CHAPTER-II.
Previous Studies

Studies done abroad

There has been a growing body of research on the possible effects of noise in the environment. Industrial machinery, urban constructions, transportation of vehicles and warning devices, all contribute to pollution. Broadbent (1957) and Kryter (1970) hold the opinion that noise is an irritant which causes physiological and psychological changes, excites emotional responses and brings about impacts on health problems. The distinct landmarks in noise research may broadly be categorized under two headings.

A. Deafness

- Many reasons have been put forward to the cause of non-occupational and occupational deafness. The reasons for non-occupational deafness include heredity, trauma, blast, excessive nose blowing, otosclerosis, etc. Glorig (1958) maintains that deafness is very far from being always occupational in nature. Murray & Reid (1946) in their review of deafness in artillery men noted that the ear was damaged by the noise of the guns and observed that the degree of deafness is proportional to the peak blast pressure of the gun. Messweazer (1954) in studying the cochlear damage noted that the loss due to explosive noise may be as high as 70 dB at some frequencies. Muirhead (1960) has studied the behaviour of shock wave and noted that such wave causes an oscillatory rather than a single transient pressure load to the ear, the acoustic damage being noteworthy for the
frequencies above 2000 Hz. Rozsahegyi & Gomori (1961) concluded that those who experienced decompression symptoms had cochlear and vestibular damage. Burns of the middle or inner ear by toxic agents also lead to deafness (Calvet & Coll, 1964).

An intense pain followed by prolonged loss for high tones above 9000 Hz was observed by Davie, Parrack & Eldredge (1949) in their experiment of short exposure to high intensity noise. But, if unequal sound intensity impinges on two sides, one ear is likely to be more affected than the other, depending on the relative position of the ear to the source of noise. Katsuki (1957) carried out an experiment on the telephone operators and came to the conclusion that the ear to which the receiver is generally held often suffers from hearing loss.

Hearing loss does not always refer to absolute deafness; neither it means that all those who are exposed to noise suffer from hearing loss. Hearing loss is characterised by two forms - Temporary Threshold Shift (TTS) and permanent hearing loss.

**Temporary Threshold Shift**

Temporary Threshold Shift has been defined, among others, by Glorig (1958) who said that temporary hearing loss means a loss resulting from a day's exposure to noise from which the ear has recovered by the following morning. The International Organization for Standardization maintains
that "an elevation of the hearing threshold level following exposure to noise which shows a return towards the pre-
exposure threshold level and ultimate recovery in less than 10 days". Either monaural or binaural exposure to noise
can cause threshold shift (Ward, 1965).

Hearing loss depends on the characteristics of the
noise spectrum—intensity, frequency and the period of
exposure. Shilling, as far back as 1942, pointed out that
the majority of TTS occurs during the first hour of expo-
sure to noise. Davies (1957) found in his research that
TTS is usually greatest for a frequency approximately half
an octave above the exposure time; but physical, anatomical
or physiological correlates have not been established to
account for this upward shift. Kylin (1959) maintained that
within limits, the amount of shift produced by a noise of
given intensity is greater for higher frequencies than low
frequency, which was further studied by Bell & Fairbanks
(1963).

Many researchers have studied the effects of conti-
nuous and intermittent noise on hearing loss (Glorig, Ward &
Nixon, 1961). They did not find any significant shift by a
continuous steady noise with a sound pressure level of less
than 78 dB. The TTS for varying time exposures to certain
broad-band noises can be calculated from the charts developed
by Glorig (1961b); Salters (1963); Ward, Glorig & Sklar
(1958). As far as intermittent noise is concerned, Ward
(1957) maintained that men working around jet aircraft do not develop hearing loss as rapidly as might be expected, and the intermittence of exposure appears to be the partial protective factor. The degree of shift caused by exposure to impulse noises up to 9 seconds' duration is relatively independent of inter-pulse interval, as shown by Ward (1962).

**Permanent hearing loss**

Permanent hearing loss is generally found to occur in the frequency band 300-600 Hz (Webb, 1976) and characteristic at 4000 Hz. With the worsening of hearing acuity, the loss at lower frequency has also been noted. Littler (1958) found from the shape of equal loudness contours that for the same region, the ear requires less energy to experience a certain sensation of loudness than at other frequencies. The rate of deterioration was reported to be of 6 dB per year at 4000 Hz (Oppeniger, Crandjean & Schulthess, 1960). The International Organization for Standardisation (1963a) holds the view that for the average individual generally exposed to loud noise, the ultimate hearing level at 4000 Hz is equal to the temporary level found two minutes after five hours continuous exposure to the noise. Lawrence (1963) made a point that anybody who has worked for more than 10 years need expect no further loss. Gallo & Glorig (1964) reported that people exposed to high industrial noise had their hearing level changed at 3000 Hz, 4000 Hz, 6000 Hz in
the initial 15 years; whereas at lower frequencies (500 Hz, 1000 Hz, 2000 Hz) changes showed linear relationship. Herman (1964) developed a mathematical model to detect hearing loss at early stage by compiling the data at 4000 Hz. Burns (1965) found variation in the pattern of deterioration by observing that hearing loss tends to be maximal at the end of 10 year exposure, after which it remains constant for 30 years. Herman, again in 1965, observed that the rate of noise-induced hearing loss is proportional to the amount of hearing remaining to be lost.

Aging: It is further observed that hearing acuity decreases with ageing, a process popularly known as presbycusis. It is argued that this change is not necessarily physiological. Pestalozza & Shore (1955) observed that precise pathological changes in this condition are obscure, and different lesions may be responsible for hearing loss. Schuknecht (1955) opined that ageing degenerates the basal turn of the cochlea and that this process spreads up the cochlea and affects the contained structures, including the afferent and efferent nerves. Nixon, Glorig & High (1962) held the view that the effect cannot be attributed to changes in ossicular chain of the middle ear, such as occur in otosclerosis. The relation between presbycusis and noise-induced hearing loss in the same individual is difficult to determine. Glorig & Davis (1961) believed that losses from noise and presbycusis are additive.
The relationship between temporary threshold shift and the noise-induced hearing loss is not quite clear. However, Giorig (1961) maintained that the greater the noise-induced hearing loss at any frequency, the smaller the TTS at this frequency. Giorig, Ward & Nixon (1962) further noted that a noise not causing temporary threshold shift may cause permanent damage. But this is a rare phenomenon. They went on to say that the shift in dB due to eight hours exposure parallels permanent loss at the end of 10 years' exposure.

**Susceptibility:** There are some individual differences in developing hearing loss. Some people may suffer hearing loss more quickly than others. But, if the noise exposure is prolonged, susceptibility to noise exposure may disappear. Such people are easily disturbed by noise, and develop nausea and vertigo. But, persons susceptible to noise are always very few (Giorig, 1957; Laauwen, 1958). Susceptibility may be found for pure tones or complex noises (Waal, 1961). Screening of susceptible persons by some predictive tests in pre-employment session have been attempted; but the tests till date have been found to be not so much useful (Lawrence & Blanchard, 1954; Christiansen, 1956; Kiln, 1947).

**B. Behaviour:** Amongst the behavioural effects of noise, annoyance draws much attention and becomes conspicuous in any job. The degree of annoyance depends on the intensity
of noise and the complexity of the task. Sateleff (1957) and Hinchcliffe (1958) showed that a slow rate of repetition for a pattern of tones is considered to be highly annoying than a rapid rate. Kryter (1957) noted differing annoyance threshold for people having different background of work experience.

A few studies have come to the light in relation to intellectual task performance. Most of the studies involving mental activities have used either continuous noise or intermittent noise (Jexison, 1954; Broadbent, 1958; Woodhead, 1964). Broadbent (1951) showed that noise in general affected intellectual task performance. He (1954) found that exposure of about 15 minutes to more than 90 dB of broadband noise has a detrimental effect on performance. He further observed (1958) that naval ratings were slowed down in the performance of a subtraction task (memory loading) at 100 dB compared with their performance at 70 dB (quiet condition). Lehman, Creswell & Hoffman (1965) tested eighteen male subjects in arithmetical calculation and reading comprehension at quiet level (20 to 25 dB), normal level (45 to 55 dB) and higher level (75 to 85 dB). They concluded that mathematical and reading comprehension scores showed significant deterioration in performance with the increasing noise level. Hoffman (1966) and Slater (1960) reported no detrimental effect at 55 to 70 dB, and 75 to 90 dB in a short written task performed by school children, compared with
the quiet level (45 to 55 dB). Clarke (1971) conducting an experiment with subjects performing I.Q. tests under (27±3) dBA, (40±5) dBA and (60±5) dBA, and with a control group working under (35±5) dBA, found no significant variation in performance under these conditions. Bryan & Colyer (1971) designed an experiment on intellectual tasks in which they found that noise had effect upon the number of questions attempted (Eysenck's I.Q.Test). They also showed that noise produced differential effects upon performance, i.e., those students who attempted most questions in the quiet were adversely affected by the noise, whilst those who did least questions in the quiet actually attempted more in the noise. They again maintained that those making most mistakes in the quiet made even more in noise; whilst those who made few mistakes in the quiet made even less in the noise. Weinstein (1974) in his study on an intellectually challenging task showed that identifying grammatical errors (P < 0.001) were poorer than detecting spelling errors. Further, he showed that subjects initially worked more slowly (P < 0.01) and less steadily (P < 0.002) during noise bursts than during intervening quiet periods, but more accurately.

The studies on the effects of noise centered around the sensorimotor and perceptual task performance. The most striking of these are described here. Smith (1951) showed that performance on name and number checking deteriorated significantly due to the presence of high intensity,
aperiodic bursts of noise. Broadbent, in 1951, advocated that the effects of white noise are more pronounced when they are experienced for the first time. McGrath (1963) found that continuous white noise decreased performance which was halted by a music of a modal intensity of 72 dB. Detrimental effects of noise on signal detection tasks were reported by Davies & Hockey, 1966; Broadbent & Gregory, 1963, 1965; Broadbent, 1951; 1953. Alluisi (1967), Fleishman (1967) and Fleishman & Bartlett (1969) found differential effects for different aspects of performance. They suggested the need for research with a wide range of standardised behavioural measures capable to tapping a large number of different categories of human performance.

Broadbent (1957) criticised that many of the studies showing the adverse effects of noise followed divergent methodological grounds. In their study to find the effects of 'predictable' and 'non-predictable' intermittent noise on digital recall, Finkleman & Glass (1970) noted the decrements for a secondary task peripheral to a primary tracking task. The studies (Hockey, 1970a; 1970b; Woodhead, 1960) carried out on several tasks simultaneously provide information that suggests on their bid to maintain performance on one activity than on others. Eschenbrenner (1971), Flutchik (1959) and Sanders (1961) showed that performance on sensorimotor and certain complex tasks are differentially impaired by exposure to intermittent versus continuous noise. Fisher
(1972) in studying the effects of random bursts of noise on serial reaction tasks showed that the performance decreased at the onset of bursts. Fleishman (1972) maintained that differentiating motor performance from mental, does not add to our knowledge about more specific categories of human skills. Hartley (1974) showed that continuous noise for 40 minutes' exposure impair performance in a different form, compared to the intermittent bursts of noise of same intensity and duration.

In the study designed to estimate the effects of prolonged exposure to two noise stressors (random and patterned intermittent, 05 dB) on the performance of reaction time, rate control and time sharing, found that performance depended on the type of task and performance measures (Theologus, Wheaton & Fleishman, 1974). They further maintained that while the reaction time task and time-sharing task were affected only after prolonged exposure to noise, rate control tasks were not. Hartley & Adams (1975); Davies & Davies (1975) observed that short exposure to noise may, however, have beneficial effects. Hartley & Williams (1977) showed that on a one-hour visual vigilance task, discriminability was higher in white noise than in music. Although impairment in psychomotor task performance in continuous and high noise fields was noticed by Shoenberger & Harris (1965), insignificant effects of intermittent noises of 60 and 80 phons were reported by Ohwaki (1950).
In the study of the effects of noise on performance, individual differences have also been found. Some investigators in comparing performance on IQ tests, reaction time and tracking task of anxious, introverted and somatic responsive persons, as diagnosed by personality tests, with that of the better adjusted persons, concluded that the former groups were adversely affected than the latter (Shambaugh, 1950; Barrett, 1950; Broadbent, 1961; Cohen et al., 1966). Blau (1951) did not find any difference in the effects of 103 dB noise on performance of tests of mental ability between the well adjusted and less well adjusted groups; whereas Angelino & Mach (1955); Auble & Britton (1958) observed that the less 'well adjusted' persons performed better in the 'noise' than their 'well adjusted' counterparts. Broadbent (1958) found that the performance of somatic or anxious type of people tended to be affected by intense noise; while more stable subjects were not. Davies and Hockey (1966) showed that, for extraverts performance on a vigilance task improved by a moderate level of noise, and for introverts it remained unaffected. Davies & Davies (1975) in studying the effects of noise on individual differences found that in cancellation task older subjects worked significantly more slowly and less accurately than the younger ones.

As far as physiological effects of noise are concerned, it is well documented that heart rate, pulse beat, etc. increase at the onset of noise, and level off thereafter. On
other effects, Finkle and Poppen (1948) revealed that in the first hour of a two-hour exposure to 120 dBA, there was a rise in blood sugar level, which then fell off during the second hour. Murrell's view (1970) that human skilled performance under monotonous conditions can be modified by prior administration of glucose was modified by Cox et al. (1973), who advocated that the effect of noise stress on skilled performance can be improved by glucose preloading. Levi (1972) has reported a number of blood chemical changes in response to noise stress; but suggested that measurement of these requires larger blood samples. Canard (1973) in studying the effects of continuous, periodic and aperiodic broadband noise on serial decoding task noted a few physiological changes as below:

(i) Finger vasoconstriction response was found to be higher in all noise conditions than in quiet.

(ii) Vasoconstriction response was higher for persons found to be highly annoyed by noise than for persons less annoyed.

Another effect of noise is speech intelligibility. The ability to communicate verbally in a noisy situation is always affected, no matter how intense is noise. Carpenter (1962) showed that normal speech varies greatly in amplitude, but a level of 65 dB at 1 meter is fairly representative with an overall range of 20 dB. Verbal communication in noisy situations in the frequency range 200 Hz to 6000 Hz play a
key role, with the vowel frequencies below 1500 Hz and constant frequencies above. The consonants being weaker in intensity than vowels become more readily intelligible in noisy environment. Background sound may cause the intelligibility of speech difficult. It also increases the hearing threshold. He further noted that the average of sound pressure levels in dB in the octave bands 600 Hz to 1200 Hz, 1200 Hz to 2400 Hz, 2400 Hz to 4800 Hz indicate the degree of interference with the ability of two people to speak to each other.

All the studies mentioned above cluster mostly around the laboratory experiments. Very little work has been carried out in industrial establishments, in situ, considering the effects of noise on personal efficiency. The inherent drawbacks of the laboratory studies are that the experiments have been conducted under controlled conditions which are different from that of in shop floors, towards air temperature, humidity, ventilation, managerial system, interpersonal relations, etc., thus making the findings unsuitable for direct application in industrial organizations. However, Broadbent & Little (1960) reported that reduction of noise diminished the number of broken rolls of films and equipment shutdowns. Kovirigin & Mikheyev (1965) showed that the postal sorters committed more number of errors when noise was introduced by means of certain external agencies.
Indian Studies

Pancholy et al (1960a, 1960b & 1961) presented their study on noise survey in Indian Cities in three parts. While the first two parts concern about traffic noise in early morning and in late night of Delhi and Bombay, the third part reflects the noise level originating from specific sources, i.e., suburban trains, aircrafts, trams, workshops and loudspeaker system. The investigators, on the study of traffic noise, recorded noise levels at 01615 hrs for a fairly long interval of time to obtain minimum, maximum and average values. To understand the special characteristics of noise, an octave band analysis at slow speed was also done. They have rightly identified types of localities and type and density of traffic. The second part of the series shows continuous measurement of noise levels at an interval of half-an-hour from 0600 hrs to 2200 hrs. The result shows the daytime average noise level in Delhi and Bombay is excessively high (80 phons), with a rare drop below 60 phons (Part I); the localities are classified into quiet (55 phons), moderately noisy (56-65 phons), very noisy (66-75 phons) and excessively noisy (75 phons), considering 50 phons as a criteria for restful sleep. But the authors did not seem to have mentioned the type of instrument used, whether the instruments were calibrated, what distance from the source of noise was maintained, and how high was the sound measuring instrument held. The third part of the series shows the
noise (76 phone) originating from vehicular traffic rose up to 91 phone when the aircraft was running at the check-up speed. Inside the buildings the noise level was found to be 86 phone with the windows facing the airport open and 82 phone with all the windows closed. The background noise level of 67 phone went up to 89 phone due to a mainline train passing at a distance of 30 feet from a house, and inside the house the noise level of 65 phones went up to 84 phone. Noise originating from locomotives was found to be as high as 95 phone. The levels of noise originating from industrial sources were also measured and shown as below.

<table>
<thead>
<tr>
<th>Description of places where noise measurement were taken</th>
<th>Average Noise Level (Phons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Outside the compound of a textile mill</td>
<td>75</td>
</tr>
<tr>
<td>2. On the road adjacent to the Printing Press</td>
<td>79</td>
</tr>
<tr>
<td>3. Near Workshop</td>
<td>80</td>
</tr>
<tr>
<td>4. When circular saw started in the Workshop</td>
<td>93</td>
</tr>
</tbody>
</table>

The above areas were thickly populated. While the average levels of noise are quantified, the authors did not explain the prevailing physical conditions at the time of measurement.

Sen (1967) in the study on the physiological effects of noise (the first Indian study) showed that the physiological responses, i.e. pulse rate, oral temperature, pulmonary
ventilation and $O_2$ uptake in young workers (21-30 yre) with ear muffs lessened than that of without ear muffs. The same trend was also found in old workers (40-50 yre).

His subjects were the weavers of a textile mill (1000 looms) in which noise was surveyed with a GR Type 1555A sound survey meter and a GR Type 1558A octave band analyser. The instruments were calibrated with a 15520 sound level calibrator and a type 1307A Transistor Oscillator. He also did not specify what distance for the source of noise was maintained and how high the instruments were held off the floor. He, however, showed that the noise level at midnight, when all the looms were stopped, was found to be 62 dBA and 52 dBA inside and outside the weaving shed, respectively. His study does not make any reference whether his subjects had ENT screening by ENT specialists for normal hearing, which is an important factor if ear muffs are to be used. In the study to measure noise originating from room airconditioners of a hotel, he showed that sound reduced by about 10 to 15 dBA when the airconditioners were put off. The same study also includes noise measurements in a nitric acid plant.

Chadha and Singh (1971) in their attempt to measure noise level in three sections of an ammunition factory, and to assess the effects of noise on hearing, used a sound level meter Type 2203 and an amplivox audiometer. They observed that the prevailing level of noise ranged from 85 dB to 101 dB. Noise was of continuous nature in two
sections and the third section had intermittent noise. The subjects were machine operators, labourers and tool setters. Audiogram revealed that 50% workers of the experimental workers suffered hearing loss as against 12% of the control group. While 22% workers exposed to noise had shown early noise-induced hearing loss in the form of characteristic 'dip' at 4000 cycles/second, none in the service group less than 2 years showed hearing loss. After the age of 25 years there was a constant rise in hearing loss amongst workers exposed to noise. This study suffers from the same shortcomings as the studies mentioned earlier. The audiometry was done at 0830 hrs in a relatively quiet room, but the authors did not mention the noise level prevalent in the room during audiometry. This is an important phenomenon in a sense that external noise, however little it is, will interfere with the listening of the signal coming from the audiometer. It should be done preferably in an audiometric booth, or at night when most of the external noise sources are generally cut off. But, on the whole, it is a good attempt to carry out audiometry.

Gupta et al (1965) carried out an investigation of occupational hearing loss. The subjects of this experiment were exposed to a noise level exceeding 90 dBA. They had thorough ENT examinations following the history of childhood diseases covering aspects such as mumps, measles, typhoid, otitis media, ear-ache, head injury and fall from
a truck, etc. The audiogram (Maico Model F-1 Standard) was calibrated and testing was carried out with each individual twice a day between 1730 hrs and 1930 hrs, and 2330 hrs and 0100 hrs in a room having noise level less than 40 dBA, as pre-employment audiogram was not available. A control group consisting of hospital staff unexposed to noise was also examined. The ascending condition of short tone testing one/two seconds was used, with the hearing "control" set at intensity below the minimal and raised by 5 dB on all frequencies. The result shows that about half of the subjects had previous exposure to noise and childhood infections were found to be scarce. Some cases showed poor mobility of the drum. It was observed that normal hearing was present in only 49% of the cases and 31% of the cases showed binaural asymmetry. There was no significant variation in numbers between the control and the experimental groups.

This was a well designed study. The authors carried out the project quite efficiently. But had the audiometry been conducted in an audiometric booth, the results would have been much more promising.

Ganguly & Rao (1954) carried out a study to examine whether reduction of noise had any effect on industrial efficiency. Eight jute weavers (age 23 yrs to 35 yrs and experience 4 yrs to 12 yrs) constituted the sample of the study. Noise level was measured with a general radio noise level meter. The study started in June and continued
through 28 weeks to the following January, with five days a week. Ear defenders were used regularly on alternate weeks. They also considered the environmental conditions prevailing during the study period. They concluded that: (i) a factory noise of about 100 decibels or less does not appreciably lower productivity, and (ii) while four weavers registered increased output when noise was reduced with the use of ear plugs, others reflected decreased trend. The authors, like the previous investigators, did not explain how high the meter was held and how it was calibrated.

Number of subjects considered in this study was too meagre. It may be expected that the ear defenders being an external agent may reduce production in the first few days and increase thereafter, thus requiring an adaptation period. But, in this study, the ear defenders were used on alternate weeks. This means that just when nearing adaptation, the use of ear defenders were discontinued. This system might have been responsible for showing decreased efficiency for some of the weavers.

Chatterjee et al (1965) determined the level of noise originating from air-conditioners fitted in the room of a hotel. This study was taken up following a complaint lodged by the residents of a nearby building situated at the western side of the hotel. They pointed out that on the western side adjacent to the building runs a railway track and on the east adjacent to the hotel runs a road. The observations were made
with a calibrated sound survey meter at thirteen locations around the hotel at 1800 hrs, 2100 hrs, 0000 hrs, 0300 hrs and 0500 hrs. Noise originating from other sources, like running cars, buses, lorries on the road and local suburban trains at a distance of about 250 ft from the hotel building was subsequently measured. The air velocity and wind direction were also recorded. The results showed that noise level near the residential building dropped by 13 dBA, 10 dBA and 11 dBA when the airconditioners were off. The background noise level recended at 0300 hrs with airconditioners 'on', showed no significant change when compared with that recorded at 1800 hrs, 2100 hrs and 0600 hrs. The authors attributed their findings to the room being located in a closed space developed a constant bounding and rebounding effect of noise vibration between the walls of the hotel and the residential building. Noise levels at other locations at 0000 hrs were found to be much less compared to that obtained near the residential building. The authors have tackled the problem quite efficiently, incorporating good diagram of the different locations. But a short description of the site would, however, have given a better understanding of the locations. Although wind direction and velocity were measured, the figures are not available in their report. They did not mention the distances of the locations from the hotel and how high the sound survey meter was held.
Nai et al (1978) surveyed the hearing acuity of artillery and armoured corps personnel exposed to noise of various military vehicles, viz., tanks, APS, etc. They have rightly measured the noise and analysed its characteristics by sound level meter and Octave band analyser. Transients of the gun reports were also measured and its amplitude time plot was recorded on oscilloscope. The audiometer was also calibrated. They found that sound pressure level of gun reports varied between 140 and 182 dB and 174 and 182 dB respectively, depending upon the charge of shell. Frequency analysis of the APC revealed that the energy was mainly concentrated in the lower frequency range, i.e. 63 Hz (110 dB) to 125 Hz (105 dB). They also found speech interference level quite high. Further, 37.9% of 1398 artillery and 44.5% of 519 armoured personnel had normal hearing acuity. Initial hearing loss was observed at 6 KHz in those with 5 years of service.

This study is a good attempt. But it suffers from the same shortcomings as the previous studies. Moreover, the study was not carried out in audiometric booth, and thereby the background noise might have affected the hearing thresholds of the subjects.