It is considered that this Law is administered effectively, and recent urban planning separates industrial from residential areas. However the extensive inclusion of light industry and workshops in basements or on first floors of residential buildings has resulted in a wide-spread, and as yet unsolved, noise problem.

2.10 ITALY (2,14)

Italian requirements on noise are limited and, in general, appear to be fairly ineffective. National requirements which could encompass noise in and from buildings are Art. 659 which provides penalties for making noise disturbing to sleep, and Art. 844 CC of the Civil Code which includes a statement that "no owner of land can prevent emissions of .....noise.....from neighbouring properties unless they exceed a certain tolerable limit determined as relative to the local conditions."

2.11 JAPAN (2, 17)

In August 1968 the National Government established the Noise Abatement Law (No. 98) which was separate from the Basic Pollution Law (No. 132) of 1967. Law No. 98 deals only with construction, industrial and business noise emissions. Under this Law, buildings to be protected form construction noise emissions include dwellings, schools, libraries, research

institutes and hospitals. The contractor is required to give notification prior to operating certain types of machines on the methods of noise control to be used. If he violates this Law he is liable to a fine or to imprisonment.

In Tokyo a variety of recommendations and requirements on noise in buildings and from construction projects exist, the earliest of which dates back to 1949. Currently the city is considering limiting noise levels from businesses which are open after midnight.

Japan's Building Code includes sound insulation statements which appear to be based on the I.S.O. reference curves for airborne and impact sound transmission losses.

2.12 NORWAY (2, 11, 18, 20)

Although no national pollution requirements exist in Norway, recommendations regarding noise control are being developed for Design Manuals on land planning and on housing.

The Building Regulations of 1969 establish maximum levels for noise from technical installations of 35dB(A) in living rooms and 40dB(A) in kitchens. (These correspond to those specified by Denmark, (see above)). Results of a survey conducted on sanitary installations by the Norges Byggforsknings Institutt in 1969 showed that noise from washbasins, sinks and W.C.'s generally gave rise to some problems, while noise from bathroom fittings and kitchen plumbing is well above the Regulations' limits.
It appears that at present Norway works to Denmark's noise insulation requirements for its buildings (refer page S4c-4), but there are no requirements specifically on construction noise. However maximum levels for construction noise are sometimes stated in the contract between client and builder.

2.13 POLAND (2)

In Warsaw, the head of the Institute for Building Technique has recommended desirable noise levels for defined areas, based on noise measurements made in various Polish cities. Some of the recommendations are as follows:

area	noise level inside building	max. external noise level	proposed noise level
industrial area near railroad	45*	100—120*	60—70*
streets with street cars and buses	35	85—90	60
residential areas with houses	35	80	50
schools, hospitals	15—25	60	40

* It is not stated whether these noise levels are in dB or dB(A).

2.14 SOUTH AFRICA (2)

The history of sound insulation in South Africa dates back to 1949 when recommendations regarding minimum airborne and impact sound insulation were propsed by the Sub-Committee on Noise of the Research Committee on Minimum Standards of Accommodation. The topics covered included aspects of building construction such as cavity and special party walls, plumbing noise, and "floating" floors.

2.15 SWEDEN (2, 10, 14, 18)

In 1969 environmental protection came into force incorporating requirements on noise control for buildings, although the sound insulation requirements regarding dwellings appear to have been promulgated in 1967.

(i) **Sound Insulation and Noise Limit Requirements for Residential Buildings SBN67**
Airborne sound insulation for walls and floors of semi-detached houses.
Between living rooms, ISO reference curve +3dB; between store rooms and living rooms, ISO reference curve.

Sound insulation of walls for other residential buildings:
between living rooms, ISO reference curve; between store rooms and living rooms, ISO reference curve —4dB.

Airborne sound insulation of floors for other residential buildings:
between living rooms, ISO reference curve +1dB; between store rooms and living rooms, ISO reference curve —3dB.

Impact sound insulation of floors for semi-detached houses:
between living rooms ISO reference curve +2dB; between living rooms and store rooms, ISO reference curve +2dB.

Impact sound insulation of floors for other residential buildings:
between living rooms, ISO reference curve +2dB; between living rooms and store rooms, ISO reference curve —3dB.

Flanking transmission is covered by statements on flanking walls and floors.

Limits for noise produced by domestic equipment are:
in living rooms — 8 p.m. to 7 a.m. = 30dB(A) and 7 a.m. to 8 p.m. = 35dB(A); turning on and off water taps in bathroom = 40dB(A).

in kitchens = 35dB(A); turning on and off water taps = 40dB(A); turning on and off water taps in bathroom = 45dB(A).

(ii) **Construction Projects**
The effectiveness of the existing requirements on construction noise has recently been the subject of an investigation by the National Swedish Building Research Council, and its report "Building Noise as a Social Problem" contains recommendations to increase their effectiveness, some of which are as follows:

—noise levels from construction projects in the vicinity of residential buildings should not exceed 65dB(A), from 6 a.m. to 11 p.m., or 50dB(A) from 11 p.m. to 6 a.m.,
—provision for prior consideration of noisy construction projects should be included in the Public Health Code, i.e. a builder would have to obtain permission from the local public health board in cases where the noise level would not be kept within prescribed requirements.

2.16 SWITZERLAND (2,11,18)

Switzerland does not have any federal requirements dealing exclusively with noise. The Federal Division of Police is at present responsible for co-ordinating all anti-noise measures at the federal level.

In 1957 the Swiss League Against Noise, with the support of the Swiss Federal Council, called a "Federal Expert-Commission for Noise Abatement". This Commission formed five sub-commissions including one on construction and industrial noise, vibration protection in residences, etc. After five years of research, the Commission concluded its work with a report to the Federal Council which has had a substantial effect on noise abatement, including that for buildings, throughout Switzerland.

In addition to this work, recommendations on noise protection in residential construction have been published by the Swiss Association of Architects and Engineers (S.I.A.), and in May 1970 these became requirements.

Zurich has conducted an active noise abatement campaign for at least the past four years and has established an Office of Noise Abatement under the city's police department. Some of the campaign requirements are:

—household appliances may be used only if their noise does not interfere with neighbours, and garbage collectors must observe all noise abatement procedures,

—bowling alleys must be designed to contain noise within the structure, and restaurant and nightclub operations must not produce excessive noise,

—singing, and use of musical instruments and of tape and record players are permitted only if third parties are not affected adversely,

—costs of monitoring noise measurements at construction sites must be borne by the builder if the prescribed maximum levels are exceeded.

(i) **Sound Insulation and Noise Limit Recommendations/Requirements for Apartment Buildings**

Airborne sound insulation of walls and floors between flats:
minimum, ISO reference curve; recommended, ISO reference curve +3dB.

Impact sound insulation of floors between flats:
minimum, ISO reference curve; recommended, ISO reference curve +10dB.

Limit for noise produced by domestic equipment: 30dB(A).

(ii) **Construction Projects**

The Swiss limits allow construction projects to raise neighbourhood noise levels by a fixed amount, but only permit peak emissions for small percentages of the time. A six number system states nominal noise levels for each of six land use zones. Construction noise is permitted to exceed these levels by an amount determined from the relative duration of the noise expressed as a percentage of the working day, as follows:

Portion of working day when construction noise occurs	amounts by which nominal noise limits may be exceeded
20%	5dB(A)
5%	10dB(A)
1%	15dB(A)

Note: typical working hours (Zurich) are 8 a.m. to 12 noon and 2 p.m. to 7 p.m., but construction work may be obliged to finish earlier.

In Zurich a requirement has been promulgated and used to shut down many construction sites when they cannot meet stated noise limits. In general, no machine may emit more then 85dB(A) at a distance of seven metres, and for construction equipment less than 100 lb. weight the limit is 80dB(A). The City of Bern has similar requirements.

2.17 U.S.A. (8, 9, 15)

In February 1972 the Senate and the House of Representatives of the 92nd Congress passed the Noise Control Act which includes requirements dealing mainly with transport vehicle, construction and commercial noise emissions. In addition, various U.S. cities, such as Chicago (Illinois) and Inglewood (California) have requirements which include limits for noise nuisance from and to premises and from construction projects. Model requirements have also been compiled and are available for adoption by many U.S. cities.

(i) **Sound Insulation and Noise Limit Requirements for Buildings**

In the U.S.A., sound insulation and noise limit requirements for new apartment and office buildings are generally contained in building codes.

The New York City Council has drawn up a code requiring the reduction of "airborne noises travelling from one apartment to another through wall partitions or floors or coming from a public hallway; the quietening of machinery such as central air conditioning; and limitations on noises through ventilators, shafts, ducts, and outlets, as well as noises emanating from a neighbouring building." The New York City Board of Estimate recently withheld approval of Tracy Towers apartments in the Bronx until the builder agreed to include certain noise reducing structures. Of more general application, the Federal Housing Administration has included impact noise rating requirements in its minimum property standards, as well as recommendations for airborne, impact and structure-borne noise control.

In addition to the building codes, requirements of certain cities limit noise to and from buildings and from their equipment. For example, Ordinance No. 2018 of the City of Inglewood limits "excessive" noise adjacent to schools, hospitals and churches, and states the following noise emission limits for machinery (e.g. pumps, fans, air conditioning equipment and swimming pool apparatus), used in any residential zone:

7 a.m. to 10 p.m. (day), 60dB(A) (also specified in octave bands),

10 p.m. to 7 a.m. (night), 50dB(A) (also specified in octave bands).

Adjustments to these base levels are included for pure tone components (—5dB), for impulsive or transient characteristics (—5dB), and for duration.

(ii) **Construction Projects**

Power to draw up limits for construction noise is provided by the 1972 Noise Control Act.

In Chicago, operation of construction equipment is banned between 9.30 p.m. and 8.00 a.m. within 600 feet of any residential or hospital building, and the limiting noise emissions from construction machinery are as follows:

manufactured after January 1 1972, 94dB(A)
manufactured after January 1 1973, 88dB(A)
manufactured after January 1 1975, 86dB(A)
manufactured after January 1 1980, 80dB(A)

All noise emissions must be measured according to the relevant American Standards of Recommended Practice.

In Inglewood, operation of construction equipment is banned between 10.00 p.m. and 7.00 a.m. within 500 feet of any residential zone, or within a residential zone.

2.18 U.S.S.R. (2)

The U.S.S.R has had requirements on noise since 1956, most of which are in the form of administrative law promulgated by the various ministries.

A relatively high percentage of the population lives in housing particularly vulnerable to noise — non-airconditioned multi-residential buildings, constructed of prefabricated concrete panels and arranged around courtyards. In an attempt to regulate noise from and in

buildings, the U.S.S.R. has three approaches: control of emissions into housing areas (e.g. from industry and traffic), control of building design and construction, and control of residents' behaviour. Noise sensitive buildings such as schools and hospitals are considered as special cases demanding stricter control.

(i) **Sound Insulation and Noise Limit Requirements for Housing**

U.S.S.R. requirements on noise in residences and similar buildings are as follows:

rule	number	date	application
SN	337—60	1960	noise levels inside apartment houses and noise-sensitive buildings
SN	535—65	1965	supersedes SN 337—60
SN	41—58	1958	location of housing with respect to city traffic for reductions in noise immissions
I	104—53	1953	directives on noise control
SN	39—58	1958	through building design and
SNiP	11.V.6	1962	construction

SN337—60 gave the following statements for maximum noise immissions into apartment buildings:

8 a.m. to 10 p.m. (day), ISO octave band curve index No. 30; ≙ 35dB(A).

10 p.m. to 8 a.m. (night), ISO octave band curve index No. 25; ≙ 30dB(A).

However, these statements have been relaxed by 5dB for buildings whose windows face a neighbourhood street, and by 10dB for buildings whose windows face a main city traffic route. SN337—60 required monitoring noise measurements to be taken in furnished rooms; if the rooms were unfurnished readings could be 3dB higher to allow for reverberation effects. In addition, if impulse or pure tone noise was present, 5dB was deducted from the permissible level.

SN 535—65 incorporates the features of SN 337—60 but is more comprehensive. It states noise limits both inside and outside apartment buildings, and factors included in determining the maximum permissible levels are: time of day, season of the year, proximity of major roads, duration of the noise, and type of district. The unadjusted maximum noise immissions stated are:—

	ISO curve no.	dB(A) equivalent
inside rooms of apartments	25	30
outside apartment buildings (courtyards, recreation spaces)	35	40

The various adjustments are added to or subtracted from these base levels.

SN 39—58, together with I 104—53 and modified by SNiP 11.V.6.62, cover noise abatement practices to be observed "by all design and building organisations" for the sound insulation of "apartment houses, dormitories, hotels, schools, children's institutions, hospitals and public administration buildings". No noise limits are stated,

but points covered include: suitable locations for kitchens, sanitary facilities, dining rooms, boiler rooms, elevators, pumps, garbage chutes, water and sewage pipes, and structures containing intense noise sources; isolation mounting requirements for equipment such as electric motors, pumps and transformers; and construction guidelines for party walls and doors.

SNiP 11.V.6.62 gives more specific construction statements, in particular with regard to the minimum allowable attenuation for airborne and impact sound through walls, floors and ceilings. These attenuations are stated by examples of wall and floor construction deemed to satisfy the attentions required.

With regard to residents' behaviour, a requirement passed in 1966 makes the creating of a nuisance, including noise nuisance, in a public place "insulting" to the social order and, as such, a minor criminal offence punishable by a fine or by corrective labour.

(ii) **Construction Projects**

There appear to be no requirements dealing specifically with noise from construction projects, however requirement GOST 11870(1966) "Standardization of measuring and labelling noise emission of machinery" makes it compulsory for noise emissions of all new U.S.S.R. manufactured machines to be measured under standard conditions. This presumably includes all machines used for construction projects.

(iii) **Success of Requirements**

Enforcement of the U.S.S.R. requirements is not strong. Many examples of non-enforcement are cited in the literature, and it is claimed that the noise provisions of the building codes are probably some of the most poorly enforced. Also, in trying to meet the requirements, designers often select certain types of construction deemed to satisfy which, in practice, do not provide the required performance.

(iv) **Moscow**

In 1960 the Moscow City Council passed a stricter version of the Federal Law on disturbing the peace which applied to all public places including communal apartments and dormitories, streets, etc.

In 1969 the Moscow City Council outlined the progress to date in noise abatement, and announced its future abatement plans in the resolution "On Means to Reduce Noise Levels in the City of Moscow". These included: designs to ensure a reduction in the noise from various types of equipment installed in residential buildings, stores, and catering enterprises; permissible noise limits for equipment and domestic appliances; and ways of controlling noise from night deliveries to stores, especially those located in residential buildings.

The executive committee of the Council has demanded that night operation of compressors, excavators and bulldozers at construction sites be restricted. In addition, the main Moscow Housing Administration recently became involved with the problem of noise within buildings, and since then more than three hundred buildings per year have been soundproofed or had noisy installations removed.

2.19 YUGOSLAVIA (2)

Yugoslavia's few noise requirements have been passed in the last three years, although government agencies have been monitoring a variety of noise sources for over ten years.

The law "Noise Insulation in Buildings" of August 1970 states the permissible level of noise in new buildings, and requires the sound insulation properties of building materials to be tested. However, this Law does not provide detailed statements regarding noise control in buildings such as theatres and radio and T.V. stations, and for these building types architects refer to the American Standards Association (A.S.A.) and the Association of German Engineers (V.D.I.) documents.

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THE NEEDS AND INTENTION FOR AUSTRALIAN LEGISLATION.

by

M. Hunt.

1.0. TYPICAL NOISE EXPOSURES

2.0 COMPARISON OF TYPICAL COMMUNITY NOISE AND HEARING LEVELS WITH CRITERIA.

3.0 SOME MATTERS OF "BASIC INTENTION" THAT COMMONWEALTH AND STATE GOVERNMENTS SHOULD CONSIDER WHEN DRAFTING LEGISLATION FOR NOISE CONTROL.

1.0 TYPICAL NOISE EXPOSURES

The noise level around us can vary in a range of 75-85 dB(A) for 80% of time as in downtime areas of large cities or from 15-30 dB(A) in remote locations in National Parks. This noise comes from many commercial, industrial and general community activity sources.

The 1963 "Wilson Report" to the United Kingdom Government reported the "Nature, Sources and Effects of Noise" resulting from an extensive survey. This is a widely acclaimed report even though it is 9 years since it was completed and it has been used in recent books by K.D. Kryter 1970 U.S.A. and W. Burns 1968 U.K.

The Wilson Report concludes that the origins of noise which disturb people at home, outdoors and at work are those as shown in the following table extracted from that report:

TABLE 1. NOISES WHICH DISTURB PEOPLE AT HOME, OUTDOORS AND AT WORK

Description of Noise	Number of People Disturbed per 100 questioned		
	When at Home	When Outdoors	When at Work
Road Traffic	36	20	7
Aircraft	9	4	1
Trains	5	1	-
Industry, Construction Works	7	3	10
Domestic, Light Appliances	4	-	4
Neighbours Impact Noise (knocking, walking, etc.)	6	-	-
Children	9	3	-
Adult Voices	10	2	2
Wireless, T.V.	7	1	1
Bells, Alarms	3	1	1
Pets	3	-	-
Other Noises	-	-	-

Typical ranges of noise sources which communities are subjected to are:

From Aircraft 90-105 dB(A)
From Rail and Tram Transport 85-95 dB(A)
From Construction Work 85-95 dB(A)
From Road Traffic 80-90 dB(A)
From (not within) Industry 45-50 dB(A)

A summary of some typical noise levels, some self-imposed, to which people within our urban and suburban communities are exposed are shown in the table "Typical Noise Levels of Some Common Sounds". It

can be seen that exposure to noise from domestic activities can be within the range of 70 dB(A) from a vacuum cleaner to 92 dB(A) for a power lawn mower.

During occupational activities within industry people are typically exposed to noise levels of the range from 80 to 105 dB(A) (i.e. large transformers to moulding machines).

TABLE 2. TYPICAL NOISE LEVELS OF SOME COMMON SOUNDS.

Noise Source or Environment	Sound Level dB(A)
Interplanetary Launcher at 300 ft.	200
Instant damage to ear	150
Severe Sonic Boom	130
Aeroplane Propeller at 15 ft.	130
Jet Take Off at 200 ft.	120
Discotheque	120
House party 4 piece Rock Band	110
Steel Riveter at 15 ft.	100
Jet Taking Off at Airport at 1000 ft.	100
Walking near a Helicopter	98
Train Stopping in a Station	95
Pushing a Power Lawn Mower	92
Inside Jet Aeroplane on Take Off	92
Heavy Diesel Propelled Vehicle at 25 ft.	92
Successful Cocktail Party	90
Medium Size Truck Max. Accel. at 35 mph at 50 ft.	89
Medium Size Car Max. Accel. at 35 mph at 50 ft.	87
Screaming Child	87
Printing Press Plant (medium size automatic)	86
Loudly Reproduced Orchestral music in Large Room	82
Ringing Alarm Clock at 2 ft.	80
Inside Compartment of Suburban Electric Train	76
3rd Floor High Rise Downtown Los Angeles Mean for Day	75
Inside Small Sports Car at 50 mph	75
Inside Small Sports Car at 30 mph	72
Busy City Traffic at Kerb	70
Vacuum Cleaner at 10 ft.	70
Typing Pool (9 typewriters in use)	65
Busy Restaurant or Canteen	65
Household Department or Large Store	62
Self Service Grocery Store	60
A Large Office	55
Men's Clothing Department at Large Store	53
Ordinary Conversation at 3 ft.	50
Average Living Room	40
Soft Whisper at 5 ft.	34
Room in a quiet London Dwelling at Midnight	32
In a quiet Garden	30
Threshold of Hearing (Good Teenage Ears)	0

2.0 COMPARISON OF TYPICAL COMMUNITY NOISE AND HEARING LEVELS WITH CRITERIA.

A measure of the acceptability of the above commercial, community, domestic and industrial noise climate can be evaluated by a number of ways which include:

(1) Comparison with related standards established by organisations such as International Standards Organisation (I.S.O.), Standards Association of Australia (S.A.A.), etc.

(2) By comparing the results of extensive audiometric testing of communities with thresholds of hearing levels as defined by organisations such as I.S.O. and S.A.A.

In this regard, I.S.O. has published a recommendation R1999 "Acoustics - Assessment of Occupational Noise Exposure for Hearing Conservation Purposes (1971)" and another document R1996 "Acoustics - Assessment of Noise with Respect to Community Response (1971)". There has also been issued by I.S.O. in 1970 by ISO/TC43/SC1 "Draft Proposal for Hearing Levels of Non-Noise Exposed People at Various Ages (1970)".

S.A.A. has a number of documents out for public review or in the final stages of preparation and these include DR.72084 "Code of Practice for Hearing Conservation" and Doc. 1707 "Code of Recommended Practice for Noise Assessment in Residential Areas".

It is of significant interest to note that there are major differences of opinion expressed in I.S.O. R1999 and SAA/Dr.72084. The former of these two documents states categorically that hearing impairment for the reception of conversational speech is confined to the frequency range of 500-2000 Hz (cycles per second) whereas the S.A.A. document contends that frequencies up to 4000 Hz should be included in establishing the related standard. Also impairment as defined by the I.S.O. document is when a permanent threshold shift of 25 dB for the average of 500, 1000 and 2000 Hz has taken place. The S.A.A. document defines hearing impairment with a permanent threshold shift for any individual frequency as shown:

Audiometric Test Frequency (Hz)	500	1000	2000	3000	4000
Hearing Threshold (dB) above Stand and Auditory Response	25	20	25	30	40

There is attached a tabulation of:

"A COMPARISON OF OUTDOOR NOISE LEVELS FOUND IN 18 LOCATIONS BETWEEN WILDERNESS AND DOWNTOWN CITY WITH ACCEPTABLE COMMUNITY NOISE STANDARDS AS DEFINED IN ISO R1996 AND AN ESTIMATION OF THE VARIOUS RESPONSES OF THE CORRESPONDING COMMUNITIES TO NOISE."

A COMPARISON OF OUTDOOR NOISE LEVELS FOUND IN 18 LOCATIONS BETWEEN WILDERNESS AND DOWNTOWN CITY WITH ACCEPTABLE COMMUNITY NOISE STANDARDS AS DEFINED IN ISO R1996 AND AN ESTIMATION OF THE VARIOUS RESPONSES OF THE CORRESPONDING COMMUNITIES TO NOISE.

		Noise Level Exceeds L%			+ Type Zone Adj.	ISO R1996			dBA Excess	
		L10	L50	L90		50	35	30		
		D		N		D	E	N	D	N
A	3rd Floor Apartment next to Freeway	83	79	76	15	55	50	45	28	31
B	3rd Floor Hi-Rise, Down town Los Angeles	82	77	72	20	60	55	50	22	22
C	2nd Floor Tenement New York	75	70	65	10	50	45	40	25	25
D	Urban Shopping Centre	68	65	62	20	60	55	50	8	12
E	Popular Beach on Pacific Ocean	65	60		-					
F	Urban Residential near Major Airport	74	59	53	10	50	45	40	24	13
G	Urban Residential near Ocean	62	55	50	10	50	45	40	12	10
H	Urban Residential 6 miles to major Airport	62	54	48	10	50	45	40	12	8
I	Suburban Residential near R/R Tracks	58	53	47	5	45	40	35	13	12
J	Urban Residential	57	51	46	10	50	45	40	7	6
K	Urban Residential near small Airport	57	50	46	10	50	45	40	7	6
L	Old Residential near City Centre	56	50	45	20	60	55	50	-	-
M	Suburban Residential at City outskirts	57	48	42	5	45	40	35	12	7
N	Small Town Residential Cul-de-Sac	50	45	41	5	45	40	35	5	6
O	Small Town Residential Main Street	59	47	41	0	40	35	30	19	11
P	Suburban Residential in Hill Canyon	60	48	39	0	40	35	30	20	9
Q	Farm in Valley	45	39	35	0	40	35	30	5	5
R	Grand Canyon	30	21	15	-					

\+ Correction to Basic Criteria 40 dB for Residential Premises in Different Zones.

D = Day
E = Evening
N = Night

In Summary:

TABLE 4. ESTIMATED COMMUNITY RESPONSE TO NOISE

Locations	Excess dBA	Community Response
D, G, H, I, M	10	Widespread complaints
O, P	15	Threats of Community Action
A, B, C, F	20	Vigorous Community Action

It can be seen that the noise climates within typical urban and sub-urban areas as listed do not satisfy standards as defined by I.S.O. nor as has been drafted recently by S.A.A. In the correcting of the situation prudence and logic would result, when the cost of correcting has been estimated prior to determining the period of time over which such a correction should take place.

There is further attached a table showing:

> "ASSESSMENT OF THE ACCEPTABILITY OF THE HEARING LEVEL OF THE 55 TO 64 AGE GROUP IN THE U.S. 1960/62 NATIONAL SURVEY OF HEARING LEVELS WHEN RELATED TO VARIOUS USED STANDARDS FOR DEFINING HEARING IMPAIRMENT AND HANDICAP."

The most significant audiometric survey data that I could find in Australia was that done by the Division of Occupational Health for the Department of Public Health South Australia. Such a survey recently carried out over twelve (12) different types of industrial groups and totalling 1,211 persons in South Australia showed that hearing levels for comparable age ranges were higher than those in the U.S. Survey 1960/62. Therefore, any lack of acceptability of hearing levels of age groups in the U.S.A. would imply that the counterpart age group's hearing level in South Australia would be unacceptable. A comparison of the 56 to 65 age group from South Australian Industry with the 55 to 64 age group from the U.S. 1960/62 Survey for the various frequencies (re ISO R389) is:

Hz	500	1000	2000	3000	4000
South Australia	21.9	23.6	36.3	51.8	56.4
U.S.A.	13	8	12.5	31.5	38.0
Differences	+8.9	+15.6	+23.8	+20.3	+18.4

TABLE 5.

ASSESSMENT OF THE ACCEPTABILITY OF THE HEARING LEVEL OF THE 55 TO 64 AGE GROUP IN THE U.S. 1960/62 NATIONAL SURVEY OF HEARING LEVELS WHEN RELATED TO VARIOUS USED STANDARDS FOR DEFINING HEARING IMPAIRMENT AND HANDICAP.

Various Standard of Reference	Assessed Equiv. Hearing Level for 55 to 64 Years Age Group		
I.S.O.	L50%	L80%	L90%
25 dB H.L. for average of 500, 1000 and 2000 Hz	11.2	20	32*
S.A.A. Dr. 72084			
Hz H.L.			
500 25 dB	13	15	25
1000 20	8	15	20
2000 25	12.5	*30	*50
3000 30	*31.5	*60	*65
4000 40	38	*60	*70
C.A.L. Average Hearing Level. = 25 dB	11.3	*37.1	*46.7
British Occupational Hygiene Society 40 dB for average of 0.5 to 6.0 Hz	25	*42	*52
American Society of Ophtalmology and Otolarygology average for 500, 1000 and 2000 Hz - 24 to 40 dB Slight	11	20	*28
K.D. Kryter/A.A.O.O. dB Every day speech level) of 65 dB) 15	11	*20	*28
Conversational Speech) Level of 55 dB) 5	*11	*20	*28
Mean Conversation Speech) Level of 50 dB) 0	*11	*20	*28
Average for 500, 1000 and 2000 Hz			

* Denotes Standard not conformed to.

In the attachment referred to above it will be observed that the assessed equivalent hearing level for the 55 to 64 age group exceeds the defined impairment of hearing by I.S.O., S.A.A., C.A.L., British Occupational Hygiene Society, American Society of Ophthalmology and Otolaryngology and K.D. Kryter/AAOO for the (L50%) mean of this group, (L80%) the top 20% and (L90%) the top 10% of this group.

It can be seen that there is little doubt that the hearing level of the community by and large, as compared with any of the referred to standards, shows that there is excessive hearing impairment.

3.0 SOME MATTERS OF "BASIC INTENTION" THAT COMMONWEALTH AND STATE GOVERNMENTS SHOULD CONSIDER WHEN DRAFTING LEGISLATION FOR NOISE CONTROL.

Although the following are my own "basic views" on the above heading, as written they have been extensively taken from a number of U.S. Environmental Protection Agency's Publications of December 1971. "The World Health Organisation defines health as a state of physical, mental and social well being and not merely the absence of diseases or infirmity. Using this definition it is evident that noise can be considered as having an important influence on the health of man. Because of its pervasive influence in all settings, activities and walks of life it has often been cited as a major source of annoyance as well as a threat to physical and mental health. For most people, the usual consequence of noises are associated with interference with listening to speech or other sounds, distraction at home and on the job, disturbance of rest and sleep and disruption of recreational pursuits. All of the foregoing can be considered components of the quality of life"----

"Noise has a number of characteristics in common with other environmental pollutants. Its effects are biological, psychological and sociological. Another common feature shared is that it is extremely difficult to establish simple causal relationships between the pollutant and its consequences. The data associated with the effects of noise covers a broad range of conditions. At one extreme, a loud explosion can result in the destruction of the sensory receptors of the ears and consequently, total deafness. The other end of the continuum is represented by temporary physiological changes which often accompany exposure to "moderate" levels of noise. As might be anticipated, most of the available findings fall between these extremes and at the best, only probabilistic, rather than casual, statements can be made concerning effects. To complicate the position even further, the adequacy of the data base differs from discipline to discipline. Physiological consequences are better understood than psychological ones, and both disciplines are further advanced that sociological science with respect to noise effects.

Although many of the findings related to noise lend themselves to a variety of interpretations, there is general agreement on a number of factors.

1. Noises of sufficient intensity have caused irreversible hearing damage.

2. Noises have produced physiological changes in humans and animals that in many instances have not resulted in adaption.

3. The effects of noise are cumulative and, therefore, the levels and duration of noise exposure must be taken into account in an overall evaluation. The recognition of this fact has been translated into legislation specifying limits of total permissible noise exposure in industrial settings.

4. Noises can interfere with speech and other communication.

5. Noise can be a major source of annoyance by disturbing sleep, rest and relaxation.

6. When community noise levels have reached sufficient intensity, social action has occurred to reduce their effects. This has often taken the form of creating new organisations (or using existing ones) to press for regulations by means of laws, ordinances and standards."

The following is extracted from the summary and conclusions of the U.S. Environmental Protection Agency's Publication "The Economic Impact of Noise".

"Firstly, it is apparent that aircraft noise is presently a major problem with substantial economic costs.
Secondly, because of lack of data on noise levels and an inadequate understanding of the effects of noise it is difficult to assess the cost of noise within the home or from nearby highways and freeways.
Thirdly, if the trend of noise generators and in urban/suburban population concentrations continue, noise could become a much more serious problem in the near future.
Finally, practical as well as economic considerations suggest that it is generally preferable to attempt to abate noise at the source rather than insulate the receiver.

Industrial noise has already been recognised as a major problem by the (U.S.) Department of Labor's regulations promulgated under the Occupational Safety and Health Act of 1970. The data on the relationship between noise levels, productivity, accidents and employee morale and turnover are fragmentary at best. It is plausible to assert that noise in the industrial environment does influence the quantity and quality of output as well as labour turnover costs. The economic impact of these considerations could be substantial, but research is required before qualification of the economic costs of industrial noise is possible. -----

Most states (U.S.) have made estimates of the amounts of money that might be required to clean up the nations rivers and streams, but almost no effort has been undertaken in the area of noise. -----

An analysis is required of the economic trade-offs between the benefits derived by communities from highways and the costs of the associated noise. Freeways provide access to areas which could influence the relocation of industry and regional growth rates. Such benefits, however, must be weighed against the cost of highway noise abatement and

the cost of the noise itself.

Studies should be made to determine the economic impact of noise standards for products. The economic consequences of noise abatement on prices, G.N.P., employment, etc., will depend upon the "time frame" in which the abatement is effected. "Crash programmes" requiring immediate compliance could produce significant price increases and have an adverse effect on employment, foreign trade and productivity. The gradual "phasing in" of such standards, however, could avoid some of these consequences. Thus research efforts should be devoted to consideration of the time required on abatement regulations, the impact of manufacturers and on the price paid by the consumer.

Another important area of further research is an analysis of the effects that noise standards have on the competitive position of United States products in foreign countries. The combined effect of all environmental quality standards on changes in costs of production and therefore price should be appraised in view of the chronic balance of payments deficit witnessed by the United States during the past decade. The principal research effort should concentrate on changes in the relative prices of United States goods in world markets resulting from the cost of compliance to environmental quality standards versus possible reduction in imports into the United States because of foreign non-compliance with United States Standards.

There is, of course, the converse problem in that U.S. exports may not meet foreign noise standards. That is also worthy of further research."

An indication of the order of cost in developing a National Noise Control Programme is reported by the Environmental Protection Agency as follows:-

"Although federal spending for noise related activities has been growing slightly in recent years, the total for the fiscal years 1968 through 1971 is estimated to be slightly more that $100 million. Table 6 shows between 60 and 70 percent of total federal spending was made by the National Aeronautics and Space Administration, primarily for research and development activities for the Quiet Engine Programme and for the Super-Sonic Transport (SST) Programme.----- This means, of course, that in recent years only a small percentage of federal spending on noise related programmes has been directed toward highway, industrial and other noise abatement programmes. The Long Range Planning Service of the Stanford Research Institute forecasts that federal spending for aircraft noise abatement will decrease in relative importance as the Federal Government allocates more resources to reduce other sources of noise.

In contrast to spending for noise abatement, the Federal Government spent $613 million on air and $829 million on water pollution control and abatement activities in fiscal year 1970, according to the first annual report of the Council of Environmental Quality.

TABLE 6. ESTIMATES OF U.S. FEDERAL SPENDING FOR PROGRAMMES RELATED TO NOISE.

FISCAL YEARS 1968 TO 1971 - $'s MILLIONS

Federal Agency	1968	1969	1970	1971	Total
NASA	-	21.6	24.7	22.3[3])	
Dept. of Transportation	10.0	3.2	5.3	8.9)	103.3
Dept. of Defense[1]	-	2.1	2.7	2.5)	
Health, Education & Welfare	0.8	1.0	1.1	1.4	4.3
Dept. of Commerce	0.2	0.3	0.4	0.5	1.4
Housing Urban Development	0.3	0.3	0.5	1.0	2.1
Dept. of Interior	2	2	0.5	0.5	1.0
TOTAL	11.3	28.5	35.2	37.1	112.1

1. Primarily spent by the Air Force.

2. Not available.

3. Includes $4.67 million for NASA Acoustics Facility.

These are a few features of philosophy and planning that have been developed in the United States during the last year. Recently I have made a quick survey of the extent of investigation activities and actual knowledge that exists in Government Departments in various states and territories of Australia. This varies significantly from state to state but in the overall picture there is a significant void of detailed knowledge in many of the areas which are currently being considered for the application of noise control legislation.

There is an Ad Hoc Hearing Conservation Committee of the Occupational Health Committee within the National Health and Medical Research Council and their terms of reference in general is to define a "draft of models legislation for Hearing Conservation" for use by State and Commonwealth Governments. It is desirable that the problem of defining the correct and uniform approach to Community Noise Control should concurrently be considered and that a draft model legislation for this segment of the overall noise problem be defined. Both these studies should include an appraisal of the economic as well as the sociological and medical benefits and costs to the Nation that will result from the tackling of an undoubted problem of noise that exists in industry, commerce and the community. There are many significant costs in carrying out this difficult investigation and research into the status of health within the nation and it would appear basically wrong for such an expense to be incurred individually by each State Government as the total cost would be many times greater.

The financing of the investigation and of a sub-committee or committee's (with appropriate working groups) within the framework of the National Health and Medical Research Council would facilitate the allocation of the necessary funds by the Federal Government to bring such an important study to an orderly and timely conclusion.

If the various states individually as a matter of "urgency" develop and enact noise control legislation and regulations that are based on an inadequate background of basic quantitatively expressed knowledge ofthe many facets of industrial, commercial and community noise problems an unnecessary financial burden could be created without obtaining the optimum desired correction of those problems.

It is hoped that the subject matter contained within this paper can in some small way contribute to a broader and clearer appreciation of the extent and nature of the problem of noise in our midst to those who have either a casual or significant interest in this subject.

LIMITATION OF NOISE FROM THE APPLIANCE MANUFACTURER'S POINT OF VIEW.

by

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Chief Engineer - Engines, Victa Ltd., Sydney.

1.0 INTRODUCTION.

The purpose of this paper is to give an opinion, from the manufacturer's point of view, on the form which should be taken by legislation and/or an Australian Standard Specification intended to limit the noise produced by appliances in use by the general public.

The writer is in charge of Engine Design at Victa Limited, which firm manufactures lawnmowers powered by two stroke engines. His responsibility covers all aspects of noise reduction for the Company's products.

The writer's training and experience is in Mechanical Engineering and he is not an expert on either acoustics or legislation. However, over the past four years there has been considerable work done at Victa Limited on noise reduction. A description of this work will be given in so far as it influences an approach to noise control.

2.0 NATURE OF THE NOISE PROBLEM ON LAWNMOWERS.

There are four major sources of noise on a rotary lawnmower powered by a two stroke engine:-

1. Exhaust Noise

   This tends to be the most noticeable to bystanders.

2. Blade Noise

   In order to obtain adequate grasscatching, most 18 inch rotary mowers must be run at speeds in excess of 3,500 R.P.M. At these speeds blade noise is a significant factor, especially to the operator.

3. Engine Mechanical Noise

   Noticeable, mainly to the operator, when 1 and 2 are at reduced levels.

4. Air Filter Air Induction Noise

   Due to the closeness of the air filter to the operator, this noise can be an irritant at reduced levels of 1 and 2.

Sources 1, 3 and 4 have a prominent impulsive component.

The major items of equipment owned by Victa Limited are:-

Hewlett Packard	8052A	Impulse Sound Level Meter
	8055A	Octave Filter Set
	15109B	One inch Condenser Microphone.

In addition, there are oscilloscopes, piezoelectric vibration transducers, various sound isolating barriers and other equipment to separate sources, and other ancillary equipment.

As the firm does not yet possess an anechoic or reverberant chamber, measurements are carried out in an open area at a suitable distance from buildings and other reflecting objects. A check is maintained on the level of background noise.

Noise Assessment Techniques.

The aim was to develop a measurement technique such that good correlation was obtained between comparisons between sound sources made by ear and comparisons made using the instrument measuring technique.

Because of limitations set by equipment and time an exhaustive survey of known methods was not undertaken. Rather, work was carried out only to the extent required to find a reasonably satisfactory technique for the problem in hand, that is, the evaluation and reduction of the noise produced by the various sources on our product.

The Impulse Sound Level Meter in use is capable of measuring in four detection modes:-

1. R.M.S. Fast: time constant 0.1 seconds.
2. R.M.S. Slow: time constant 1 second.
3. R.M.S. Impulse: Time constant 35 milliseconds, meter reading stored with a decay time constant of 3 seconds.
4. Peak: indicating absolute peak, rise time less than 100 microseconds, discharging rate less than 0.1 dB/second.

Each mode has been tried in each of three methods:

A. Meter with A weighting filter.
B. Noise Rating Numbers.
C. Kryter method for measuring annoyance using octave filters.

Method A (A weighting filter) was found to be useful as an approximate method which could be easily applied, when used with an R.M.S. mode.

Method B (Noise Rating Numbers) was found to be of little value in any mode. This appears to be due to the complex nature of the noise spectra, which did not exhibit peaks consistently associated with a particular frequency.

Method C (Kryter method) in the impulse mode was found to give the most consistent results, although it requires good judgement on the operator's part in that he must ignore the occasional impulse above the average level - a chart recorder would be of assistance in this regard.

The Peak mode was found to be unsatisfactory in all methods because the sources measured appeared to have occasional peaks well above the average level.

The above description shows that, for our particular product at least, the rating of the noise produced as regards annoyance is not a simple matter and requires the application of a considered and careful technique.

3.0 THE NEED FOR CONTROL OF NOISE.

There is steadily growing public demand for control of all types of pollution. Manufacturers, such as ourselves, recognise this and are working on all aspects of these problems.

However, the noise problem is a little unusual in that the person creating the noise and closest to its source is likely to be the least affected by the problem he is creating. Thus, he may wish that his neighbour had bought a quieter lawnmower but be unconcerned at the noise level of his own.

Therefore, it is probably unrealistic to expect that buyer resistance will control the problem, especially when a substantial reduction in noise must result in some increase in cost of the machine.

In the writer's opinion, control of the noise problem in appliances requires the fulfilment of two conditions:-

1. That legislation requires that the user meet certain standards in his selection and use of the noise producing appliance.
2. That the manufacturer produce appliances which he certifies will enable the user to meet the required standards.

3.1 EXISTING LEGISLATION AND STANDARDS RESTRICTING THE NOISE OF APPLIANCES.

In Australia there is no current legislation or standard restricting appliance noise in a quantitative fashion.

Overseas, the U.S.A. and Canada have specified a noise level at the operator's position for powered lawnmowers. This level is 92 dB(A) for a "walk behind" rotary lawnmower. Germany and Sweden require that a powered lawnmower does not produce a noise level that is a "nuisance".

4.0 POSSIBLE METHODS OF CONTROL OF APPLIANCE NOISE.

Methods of control can be divided into two types:-

A. Where the noise measurement is made in proximity to any place where the appliance is in use.

B. Where the noise measurement is made under standardised conditions at the manufacturer's premises or at a testing laboratory.

Each method presents difficulties. The advantages and disadvantages are as follow:-

Method A - Noise Measurement Taken Where Appliance is in Use

Advantages

1. The exposure of the public to noise is more directly controlled, i.e. the measurement is taken at the point of actual annoyance. The surrounding conditions (such as distance from source, nearby buildings, intervening walls) are automatically taken into account.
2. The presence of more than one noise making appliance does not present any difficulty in control of the overall noise level.
3. Any modification of the appliance after manufacture is automatically taken into account.

Disadvantages

1. The fact that sound measurements are required at any place where the appliance is in use will tend to mean simplification

of measurement technique and equipment. As discussed previously, the use of simple techniques such as dB(A) measurements and Noise Rating Numbers tends to give an inaccurate result, onpowered lawnmowers at least.

2. It would be very difficult for a manufacturer to specify how his product would perform under the great variety of conditions encountered where appliances are used.

3. Before a member of the public could be certain of his grounds for complaint he would have to arrange a noise measurement. This may lead to the proliferation of amateur acoustics 'experts' and an unnecessary volume of complaints.

Method B - Noise Measurement of the Appliance under Standard Conditions Remote from the Area of Use

Advantages

1. The measurement technique can be as sophisticated and painstaking as is necessary to gain a fair and accurate result. This is possible because the measurement is carried out at a workshop or laboratory.

2. The performance standard for the appliance is clearly defined in terms of standard conditions so that the manufacturer is in no doubt about the ability of his product to meet the required level of performance. The customer can buy the product knowing that it has the standard of performance required for his conditions.

3. The legal position at the place of use of the appliance can be ascertained by a member of the public without the use of a sound measuring instrument. The factors involved would be ones such as time of day, the noise rating class of the appliance, which are relatively easily determined.

Disadvantages

1. Because no sound measurement is taken at the place of use, the control of the noise exposure of people near the appliance is less direct in that it depends on various conditions at the site as well as the noise classification of the appliance as determined at a laboratory.

2. The presence of more than one noise producing appliance is not easily allowed for.

3. The modification of the appliance after manufacture means that the appliance would have to be retested in a laboratory if there was any possibility that the noise produced had been increased by the modification.

Method B fulfils two criteria:-

1. The noise measurement of the appliance is done under standardised conditions.

2. It neither requires nor encourages the general public to involve itself in the complex business of acoustical measurement.

In the writer's opinion, these two factors tend towards a fair and convenient situation for the manufacturer and make for more easily implemented legislation for those whose responsibility is the control of noise pollution.

Therefore, Method B, despite its disadvantages, is preferred over Method A.

Outlined below is a suggested method of control based on Method B.

4.1 SUGGESTED METHOD OF CONTROL.

1. The noise level of the appliance (or a representative sample) would be measured accurately under closely specified conditions to ensure its compliance with a set standard of performance such that:-

   A. The noise produced at the operator's position was below the level which would cause permanent hearing damage under normal operating conditions.

   B. The noise level, encountered by people other than the operator under specified conditions, was not liable to cause annoyance.

   The system of measurement used would be such that it would accurately predict hearing damage and annoyance.

2. According to the standards complied with under (1) the appliance would be assigned a class designation which would be displayed on the machine.

3. According to the class of appliance, its conditions of use would be specified. Conditions of use could cover time of day, type of locality (residential, industrial, rural), distance from neighbour's dwelling, etc.

   For example, the class of appliance which covered domestic lawnmowers might be restricted in a residential area to use in daylight hours after, say 9.00 a.m. The class of appliance covering a larger, higher powered type of mower used by councils and contractors would, perhaps, be restricted to normal working hours, Monday to Friday in a residential area, but be unrestricted in a rural environment.

5.0 TIMING OF LEGISLATION.

It must be emphasised that the production of a mass produced article such as a powered lawnmower, involves tooling worth several hundreds of thousands of dollars. Reduction of noise from such a machine does not involve only one part, such as the muffler, but can require modification of virtually the whole machine, due to the varied sources which are radiating sound.

Design work and preparation for production must be prolonged and thorough and changes to the design cannot be made overnight.

It is essential that any legislation incorporate a phasing in period of several years and that manufacturers be consulted on proposed legislation.

6.0 CONCLUSIONS.

The main points that the writer has attempted to bring forth are:-

1. The rating of an appliance as to its noise annoyance is

too complex a matter to be carried out by simplified site measurements.

2. Products should be rated to safeguard the bystander from annoyance and the user from hearing loss.

3. Sufficient time should be allowed in legislation to allow the manufacturer to phase in changes without disruption to his production.

4. The manufacturer should be consulted on legislation which affects his product.

MORE ANTI-NOISE LAW - A NEED OR A NOTION?

by

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PREAMBLE

1.0 BASIS OF APPROACH

2.0 PROBLEM APPRAISAL

- 2.1 Scale of Acceptability/Dissatisfaction.
- 2.2 Fixed Limits - Real or Hypothesis?
- 2.3 Are Available Laws Unsuitable?
- 2.4 Neighbourhood Nuisances.
- 2.5 The Value of Instrumentation.
- 2.6 Environmental Therapy.

3.0 CONCLUSIONS.

PREAMBLE.

Noise is the symphony of the machine age and a permanent part of our life. It should be controlled like an orchestra.

Levels of noise and the degree of its social nuisance may be reduced. But is the result entirely satisfactory?

Halving the volume of a sound, although it might involve tremendous physical and economic effort, often has little effect upon its "nuisance" value to the human ear. Complete noise prevention, whether it be by reduction at the source or by soundproofing comes at a high cost.

The stand-out emphasis in this submission, therefore, is "reasonability and practicability". Is the need for additional legislation reasonable, and if it is, how practical can it be expected to be?

1.0 BASIS OF APPROACH.

Experience with the local authority of the largest industrial city in the country for three decades has involved scores of noise problems ranging from barking dogs to insidious sounds of industry. Solutions have varied from personal counselling to litigation. Most problems have been solved, others are under review, and still others are emerging. The conclusions made in this paper are, therefore, based on many case histories and may differ from a "text book" approach.

2.0 PROBLEM APPRAISAL.

Of the whole gamit of human activities performed, one could broadly say that there was only one activity which 95% of the population perform in the same way - sleep. The author has always considered the impairment of sleep the fundamental basis of community noise appraisal. This leads to the identification of social deviants and, in turn, spearheads corrective action.

2.1 SCALE OF ACCEPTABILITY/DISSATISFACTION.

As noise is a sociological problem, we must interview, appraise, counsel, require and if all else fails, place the problem before a Court for adjudication. In matters involving neighbourhood impairment, a strong view is held that each problem has its own "scale of acceptability" and, conversely, "a scale of general dissatisfaction". Reasonability must be the target. Measurable noise limits can be useful guides but on no occasion should these limits be used to displace good "sound" common sense. Have you noticed how little one is disturbed by nature's noises? A gale in the night can make a fearful noise, - so can rain lashing against a window - yet more people will retire to bed and sleep through it and ignore these natural noises. Yet the night-long traffic on a main road can disturb hundreds of people.

2.2 FIXED LIMITS - REAL OR HYPOTHESIS?

There is no correlation between the way in which different people live and use their homes. So we must have a measure which will cover the population at large. Having done this, we can then produce a relationship between some physical variables which we can measure and the growth of social annoyance. We can then put reasons forward why we should accept a limiting criterion for noise nuisance at a point along the scale.

The result must surely be hypothetical. It may not always be possible for technology to satisfy limiting statutory standards if they exist.

In these circumstances it is incumbent upon law makers to include certain "escape" provisions. This is normal, politically. Here is a great weakness in regulatory control. Advantage is taken by offenders wherever possible and precedents are created. Also, maximum prescribed limits are interpreted as the norm and the ambition to achieve a better standard disappears. The author has some knowledge of this occurring in other environmental disciplines established in recent years. As an environmental control tool, measurable limits prescribed by law may compound an already complex situation.

At best, statutory law is only a defacto attempt to resolve real problems. Precise limits in the global assessesments of an environment made up of multifarious noise ingredients could only be academic and seldom achievable. These comments, of course, are not intended to apply to controls on the noise output of individual components such as manufactured units and their operation.

2.3 ARE AVAILABLE LAWS UNSUITABLE?

These comments refer to the state of New South Wales and the functions of a local government authority. Certain provisions, wide in concept, are available as a quasi-judicial power to Councils. Local government is close to people and noise problems affect those people. With these powers properly exercised, much has been and can be achieved.

It is an unfortunate fact that an aggrieved person will do all that he can to influence a local authority to exercise its powers to control and regulate the use of premises or objectionable noises thereon. This employs public funds and resources to his benefit. Here experience and unemotional appraisal of the problem is important. It is factual to say that most complaints fall into the category of "private nuisances" for which the aggrieved has recourse at law, but declines to use it. A "Public Nuisance" is a different matter and, quite rightly, should be resolved under the leadership of the public authority.

What action should be taken in the case of environment noise nuisances? If formal action is contemplated, complainants are informed that the local authority will deal with the nuisance on the assumption that they will support it in any Court hearing. Whilst holding the opinion that a Health Surveyor offering evidence in noise control should be able to substantiate a case, the presence of aggrieved residents in Court to support the local authority is essential. The author had no "noise memory" and doubts if many people have.

Before recommending statutory action in which the local authority enjoys

quasi-judicial power it has been a firm policy that:-

1. Each elected member of the authority has a personal knowledge of the conditions being reviewed;
2. The party responsible for the conditions complained of is afforded the opportunity to be present or represented and submit reasons why statutory action should not proceed;
3. A majority decision is taken to invoke powers; or accept a suitable compromise.

This procedure is very effective.

2.4 NEIGHBOURHOOD NUISANCES.

No matter how beneficial a "negotiated quiet" may be in dealing with what would normally be a private nuisance, some people continue protestation. This is an area which is in need of some simple "do-it-yourself" access to a Court of summary jurisdiction. Legislation based on the British Noise Abatement Act where a complaint can be made to a Magistrate by any three or more aggrieved persons who own or occupy premises would be an advantage. This would appease any mistrust they have in the ability of an authority to remedy their complaint. Malicious prosecution would also be actionable.

2.5 THE VALUE OF INSTRUMENTATION.

Whilst this factor does not strictly come within the ambit of this paper, it is prudent to offer comment having previously indicated opposition to calibrated limits in global environment noise assessment. It is true that instrumentation has some value in noise appraisal when in the hands of a practitioner. It is equally true that in the hands of others it may become an uncontrolled monster. Few are familiar with the science of acoustics and sound. The fixing of limits, the ready availability of instruments and regulatory law may make this deep science appear too simplistic and it may become prostituted by amateurs. It is unfortunate that many school leavers today confidently believe that they "know all about decibels" and regard them in the same light as a pint of beer or some other tangible or measurable thing. In the next decade this partial ignorance may become an influence to be reckoned with.

2.6 ENVIRONMENTAL THERAPY.

This is the most meaningful approach to noise pollution. Generally there are two areas for consideration -

(i) Noise nuisance in existing environments;

(ii) Avoidance of noise in a planned environment.

As an example, consider building construction, which is based on two forms. The "tent" - a framework supporting a light cladding - and the "mud hut" - a structure with load-bearing walls. For these structural types the practical acoustical modifications available to reduce the noise problem are manifold.

3.0 CONCLUSIONS.

In the sphere of curing a deteriorating environment it is most difficult to equate ideals with practicalities. Law-backed calibrated limits in the global assessment of environmental noise in a given situation do not appear to be the answer. Given this fashionable legislation, however, there is well founded doubt that its full enforcement would eventuate and it would be likely that there would be a long period of adolescence. Other countries have experienced this. Laws are always weaker than informed reformers would have them. Existing provisions of the "nuisance" law have deficiencies, but it is questionable whether the law has been given full opportunities of application. There is a useful place for legal machinery to deal with "neighbourhood nuisances" by those directly aggrieved. This could be on similar lines to those of the British Noise Abatement Act.

The establishment of standards for all noise producting manufactured units, and noise reducing materials and the adherence by users to these standards is the most practical way to educate and engender a demand for quiet. It is more beneficial to all concerned to develop a technical expertise to consult, persuade and recommend than to become a law enforcer. There must always be care that legal restriction does not overtake technological progress.

We should tread lightly the path of sophisticated anti-noise law.

THE NEEDS AND INTENTIONS FOR BETTER NOISE CONTROL IN BUILDINGS

by

Keith Cottier,
Allen, Jack and Cottier, Architects.

I was asked to present an Architect's view of the "Needs and Intentions for Australian Legislation" as related to the control of noise in buildings. Together with the preliminary information regarding this Conference, this title presupposes that there is definitely a need for better acoustic conditions in buildings generally, and that legislation is the best manner of achieving the required improvement. Now I have strong doubts about the legislation, so I would prefer to rephrase the title, to read "The Needs and Intentions for Better Noise Control in Buildings".

There is, of course, undoubtedly a need for better acoustic conditions in buildings, just as there is generally a need also for better thermal conditions, aesthetic conditions, space utilisation and, as we have recently been reminded by the newly formed and unlikely coalition of the Builder's Labourers Federation and the National Trust, a need for better control as to where buildings are permitted, and when their destruction is permitted. Noise control is not an isolated factor - in so many areas there is need for a general improvement in our living conditions.

Despite the fact that man's recently acquired technological and scientific knowledge has mostly been channelled to the ends of destruction and pollution, just a few of its results are appearing in buildings. So that, alongside the truly medieval practice of bricklaying, for example, we are almost taking for granted advances such as air conditioning, which is becoming increasingly sophisticated, to the point where an individual tenant can select the exact temperature and humidity that he requires. With regard to acoustic conditions in our buildings, however, technology has generally brought with it a deterioration rather than an improvement, as walls and floors have become increasingly thinner and lighter, and expected profit margins fatter and fatter.

In examining this problem, it may be necessary firstly to restate the obvious - that buildings themselves are not a noise source. It is the equipment in and around the buildings that is responsible for much of the noise problem. The vast array of domestic appliances and gadgets with which we surround ourselves, the industrial equipment and machinery of our factories, and the cars, planes and trains in which we travel, these all emit a ridiculous amount of noise for the work they perform. In so many instances this noise could easily be reduced at a very small cost. Mr. Nader and his raiders, one hopes, have lead a real awakening to this type of problem, and manufacturers must be made aware of their responsibilities with regard to noise. I can see no real reason why the levels of noise produced by all our machinery and motors should not be controlled by legislation. This would at least allow us to talk to one another when the dishwasher was on. But a great part of the problem would still remain.

The machine made noise will be lessened, but the noise made by us all carrying out our daily living activities is much more difficult to control. We are not as consistent or predictable as mechanical machinery and our functions rarely as single minded.

Noise in buildings is generally separated into the two simple categories of airborne and impact noise. In Australia, the effectiveness of airborne noise control, at least in multi-tenancy buildings, has been at best a direct result of the stringency of the relative fire controls or ratings of doors and walls. Even on this basis the division walls would fall below most minimum European standards regarding noise transmission, and these fire walls are continually being reduced in thickness and density, as new materials are developed and tested. In the domestic sector in

Australia we have in addition the problem of the ubiquitous detached cottages, each built 3' from side boundaries (a statutory minimum in most areas) and thus creating a perfect machine to magnify any noise emitted via the side windows. With regard to impact noise, one only need imagine the conditions in todays home unit blocks if carpet were to become unfashionable. Without delving too deeply, the existence of the need for better control of noise in our buildings becomes all too evident.

The establishment of minimum acceptable levels of noise insulation between adjoining occupances is the common method of tackling this problem. Such standards exist in many European countries and have done so for many years, the first having being established just prior, I think, to World War II. My knowledge of these is not extensive, but it does appear that there is no firm agreement between the different standards in many areas, and there is certainly wide variation in the extent of their interest and powers. Several are still based on broadly averaged figures that often do not reveal the wide range of effectiveness of insulation through different frequencies. They are all, of course, based on some series of averaging exercises, tests on noise acceptability levels, intelligibility of conversation, number of words understood, etc., and conducted on an averaged cross section of the population. We are all, I'm sure, aware of the types of dangers and fallacies attributable to the elusive average man and his demands; but he still remains our best bet. Some of the European specifications are presented as mandatory regulations and others as recommended practice. The difference is, I think, quite critical.

In order to regulate, one must legally define the situation, and the acceptable minimum standard, and determine also how the regulation is to be administered. The first hurdle is the definition of situation. Buildings are becoming increasingly complicated and specialised in function, equipment and organisation except for one or two areas such as the residential sector. Here, despite a continuous change in trappings, and fashion, the basic needs have changed little over a period of years and appear unlikely to change greatly in the foreseeable future. One might include commercial office areas in the category also, but we have seen recently the sweeping change of "Office Landscaping" and more and more machinery and hardware could increasingly change our work patterns and requirements. There has been a similar reaction to compartmentalisation in schools also, and industrial buildings vary continually related to the processes and their developments, so that, inevitably, many building types or situations, together with noise controls related to them, end up in the 'too hard' basket, and the legislators, because they must be so specific, concentrate on what is more readily known and understood and predictable - the wall or floor between you and your neighbour. This, it may be argued, is better than nothing, but it does leave untouched more damaging noise problems such as those in factories and heavy industry. This situation is illustrated by the existing noise control regulations, which to my knowledge all deal almost exclusively with the residential situation, and then on the assumption that one's neighbours noise is far more offensive than that of one's children.

The definition of an acceptable minimum standard is also difficult, due mainly to the wide individual variation experienced in noise tolerance. Some people are thrust into the depths of depression by the lack of other people's noise around them, others into extreme irritability by the existence of the noise. The cut off point of acceptability has a wide range. European tests have, for example, all showed that people in high income bracket, living in expensive apartments, are far more sensitive to noise

than people in low income, poor quality, overcrowded flats. With a moral obligation to keep building costs down and to allow the individual maximum freedom within the bounds of community security, no Government today is likely to set the acceptability criteria at levels much higher than is demanded by the low income group. This group is, of course, like most other oppressed groups, conditioned to the lower standard, with the system designed to keep them there. Legislation has a bad habit of resulting in a situation quite different from that intended by its promoters - instead of better noise control in buildings, the legislation is quite likely to produce merely minimum party wall or floor ratings that are acceptable only to 60% of the low income group (who have never known any better anyway!).

This is coupled with the problem of how such standards are to be administered. The ideal situation is that each building is assessed on its relative situation; its requirements set by an authority - a highly qualified and highly efficient but benevolent authority; the building designed to meet these requirements, and, on completion, tested and given the acoustical good housekeeping seal of approval. If only it could work like that. In reality in Australia the rules must be exact rules and simple rules, written in the language of builders and building designers who should not need to call in an acoustic expert every time he is planning a project. Structural Engineers alone, enjoy the privilege of having their professional work considered essential for building approval; insufficiency in their sphere has more drastic immediate effects on the public's well being. Remember also that in Australia those who would administer these standards, the Building Departments of Local Governments, are, especially in metropolitan areas, already overworked; they are often already asked also to pass judgements well beyond their technical training. Rather than specify the desirable end result, our present system will demand the publication of acceptable building materials or construction methods. Again this would, in many cases, result in an improvement of conditions. However, it is most unlikely that essential associated requirements, such as controls of flanking transmission through windows, plumbing noises, position of electrical conduits and outlets could ever be defined satisfactorily in these sorts of terms, again because of the variation in individual conditions.

There are two other comments I would like to make regarding building regulations, applicable in relation to minimum standards. Firstly, minimum standards become THE standard. Once the minimum is adhered to, that subject is closed. There is a minimum width for fire escape stairs. I cannot recall having seen an escape stair wider than the minimum, irrespective of whether it is serving three floors or thirty. Secondly, regulations are based on buildings and situations as we know them now - and we are facing accelerating change. Difficult as it may be to satisfactorily legislate, it appears to be quite impossible to change or update the legislation that exists. Scarcely one of the building regulations and ordinances under which we work in Sydney today is identifiable with the techniques of construction today and is achieving the intent which was obviously its raison d'etre - if that intent is still itself valid. This problem will only get worse.

Recommended noise insulation levels of standards can be quite different if not involved with legislation. Codes of Practice produced by the Standards Foundation of Australia are, because of their wider scope, far more applicable and useful in today's building than the majority of our regulations. The legal regulation must be milder and will serve mainly to cut off the extremely bad cases, as I have illustrated previously. It will be related to what is intolerable to all, rather than

what is acceptable or desirable for most. The great advantage of the recommendation is that the real acoustical needs may be expressed without too much compromise with other factors. It can give examples, suggestions and comments and discuss the real aims. It's purpose is to assist rather than restrict and it is usually accepted in this form, contrasting with the eventual search to find a way around restrictive laws. The standards as recommendations will take longer to achieve change. If accompanied by a good promotional campaign however, I am sure they will ultimately achieve far more than the legislation that would result under our present system of building controls.

I realise that I may be accused of putting an excessively pessimistic case when an idealistic one was called for; so I would like to return to some of those specialised useage buildings to which I referred previously. In many of these buildings that demand special acoustic conditions, for example libraries, lecture theatres, schools, one finds so often that the standards of noise control and insulation are comparatively far higher than in everyday buildings. The same is true in many of the so called "prestige" office buildings where, a few years ago in fact, these buildings were planned around the module of an acoustic tile, surely one of the truly great advertising and P.R. coups. So that in the specialised situation, the more difficult situation, we are achieving, without legislation, better standards than in the every day situation. It is not merely due to the presence of an acoustic consultant because they are still rarely there and it is not simply related to available funds. In the specialised building, noise control is a problem to be solved. In the houses and flats, the little buildings, it is not seen as a problem, so that no attempt is ever made to solve it. What is needed perhaps is an acoustical Germaine Greer - to sell the fact - that there is a problem. We need to make a Class A noise insulation rating more fashionable and desirable than a self cleaning wall oven.

THE ROLE OF 'STANDARDS' IN LEGAL AND ADMINISTRATIVE ASPECTS OF NOISE CONTROL.

by

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Standards Association of Australia.

1.0 STANDARDS

1.1 A DEFINITION.

STANDARDIZATION may be described as a procedure whereby voluntary consensus is reached amongst all concerned as to the most acceptable current solution of a recurring problem.

It is based on the consolidated results of science, technology and experience; it presents a practical and realistic solution; it determines not only the basis for present, but also for future development; it should keep pace with advances.

The formal presentation of this solution is termed a STANDARD.

1.2 AN APPLICATION.

This process and its expression through national standards is especially suited to noise control because:-

(a) noise is a matter of biological and psychological concern for which absolute limits are clouded by varying human reactions, and hence effective control is dependent on community awareness and acceptance

- standards express a community acceptance and may stimulate awareness

(b) The multitude of controlling authorities within the Commonwealth Government, State Governments and Local Governments invites confusion unless controls are harmonised

- standards offer a basis for uniform practices

(c) in areas such as noise control which involve new concepts for the community, premature or uninformed controls may be unnecessarily restrictive, misleading as to future developments, and arouse overall resistance

- standards offer guidelines which can be implemented with discretion or which fulfill an educational function, providing a framework for development and systematic accumulation of experience.

National standards in advisory form such as 'Codes of Recommended Practice' and 'Drafts for Development' are appropriate to this situation and may be readily revised or amended in the light of experience to become, eventually, full standards.

1.3 THE BREADTH.

The subjects of standards are limitless and may include material things, abstract notions, procedures, symbology, etc. Virtually any area of human endeavour which is the subject of consultative activity and

mutual agreement may find formal expression through the standardization process. Within the Standards Association of Australia (SAA), broad domains of standardization include -

Agriculture	Data Processing
Acoustics	Metals
Automotive	Conditions of Contract
Building	Packaging
Civil Engineering	Plastics
Chemical	Rubber
Clothing	Safety
Dental	Telecommunications
Dairying	Timber
Electrical	Textiles
Lighting	Welding
Medical	Water Supply
Mechanical	

The actual aspects of standardization are also extremely broad, and these may be dealt with individually or in combination in any particular standard, e.g.

Nomenclature
Composition, Dimensions
Testing Procedures
Quality, Performance
Variety reduction
Practices - Design and Construction
- Installation
- Safety
- Operation.

1.4 THE COMMITTEE PROCESS.

The Standards Association of Australia, as Australia's national standards body, provides a national forum for consultation among national interest-groups. The normal procedure is to form expert committees of national representatives having specialised knowledge and experience about the subject matter, and to rely on the SAA staff member to provide the 'standards know-how', i.e. standards procedures and guidelines; content balance; type and format of standards; co-ordination, both intra-national and international.

The aim of the committee is "to obtain and express a genuine consensus of expert opinion in the form of a standard with is practical and realistic and acceptable to the community of concern." The composition of such a committee as will ensure workable numbers on the one hand and a balanced viewpoint on the other, is an important and delicate matter, and a random sample of a number of committees has revealed the following pattern of representation:-

Manufacturers and suppliers	- 32%
Government Departments and users	- 20%
Private users	- 20%
Government Departments and Statutory Authorities	- 17%
Testing and Research Interests	- 8%
Miscellaneous (academic and professional institutions, etc.)	- 3%

As a matter of administrative procedure, such committees operate under the general supervision of Industry or Standards Committees, which establish and supervise relevant standards programmes for a particular industry or area, e.g. electrical, mechanical, chemical, timber, plastics, acoustics.

1.5 THE PUBLIC REVIEW PERIOD.

A universal step in the preparation of both national and international standards based on the consensus principle is the issue of a draft for public critical review. This is a most significant and important stage; significant because this is the feeler by which general consensus and acceptance can be gauged; important because its timely issue can speed up the completion of the standard by resolving technical issues and matters of principle which might otherwise delay progress.

A minimum run-off for circulation throughout Australia and overseas is about 300, but many more are issued where the document is of widespread interest. The initial run-off of the recent public review document on Hearing Conservation, for example, was about 1,000 copies.

2.0 LEGAL IMPLICATIONS

2.1 THE LAW AND THE COURTS.

In general, Australian standards have no legal or mandatory force, except that given them by virtue of -

1. A contract between two agreeing parties, e.g.

   Supplier and purchaser
   Architect and contractor
   Certification Mark Authority and applicant - or

2. As may be given them by cross-reference in legislation, statutory regulations or the like.

Standards have an inherent authority, however, based on their intrinsic merit, and providing their preparation follows the principle of balanced representative participation and consensus agreement, they have been highly commended in the courts and in legislative bodies as being in the public interest, and granted immunity from antitrust and restrictive trades practices laws.

2.2 BRITISH LEGISLATION.

Protective British legislation specifically excludes collaborative activity by industrial groups who are combining their efforts under the aegis of the British Standards Institution in the preparation of standards. Presumably the exclusion of BSI (which is mentioned by name in the law) is because of its well-known reputation, coupled with the fact that it is a quasi-government body in which industry and government work together in the public interest and something like a public audit of its work occurs through its connection with the Ministry of Technology.

2.3 AUSTRALIAN TRADE PRACTICES ACT.

Australia has its Trade Practices Act 1965-67, the purpose of which

is "to preserve competition in Australian trade and commerce to the extent required by public interest". This Act refers to 'examinable agreements' and 'examinable practices'. An 'examinable agreement' may be considered to be an agreement where there are restrictions in respect of prices, conditions, benefits, qualities, kinds of goods that may be made, acquired, stocked, sold, etc. An 'examinable practice' covers monopolies, discrimination in prices, refusing to deal, etc.

The activities of SAA are specifically excluded from either of the above by virtue of Section 38 of the Act, which states inter alia, that regard is not to be had to 'provision for compliance with standards prepared or approved by the Standards Association of Australia', and the Act also excludes the authorised use of a certification trade mark.

2.4 THE SHERMAN LAW U.S.A.

The legal consequences of standardization are, in the United States, mainly those which flow from the application of the Sherman Law. This basic law forbids only such contracts or combinations as 'by reason of intent, or the inherent nature of the contemplated acts, prejudice the public interests by unduly restricting competition or unduly obstructing the course of trade.'

No federal court has ever held standardization as such to be illegal under the antitrust laws. On the contrary, standardization frequently has been commended by the courts and the Federal Trade Commission. The Supreme Court of the United States has described standardization as an activity 'admittedly beneficial to the industry and to consumers.'

In the United States there has been a variety of lawsuits through the years in which standards, when properly prepared, have been regarded with favour by the courts. In the middle of the 1960's, a particularly important court action was taken in Pennsylvania against a large manufacturer in which ASTM Standards (American Society for Testing and Materials) were involved. The Society was completely exonerated by the U.S. District Court for the Eastern District of Pennsylvania, but so seriously did the Society regard the matter that it made a special appeal to the Court for a ruling upon the position of the Society with special reference to U.S. antitrust legislation. The judgement of the Court, after a careful and thorough review of the details of the Society's regular standardization procedures, was most favourable. In its findings of fact, the Court stated (in part) that:

> "Because of the balance of interests represented on ASTM Committees, and because of the detailed and scrupulously observed procedure which governs their operation, it is most unlikely that the views of one member or one group of members could predominate over the consensus of opinion of the committee as a whole. The technically qualified, balanced membership of ASTM committees, and the democratic procedure governing their operation, make it likely that the results reached by them will be scientifically sound and will represent the general interest."

In its conclusionsof law, based upon the recited facts, the Court stated (inter alia) that:

"There is a strong public policy in favour of protecting ASTM's standardization work.... Because of the heavy reliance of federal, state and municipal governments upon ASTM for specifications, the Society may be regarded as an essential arm, or branch of government and its acts may be entitled to immunity from the anti-trust laws accorded government acts."

In rendering its opinion, the Court stated that "The Courts will be available for the protection of ASTM in its fine work on a case-by-case basis until such time as the legislature provides more definite rules for application of the antitrust laws to its work."

One could not wish for a stronger endorsement of standards and standardization work than this thoughtful judgement of an important court. It is to be noted, however, that the judgement of the Court was based upon the consensus principle as it is applied in all ASTM work.

3.0 REGULATORY IMPLICATIONS

3.1 THE ALTERNATIVE TO STANDARDS.

Notwithstanding the inherent authority of standards as formulated through the national body, an Authority may consider it expedient to prepare technical regulations unilaterally. In the case of noise control regulations, it will be seen that such a course will result in a quite complex standardization process.

Noise is a phenomena for which absolute limits cannot be defined in precise quantitative terms. Its control is ultimately concerned with the biological and psychological reactions of people whose respective sensitivities to noise will differ widely. Consequently, the description of any limitations must be a compromise of scientific fact, human experience and community acceptance.

Complete protection for one hundred percent of the population may be a doubtful practicable consideration, and the selection of levels at which a statistical percentage of 'sensitives' may find it necessary to change their place or type of employment or their living places is a delicate balance of human and economic considerations. To this end, the views of the medical profession, audiologists, psychologists, acousticians, and trade unionists, must be balanced against the political involvement of the community.

If this is not complex enough, it must also be recognised that there are many ways of dealing with noise sources, and in this regard the views of engineers, architects, manufacturers of building materials, town planners, traffic authorities, and industrialists must also be sought. Further to this, the development of instrumentation and methods of measurement to allow the expression of the science in quantitative terms is an essential aspect of an effective regulation, and so a further group involving physicists, academics and appropriate professional societies will need to be consulted.

Apart from these technical complexities, however, the regulatory authority who opts to act unilaterally will also be faced with continued pressure, both urgent and important, to issue rulings and interpretations on such matters as whether or not some new material, design, innovation, manufacturing technique or device incorporating concepts not previously

contemplated are in accordance with the requirements of the appropriate regulations or the spirit of the regulations. Under these complexities and pressures it is not unnatural that an element of conservatism comes into the drafting of regulations by a single authority, and that the regulations are likely to be written around the demands of the most pressing sectional viewpoint without taking due account of the total community concept.

A problem of a different kind in the implementing of regulations, is variation of requirements between authorities having overlapping interests in the one State, and between States, on matters for which there should be common solutions. Such variations add enormously to operating costs, particularly in the case of organisations with inter-state activities, because of the confusion and delay which results in seeking separate 'approvals' or because of alterations in design or constructional details or performance requirements to meet the needs of different 'approvals' bodies.

Hence, there are three important questions to be answered in the preparation of regulations applying to technical matters:-

(i) The drafting procedures to be adopted to ensure that they reflect the readiness of the community to accept, and its economic ability to pay for the performance level sought.

In the case of safety levels, for example, pedestrian accidents on our roads could no doubt be eliminated entirely by the installation of adequate overpasses and underpasses if the community is prepared to pay for them and use them.

(ii) The procedures by which they can kept up to date with rapidly changing technologies, including the issue of rulings, interpretations and amendments.

(iii) Procedures whereby uniformity between States and overlapping authorities will be established.

3.2 THE ADOPTION OF STANDARDS.

Faced with these ever-growing problem areas, it is understandable that Australian regulatory authorities have established an extensive and close liaison with the Australian national body for standardization, the Standards Association of Australia.

The possibility of using Australian standards to promote uniformity in technical regulations varying from State to State was recognised in the late twenties, and SAA work was extended to include standard rules (codes) for such things as boilers, cranes and hoists, and electrical installations. This has become an area in which SAA has contributed in a major way to the harmonisation of the requirements of technical regulatory authorities in the several States. There are presently over fifty Australian standard codes which find mandatory application by a wide range of statutory authorities in the fields of building and plant and machinery. In addition, many hundreds of SAA specifications for materials and equipment are also given mandatory status by regulatory authorities. In these instances special care must be given to the wording of a standard. It must be precise and direct and free of areas of discretion, if uniform implementation is to be achieved.

In this regard, the draft 1972 Building Regulations of South Australia lists types of provisions which may be found in standards intended for adoption by two agreeing parties, but which would not be included in the endorsement of any standard called up in a regulation. Such requirements, for example, designated 'alternative', 'optional', or 'as agreed', whilst being quite suitable for standards intended to be adopted on a voluntary basis, have no place in standards for regulatory purposes.

Consequently, in the drafting of standards, the intended or anticipated implementation of the standard has an important bearing both on content and format.

4.0 STANDARDS AND LEGISLATION

4.1 MORE POSITIVE CO-ORDINATION AND PLANNING.

It has been proposed from time to time that standards should be directly referred to in legislation in preference to their implementation at the discretion of a regulatory authority. Some Parliamentary draftsmen claim that such an action would be a transference of the rights of Parliament, and hence is unthinkable. Alternatively, they argue that any such reference would be restricted to the edition of the standard at the time of reference and would not include future amendments or revisions, thus in effect making the cross-reference unworkable.

These views are not held by all, however, and there are those who take the view that the 'authority and public interest' aspect of standards as previously dealt with, plus their ready availability throughout Australia, render them appropriate for cross-reference.

Obviously, with increased demands for technical legislation and the great growth in standardization activities, there is a need for better understanding between legislative bodies and the Standards Association to ensure that the most effective use of overall facilities is made through programme co-ordination and forward planning.

4.2 A NEW ZEALAND PROPOSAL.

It is of very real interest to note a scheme for flexible legislation which is being promoted in New Zealand. This scheme is based on a reconstruction of New Zealand's Building By-Laws and acknowledges three points:-

1. Most traditionally based regulations state what is virtually a specification for one particular solution meeting a general and often unstated technological requirement.

2. Changes in legislation can only be made by prescribed procedures and are difficult to achieve.

3. There are physical difficulties in providing a ready means for the ordinary citizen or regulatory authority to keep up to date with changes.

The proposal envisages a four-way approach for technical regulations, viz.-

(a) Law

(i) To prescribe a standard of duty
(ii) To name means of compliance.

(b) National standards, where appropriate, to be listed as means of compliance.

(c) To provide for annual up-dating of means of compliance.

(d) An approvals system to provide a mechanism for acceptance of materials and methods not yet embodied in national standards or unlikely to be so covered. This is to be organised through the New Zealand Standards Association and will be taken into account during the annual up-dating of standards.

5.0 ADVISORY APPLICATION

Reference has already been made to the need for public awareness to ensure effective noise control. Awareness will only develop from education, formal or informal, and Australian standards have proved themselves effective in this regard on both counts -

Formal - in their mandatory application or their use for educational purposes as text books;

Informal - in providing authoritative information to those who seek guidance as to'good practices'.

6.0 OTHER ASPECTS OF STANDARDIZATION.

6.1 INTERNATIONAL STANDARDIZATION.

International standardizing bodies were established first in 1906, the International Electrotechnical Commission, and then in 1926 the International Federation of National Standardizing Associations, to become in 1947 the International Organization for Standardization. Since their inception, they have issued about 1,500 standards. Their success in 'facilitating the international exchange of goods and services and in developing mutual co-operation in intellectual, scientific, technological and economic activities' has been such that it is estimated that some 10,000 standards will be required over the next 10 years. Further, it now appears that Governments who are signatories to certain trade agreements may agree that their acceptance of such standards will be implicit regardless of national standards.

The Standards Association of Australia not only provides a means whereby Australian interests may take advantage of such intellectual and scientific activities, but also means whereby Australian points of view can be argued in the preparation of international standards.

6.2 CERTIFICATION MARKING.

The acceptance by Regulatory Authorities of the AS Mark on equipment and materials, signifying compliance with relevant Australian standards and their manufacture under a scheme of supervision and control acceptable to the SAA Certification Marks Section, provides a convenient, reliable and national means of ensuring suitability for purpose.

7.0 CONCLUSION.

Australian standards have an inherent authority derived from their formal procedures of preparation and complemented by their acceptance as being in the public interest.

The control of noise is of such a complex nature that the drafting of requirements, whether at Commonwealth, State or Local Government level, results in what is actually a standardizing process. The weakness of unilateral action by any regulatory authority, however, is its inability to develop requirements which may be uniformly applied throughout Australia; and the maintenance of a level of implementation which is in accord with latest technical advances. Hence the delegation of such standardizing procedures to the Standards Association should be a first consideration.

In so doing, national standards may promote uniform practices throughout the Commonwealth or where there is insufficient experience about a particular matter provide authoritative guidelines for ensuring the systematic accumulation of experience and knowledge.

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