AIR POLLUTION IN NEW ZEALAND

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STATE OF THE ART

The control of air pollution is more of an art than a science, still lacking an adequate power of numeration to qualify as a truly scientific discipline, despite a long history of concern about it. There was, for example, legislation against air pollution in London in the 13th century, and, until the time of Pasteur, sundry qualities of "night airs" and "fetid vapours" were held responsible for most human ailments. When the public health revolution occurred in the 19th century the establishment of a very real relationship between water pollution and personal hygiene and disease seems to have diverted attention from air pollution. It became the Cinderella of the environmental sciences and was largely neglected until the second half of this century.

The lack of progress in more recent years has been, at least in part, the result of inadequate instrumentation. It has been possible to measure very low concentrations of pollutants in the atmosphere for a considerable time but only by tedious wet chemistry methods requiring comparatively long sampling times. The results of such measurements, even if they gave adequate resolution, which mostly they did not, hid the detail which was subjectively obvious to the sense of smell or sight. This often led to impatience or down-right disbelief of the results of scientific investigations in the field—a very discouraging situation for the scientist. The problem was, in fact, very much more complex than it appeared—analytically one or two magnitudes more difficult than the allied areas of industrial hygiene, water pollution and radioactive pollution, all of which have progressed much faster.

The British Alkali Inspectorate, a remarkable organisation which has been in the field of air pollution control since 1863, developed a technique based on the "best practicable means" (B.P.M.) of control to almost the level of a philosophy using the very minimum of instrumentation and exact measurement. Today, however, action seems to require to be supported by numeration. New instrumentation, capable of the required resolution (parts per billion concentration) coupled with the depth of focus in time that computer techniques provide, offers the possibility of a truly quantitative approach. The next generation of instruments, based probably on tuneable laser beams, will complete the revolution. Within ten years it should be possible to monitor the global distribution and history of many air pollutants continuously from satellites, to readily follow the hour by hour changes in pollution across a city and, by directing a torchlike instrument on the gases from an industrial chimney, determine whether it complies with legislation. The accessibility of the atmosphere to observation should then become a great asset in pollution control enforcement.

Some of this is already possible, and it is changing the whole approach to air pollution control in countries which can afford the equipment and expert staff, but the costs involved present something of a dilemma to smaller nations. There is a danger that we may lose sight of a simpler approach which is perhaps adequate to our needs and situation. We may have to think for ourselves and develop approaches to control and monitoring suited to our pocket and conditions, rather than those of the Ruhr, Tokyo and New York. This symposium could be the starting point for just such an individual approach, but first let us briefly look at the situation in New Zealand at this time.

GLOBAL POLLUTION

Short of another Tarawera or Taupo ash shower New Zealand's contribution to global air pollution is likely to remain relatively insignificant. This does not excuse us from supporting international efforts to establish a real basis of understanding of what is being done to our atmosphere. We have as large an interest in that as anyone else. There has been astonishingly little done in this direction so far. We do not know if the earth is warming up or cooling down due to man-made pollutants, but suspect one or the other, and only very recently has there been any hint as to the ultimate fate of carbon monoxide. Practically no question can be asked about air pollution to which a scientifically adequate answer can be given. This is not a good situation, and our geographic isolation may provide special opportunities for monitoring global pollution so that we can assist in providing better answers.

However, it is quite wrong to think of the atmosphere as something that can be filled up with air pollutants. It is a dynamic, self-cleaning, self-renewing medium which has withstood disturbances of at least the order our present activities are causing from natural emissions in the past. The immediate problem, at least for us, is local overloading. We have a long way to go in this country before we need abandon natural dispersion of pollutants as an adequate method of control, though we might be wise to show forbearance in this with persistent pollutants and as part of our demonstration of concern that all nations should begin to act responsibly.

MONITORING IN NEW ZEALAND

Within the limitations of the methods which have been available until recently we have looked at all the supposedly significant common pollutants (sulphur oxides, suspended particulates, hydrocarbons, nitrogen oxides, carbon monoxide, fluorides and oxidants) sufficiently over the past 15 years to have a very fair idea where we stand. Of course new problems, and new opportunities for atmospheric studies, are arising all the time. Recently, with the co-operation of a United States university, we have, for example, been able to have more sophisticated work done on suspended particulates by neutron activation. With the appointment of Dr Gavin Daly, a plant physiologist, as consultant to the Department of Health a start has been made on use of plants as pollution indicators—which Goodman and Roberts (1971) have suggested may be an approach to simpler techniques in monitoring.

Our pollution problems are just about proportional to urban population densities when compared with similar measurements overseas, although on that basis Christchurch seems rather worse than it ought to be in the winter months.

The topography of the Christchurch area discourages dispersion of pollutants, but present problems are primarily due to the anachronism of domestic open fires with coals of high volatility and consequent smokiness. In the months of June and July concentrations of soot in the atmosphere are similar to those in London air. This is not because Christchurch has become worse (the indications are that, if anything, it has got better), but because London has been so much improved by clean air legislation which has, in particular, reduced domestic sources of smoke.

Auckland has a different type of pollution problem in which industry and motor vehicles are the predominant sources of pollutants. Experience has also shown that Auckland has rather special dispersion problems which accentuate nuisance with odours.

Other towns such as Dunedin, Lower Hutt and Hamilton are, on average, less polluted, but New Zealand is a country of very high relief and many deep valleys. There are many topographical traps for air pollutants, such as the Hutt Valley, where higher urban density would seriously strain the capacity for natural pollution dispersion. On the other hand New Zealand is subject to the frequent passage of cyclonic conditions, and prolonged periods of air stagnation are unusual. Conseqently, our pollution problems are most likely to be a nuisance rather than a serious health hazard. Recent research is tending to show that the seas around us are one of the important sinks for global air pollutants.

RESOURCES FOR CONTROL

There has been specific air pollution legislation in New Zealand (Part V of the Health Act) since 1956. We were one of the first countries to have such legislation although its mandatory provisions are limited in application to certain industries with a high pollution potential. Similar powers have been optionally available to local authorities for most industrial furnaces and boiler plants since the 1964 Smoke Restriction Regulations were introduced. Existing legislation is deficient in respect of control over motor vehicles and agricultural and domestic sources of air pollution. It was the recommendation of last year's Board of Health report on air pollution that new legislation based on a universal responsibility to adopt all practicable measures to reduce discharge of pollutants should be enacted. This would be a truly conservationist approach.

The Department of Health has a staff of five graduates and three technicians directly employed in air pollution control and monitoring, education and equipment evaluation. There are also about 100 health inspectors, mostly on the staff of local authorities, who have qualified in air pollution control to a good sub-professional level at courses run by the Department of Health. It is of some interest that there are nominations of students from overseas to the latest of these courses. There are research and support programmes in the D.S.I.R., Meteorological Service and most universities. Two Clean Air Societies are actively promoting public interest and two Regional Air Pollution Committees are doing promotional and technical survey work on air pollution.

This may not be an adequate response to the threat of air pollution in this country, but, taking into account the size of our population and problems, it is not too disproportionate to the effort in larger countries. As a result of the enforcement of existing legislation, new industry being established is well equipped to control air pollution. Older industry is certainly no worse and often better than in most other countries. However, there is room for more effort in all aspects of control and for more research into some special problems which are far from adequately solved here or anywhere else.

SPECIAL PROBLEMS

Some of these are unique to this country, others are common throughout the world but made different by our circumstances. Probably the most interesting of our unique problems are those whcih arise from building urban communities (such as Rotorua and Taupo) close to areas of geothermal activity. There are concentrations of hydrogen sulphide in parts of Rotorua which must be unequalled in any other urban communtiy and would be regarded as totally unacceptable if caused by industry. Hydrogen sulphide mixed with carbon dioxide, as it is found in the thermal areas, is a lethal combination. At the concentrations usually found in the open it seems to have little direct effect on health but less than one part per thousand million in air will adversely affect electrical equipment. Although the source of such gases cannot be controlled there is probably a great deal more that should be done in studying structure, design and materials for use in these areas.

Timber production is a major industry in this country and presents several problems of air pollution control which are, at best, only partly solved. Among these is the sheer bulk of the waste material (amounting to 50 per cent of all felled timber). Much of the waste from exotic timber is impregnated with boron salts and some with arsenic salts and thus presents a special problem of disposal whether by burning or by any other means.

Domestic smoke is still something of a problem in the South Island but the answer is not quite the same as that which has been so effective in Britain. The economics of providing smokeless solid fuel for the very limited seasonal requirement for domestic heating are not encouraging. Unless there is some rather unlikely technical breakthrough we have to face abandonment of the open fire in urban areas.

Although we have an exceptionally high ratio of motor vehicles per head of population, already available modifications to engine design, if applied, should keep ahead of our needs, so that motor vehicles need never become the problem they have in cities of the United States of America. However, there remains the question of determining the optimum time to introduce control here. Early introduction would be a waste of resources better employed in other ways, but late introduction, considering the delay of many years in new standards becoming effective over the majority of vehicles on the road, could be more damaging. Diesel smoke is an existing annoyance. Delay in solving it is almost totally due to the lack of a suitable simple method of measuring smoke emission on the road. A technical study has recently been made of this problem in New Zealand by a small combined Department of Health and Ministry of Transport team without coming up with any new solution. This was to be expected but the research was a necessary step in convincing ourselves and others that there is no simple solution, and that to make progress we will have to accept some rather unscientific but practical procedures.

Most of our present air pollution problems have a technical solution but not always an economic one. As it is in the interests of all of us that control is exercised in the most economic way to achieve the desired end, there is room for much more research in evaluating the effectiveness of alternative equipments. It is rare that a process developed overseas can be adopted without some modification to suit conditions in this country, and failure to appreciate this has often resulted in poor performance and excessive costs.

TOWARDS THE FUTURE

New, more comprehensive, air pollution legislation has now been drafted and may soon be a matter of public debate. In view of the suggestion made earlier—that we may have to follow a somewhat different approach to that of larger, more industrialised countries—it is profitable to consider the options open to us.

These are determined by the nature of air. It is a light fluid of low viscosity usually in more or less turbulent motion but subject to enormous variability in the speed with which pollutants discharged into it are dispersed or removed from it. It is this variability, which is dependent in complex ways on meteorology and topography, that sets the parameters of the problem shown graphically in Fig. 1.

A source of pollutant 'A' (which may be a factory, a domestic fire or a motor vehicle) con-

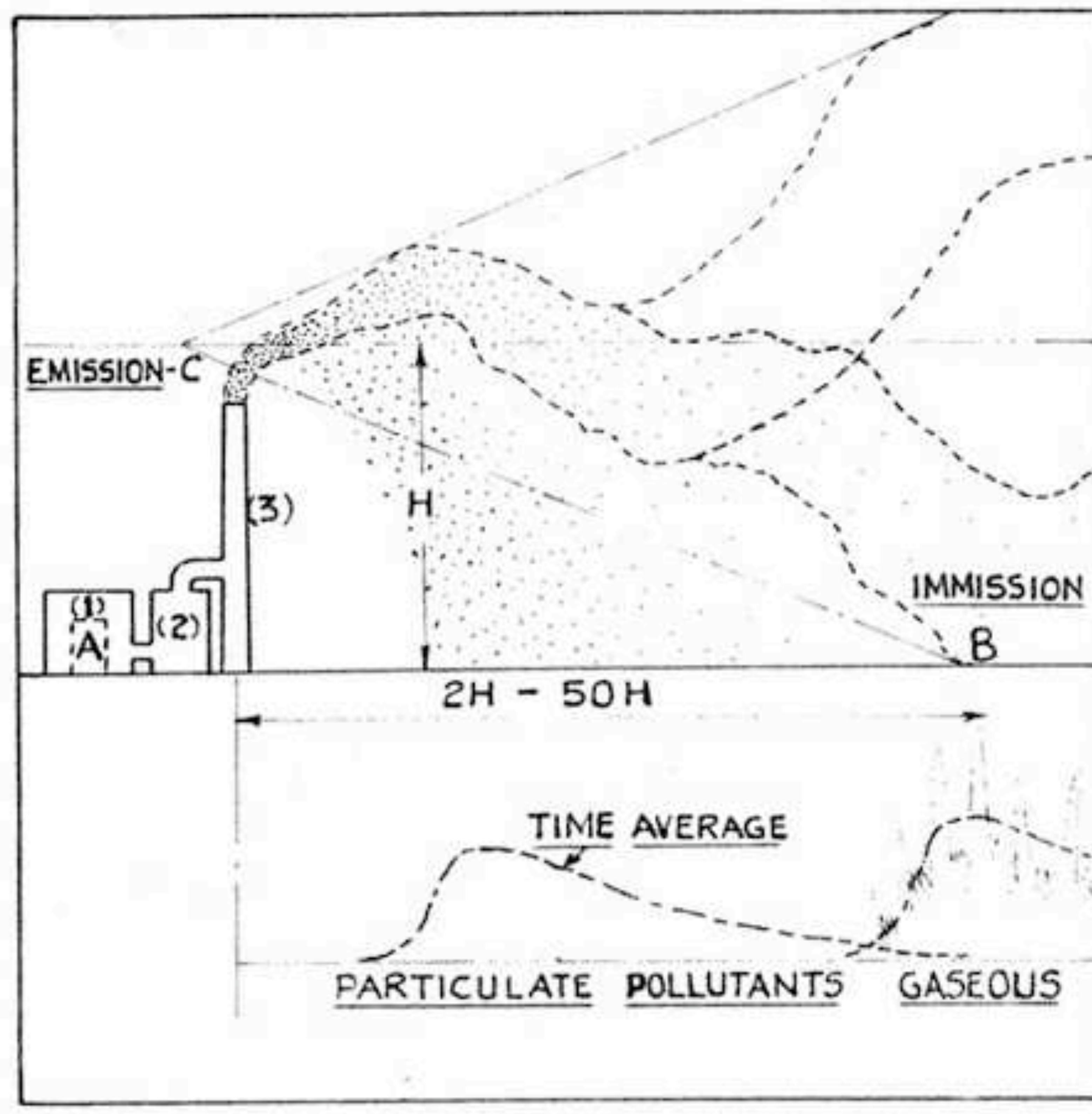

FIGURE 1. *Graphic representation of dispersal of pollutants in the atmosphere and their removal from it.*

tributes to pollution at 'B'. The important pollution at 'B' is usually close to the ground level and it is a composite of numerous plumes of dispersion from all upwind sources. This is known as the 'ambient air concentration' of pollutants. Sometimes, particularly if referred to a single source, as shown in the diagram, it is known as the 'Immission'. This is to be carefully distinguished from 'Emission', which, in this instance, is taken as the concentration or quantity emitted to the atmosphere at 'C' after control procedures have been applied at (1), (2) and (3).

The scientific approach to air pollution control has 'B' as the starting point. It seeks to establish ambient air concentrations which are acceptable as 'air quality standards'. These are based on what are termed 'air quality criteria', i.e. the known effects of certain concentrations of pollutants for certain times of exposure. This is the approach followed in U.S.A.

In theory this is by far the most logical way to control air pollution. It has a fairly exact parallel in the 'Maximum Allowable Concentrations' used in industrial hygiene and river pollution control. The application of this concept to air pollution is, however, vastly more difficult and so far more a theory than an actuality.

The reason for this is the inadequacy of the information available—i.e. the data to set air quality standards and the variability and uncertainty of the coupling between 'B' and 'C'.

A tremendous effort is now going into establishing air pollution criteria for health effects in humans and animals, for damage to crops and materials and also for ecological side effects and æsthetic considerations. The mere listing of the range of effects to be considered reveals the magnitude of the task. The past history of inadequate instrumentation and scientific neglect of the whole field of air pollution offers little hope that the most exacting study of available information will allow scientifically supportable criteria to be set. Certainly at the moment it is more in the nature of a confidence trick. If a number is repeated often enough in sufficient journals it tends to acquire authority. Examine the published lists of air quality standards from different countries and they too patently divide into two categories—those based on Russian data and those based on United States data. These are currently becoming somewhat more compatible but whether as a result of sound scientific research or plain averaging is not clear. Single pollutants such as sulphur dioxide are bad enough to evaluate but the air contains many interacting and probably synergistic pollutants. A start has barely been made with these. In the final analysis many criteria must be primarily æsthetic and it is difficult to see how these can ever be fully specified as numbers.

A basic reason for the difficulty in establishing criteria is that we are concerned with effects which, to be acceptable, must be set at levels below those discernible by other than statistical methods. The trail gets lost in pursuing it downwards into the grey area where cause and effect are not simply related but are really part of a complex of inter-related factors—an area where experiment on a different species or under laboratory conditions is no longer relevant because we are dealing with the whole life stress pattern and not its separable parts. A real danger here is that we confuse the ability to measure a pollutant with an effect which belongs to the whole complex. As instrument power increases this danger becomes increasingly relevant.

The further problem is that, having established the criteria, they have to be interpreted in terms of control over emissions. Space does not allow me to go into the complexity of the coupling between 'B' and 'C'. It can obviously vary from none at all when the wind blows from 'B' to 'C' to something approaching one to one when 'B' is close to 'C' and on the same level. Even when we simplify the problem by taking 'B' as the point of maximum ground level concentration this point is itself variably distant from the source two to fifty times the height of emission according to meteorological conditions.

Disperson of air-borne pollutants is not primarily by gaseous diffusion, which is readily calculable, but by turbulent motion of the air. This varies from nearly zero in a strong temperature inversion to a condition where pockets of pollutants from an emission such as 'C' can be swept almost undiluted to ground level close to the source. The cone of dispersion of the diagram is a simplification of what really happens, representing, at best, average conditions with a very steady wind over a period of about one hour. But man is quite capable of detecting an odour on exposure of less than a second. Models are available to connect 'C' to 'B' under idealised steady conditions with a predictability of about plus or minus 50 percent, but ideal conditions are the exception, not the rule.

Such models can, however, be used as proportioning tools. To quote the classic example of the first attempt to set emission standards for motor vehicles, the argument ran something like this. In Los Angeles in 1940 there was no smog and 'x' motor cars each producing 'a' volumes of fumes. In 1960 there were 'y' motor cars each producing 'b' volumes of fumes and there was smog. In 1980 there will be 'z' motor cars; therefore, to avoid smog, each must produce only 'xa/z' volumes of fumes. Similar arguments, aided by dispersion models, can be used to predict results of increase or decrease of emissions where there is sufficient background information. It is unlikely that such simple arithmetic would work out in practice. Tracers such as sulphur hexafluoride can be detected in sufficiently low concentrations for practical model testing but a major problem is then the time required to sample a representative range of meteorological conditions.

The new instrumentation and the great power of the computer can change this paucity of real information into a flood of indisputable fact but not necessarily do anything to achieve better control over emissions. This is the argument of what might be termed the British 'traditionlist' School of air pollution control. Effort and money, they say, may be poured in at the wrong end of the diagram in the form of excessive monitoring and research on air quality. Indeed, over the past years they have demonstrated in the success of their Clean Air Act that great progress can be made with the more pragmatic approach of the 'Best Practicable Means' (BPM). This can be equated in the diagram with:—

(1) choosing the best process to minimise emission and containing all emissions;

(2) treating the collected emissions to reduce them as far as practicable; and

(3) discharging that which cannot be reduced at a height sufficient to adequately disperse it.

This is done to the extent of technical feasibility and economic practicability—beyond which there is, after all, not much that can be done anyhow. This approach does take into account all kinds of matters which cannot be covered by simple numeration, such as management capability, maintenance of plant, and æsthetics. The conservationist might not like it much at first sight because it seems to ignore the effects of the pollutants discharged. However, there is a sense in which it does approach conservation ideals more closely than the air quality concept. It does not assume that there is any fully acceptable level of air pollution which can be allowed. It says instead that we are all going to be idealists and adopt the best control measures to hand irrespective of their necessity but not quite irrespective of their cost. The real objection to this approach is that it fails to provide a stimulant to finding better but possibly more expensive methods of control. Progress is to some extent accidental or the by-product of the search for cheaper control.

A third approach is that termed 'Emission Standards Control'. Attention is concentrated on 'C' and standards set for concentration or mass emissions which will be permitted. This approach is seen as being tough because it leaves no room for argument. The polluter is either at fault or in the clear. Industry likes it because it knows exactly where it stands. Conservationists may be deluded into liking it because it appears so positive. Air pollution control officers may like it because it is relatively easy to police, if you have enough inspectors. Unfortunately it is also the least logical of the three and, in practice, really just a frozen B.P.M. The emission standard set cannot be made tougher than the B.P.M. at the time of setting and it is not easy to get it changed if there are improvements in technology. It bears practically no relationship to what happens at point 'B' because it provides only a single or a very limited range of allowed emissions for all circumstances, however different.

To these three approaches may be added one other—the nuisance approach. Nothing is done until you can smell it, taste it or feel it, and then you seek an injunction to stop the emission. As the ultimate weapon against pollution this has its merits. As a way of controlling growth of air pollution, remembering that many sources may be together responsible and that our objective is to prevent air pollution developing, it makes no sense at all.

The answer is that there is no simple answer. The B.P.M. approach is the most flexible but requires the greatest knowledge, intelligence and integrity to make it work. There are some situations in which there is no alternative but to use the statutory limit approach, to set emission standards and police them, but this should be done recognising its limitations—that it is a temporary not a permanent freezing of the B.P.M. It is convenient administratively but is neither scientific nor sensible economics. Both these approaches have to be tempered by using air quality criteria wherever we have them for guidance and by keeping the nuisance legislation in case all else fails. In the present state of knowledge the control system must be kept flexible. We must avoid legislating ourselves into a legal *cul-de-sac*. In a dynamic growing society we must never look for a final solution but only for an interim solution properly provided with feed-back. We need a flexible intelligent approach which can change to meet new developments, but it is difficult to put that into legislation! This applies also to the method of enforcement. This can be through force of public opinion, education, fine or tax on excessive emissions or by incentives in the form of tax concessions or subsidy. Whatever way is chosen the objective should not be retribution but achievement of reduction of emissions at the least cost to the community as a whole. Usually with industry this end will be best achieved when the enforcement procedure is sufficiently flexible to induce the industry itself to co-operate in finding the solution.

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