THE PROBLEM OF NOISE

Chapter I

1. Opinions and Facts

Everybody agrees that a lot of noise is a bad thing. Yet each year the world in which we live becomes more and more full of noise. In almost every civilised country expert committees have been appointed to investigate what we all call the "menace of noise". Sporadic newspaper campaigns are carried out and are always popular. They produce masses of letters from masses of people who object to all sorts of sounds which they do not want. Opinions are rife and sweeping. Facts which can be regarded as scientifically established are, alas, far more difficult to find. But the facts about noise are slowly accumulating. Each of the last five years has seen the publication of the results of an increasing number of investigations more or less directly aimed at the problems of this book.

Human reactions to noise in real life are an extremely complicated affair. Science, ignoring perhaps the immediate popular demand, must attack the simpler problems first. A survey of the distribution of topics in recent controlled investigations on noise is not without interest. I have, I think, collected practically all the well-accredited work of the last few years. Of this 60 per cent. is either entirely or predominantly physical, the bulk of it dealing with most fundamental and necessary attempts to achieve a measurement of noise; 28 per cent. deals with the direct physiological effects of noise stimuli, and of the remaining 12 per cent. only a very few papers discuss those psychological problems which, for the ordinary person, whether he is engaged in heavy industry or not, constitute the most important and interesting of the questions connected with unwanted auditory stimulation. Precisely as should be expected, perhaps, it is just where opinions are the most common and the most dogmatic that the established facts are the most scanty.

2. What is Noise?

Noise is any sound which is treated as a nuisance. This neither appears nor is a very exact defini-

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tion; but, from the point of view of the present discussion, it is probably as good a one as can be obtained. Certainly the physical definition of noise as sound resulting from stimuli which cannot be resolved into periodic vibrations is, apart from other difficulties(1), a hopeless one. At the basement of the laboratory in which I work, an electrical generating plant is in constant use. The dynamos produce a musical tone which can be heard all over the building. I have yet to meet any research worker in the laboratory who fails to treat this musical tone as a noise. Even a tuning-fork, yielding only the purest tone, can be a horrid nuisance on occasion. Let anyone sit in a sound-proof room—as I have repeatedly done—for two hours at a stretch and listen to the sound of an electrically maintained tuning-fork coming intermittently throughout the whole of that period. At the end of the experiment he may feel inclined to use much the same language of the tuning-fork as that which the less restrained members of the community employ when they write to newspapers about clattering milk pans, clanging bells, or shattering motor-horns.

If we turn to physiology for a definition we get at the moment less help still. The physiologist must attempt to define noise in terms of the reacting mechanisms in the auditory apparatus of the body. Broadly speaking, as most people know, the human ear contains three working sections. The outer ear collects and directs the sound waves which come to us from their external source; the middle ear transmits these waves to the inner ear, and it is from the delicate and intricate structure of the inner ear that the impulses are initiated which pass along the auditory nerves to the brain, and so make it possible for us to identify and interpret the sounds which have reached us. Nobody knows precisely how these physiological mechanisms work in the case of noise. Their most important secrets lie undoubtedly in the activities of the inner ear, of the auditory nerve tracts, and of the end stations in the brain.

Recent research seems to point unmistakably to the cochlea—the inner ear—as acting in some respects as a resonator and in some respects as a telephone(2). But how, in either respect, it distinguishes tone from noise—if indeed it does this—is wholly unknown. Moreover, that aspect of noise which is the most important for us, namely the annoyance which it produces, certainly cannot have a location in the ear, and as certainly nobody is within measurable distance of knowing whether it has, or where it has, a place in the brain.

We must therefore fall back on the rough working definition that any sound is a noise when it is treated as a nuisance. Why and when are sounds treated as a nuisance? It is useful, though not, of course, decisive, to attempt some preliminary classification of reasons. One guiding fact must be held in mind all through. The qualities of any particular sound depend largely upon the background against which the sound is experienced. This background may be auditory or not. If a man hears an unusual sound coming apparently from the inside of his car when he is driving, he is likely to be disturbed and irritated until he can identify and localise it, although a very similar sound with a different background might pass unnoticed or produce no annoyance. In a large number of cases, among them many which may be of great importance in industry, the background is not auditory at all. When we get rid of an unwanted bore, the slam of the door as he disappears may be grateful to the ears, though door slamming may take a high place in our catalogue of nuisances under other conditions. To this important question of noise relation to its background I shall return more seriously later.

There are certain characteristics of sounds which make them stand out, or "attract attention", on almost any background. The most important of these are loudness, ambiguity of direction and unfamiliarity. Of these the only one with an obvious physical correlate which seems capable at present of being dealt with in a reasonably accurate manner is loudness; and so it is not surprising that loudness and noise are closely connected in the popular mind, or that a large part of recent research should have been concerned almost wholly with this quality.

Now it is obvious that to be able to state the relative position of a sound in a scale of intensities itself throws no light whatever upon the effects of noise on work. Further, in treating loudness as a correlate of intensity, we are clearly isolating one characteristic only of a number which noisy sounds possess. The characteristic is doubtless important, but we must not conclude at once that because it has received more detailed treatment than any other it is of necessity the most important. Still, if we are to arrive at any safe generalisations about the effects of noise on work, it looks as if we must be able to compare noises in some way, and even a partial and inaccurate way is better than none at all.

3. The Measurement of Noise

We must therefore turn first to recent researches into what is called the "measurement of noise". By measurement of noise is generally meant the equation of a sound to a standard sound in respect to one or more of its characteristics—loudness is almost the only characteristic that is actually used—when the position of the standard sound in a scale of intensities is known.

Broadly speaking, two methods are possible. The first is a purely physical method, in which an attempt is made to measure the actual energy output of a given source of noise and to equate it with a similarly measured output of a standard sound source. This, from our present point of view, is of very little use, not only because the apparatus required is delicate, not easily portable and requires expert management, but because, even when the energy output of every component of a complex noise is known, we are still very far from being able to conclude anything about its total effect when all the constituents are simultaneously present. (But see also § 7 of the present chapter.) The masking and interfering effects of constituents of different frequency might even mean that a reduction of the energy output in the case of some of the constituents would leave the total effect more thrusting and annoying than it was before.

Consequently, both for theoretical and practical reasons, the method almost always adopted is a mixture of a physical and a psychological procedure: the measurement is an aural measurement. All the devices in use derive from a scheme originally proposed by Barkhausen. A vibrating reed or tuning-fork is used as a standard source of sound. The stimuli are conveyed to a telephone which is held near or against the observer's ear. Then the standard sound is adjusted in intensity, by the variation of a calibrated potentiometer, until it appears to be just as loud as a noise heard by the other ear, and the noise is expressed in whatever units of intensity are being used to indicate the position of the standard sound on a scale of intensities (3).

At first sight this looks as if it must be a very inaccurate method, admitting wide divergencies of judgment. Yet a considerable number of independent investigators, in this and other countries, have demonstrated that with trained observers the method yields results which are unexpectedly consistent and of practical value (4).

The Bell Telephone Company of America have developed a slightly different technique, a little less easy to use, perhaps, but particularly adapted to certain situations (5). With this the telephone which conveys the standard sound is so held that the noise and the comparison tone both enter the same ear. The normal threshold for the standard sound—that is to say the minimum audible note—is known. Now the standard tone has to be adjusted until it is just drowned, or masked, by the noise; and the noise is expressed in terms of the rise in threshold* which its presence produces. This method is obviously the better one whenever a task is set which demands the identification of a particular sound upon a background of noise.

The simple method suggested and used with great success by A. H. Davis in this country combines both of those already mentioned(6). With this a standard tuning-fork is used. The fork is struck and held in a constant position near the ear of the observer. The rate at which its sound decays is known, and the tone can be either equated with the apparent loudness of a given noise, or the moment at which the fork ceases to be heard when the noise is present can be recorded.

These are the methods. In what sense do they measure noise? Clearly noise is not being measured directly. It is being equated, for one only

* "Threshold" is defined as the minimum value of a stimulus which is capable of producing a sensory response. Sometimes the value is assigned which produces 50 per cent. correct reactions in a series of experimentally controlled tests; more often, and probably more satisfactorily, 80 per cent. correct reactions are required.