THE EFFECT OF BULLDOZER NOISE ON HEARING—AN ATTEMPT TO PROTECT THE EARS FROM IT

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Effect of noise on hearing either in terms of T. T. S. or P. T. S. has been a subject of interest of many people. A number of studies have been conducted to study this phenomenon, around the country and around the world *(Larsen,* 1939; *Rosenblith,* 1942; *Me Coy,* 1944; *Urposurala and Eniolahikainen,* 1948; *Kryter, K. D.,* 1950 *and* 1963; *Coldner.,* 1953; *Cox, Mansur and Williams,* 1953; ASA, 1954; *Gangoli and Prakash Rao,* 1954; *Lindquist, S. E., Neff, W. D., and H. F. Schuknecht,* 1954; USAI, 1954; *Webster,* 1954; *Adiseshaiah, et al,* 1959; *Ward, W. D., A. Glorig, and D. L. Skian,* 1959; *R. E. Fleer and A. Glorig,* 1961; *Gallo, R. and A. Glorig,* 1964; *Mahananda, P.,* 1972). This may be the first report on effect of bulldozer noise on hearing.

Noise, for the present purpose, has been defined as an acoustical signal which is injurious to hearing. Noise produced by the bulldozer which was levelling the field in the premises of the All India Institute of Speech and Hearing was used as a noise source.

Experiment 1

To study the pattern of noise that was produced by the bulldozer, the noise level in the driver's cabin was measured using an SPL meter with an octave filter set (B and K Type 1220). The microphone of the SPL meter was held at the level of the ear of the driver. The readings were taken on two days, five times each day with an approximate interval of one hour between each reading. Table 1, shows the comparison of the average intensity of noise at different frequencies, produced by the bulldozer, with the Damage Risk Criteria given by Glorig, Ward and Nixon (1961). It ranged from 44 dB at high frequencies to 110 dB at low frequencies. The noise was above the Damage Risk Criteria given by Rosenblith and Stevens (1953) and also ASA Subcommittee (1954). Even though the noise was predominent in low frequencies, the average level exceeded the Damage Risk Criteria (Glorig *et al* 1961) more in higher frequencies (12 dB) than in lower frequencies (by 2 dB). Hence it was expected to cause a hearing loss in drivers, who would be exposed to this noise for more than eight hours a day.

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FREQ.	D.R.C. GIVEN BY GLORIG, A..W. D. WARD & J.NIXON	PRESENT READING	DIFFERENCE
63	102	107	**5**
125	95	94	
250	91	98	7
500	87	96	9
1000	85	97	12
2000	82	94	12
4000	80	92	12
8000	79	87	8

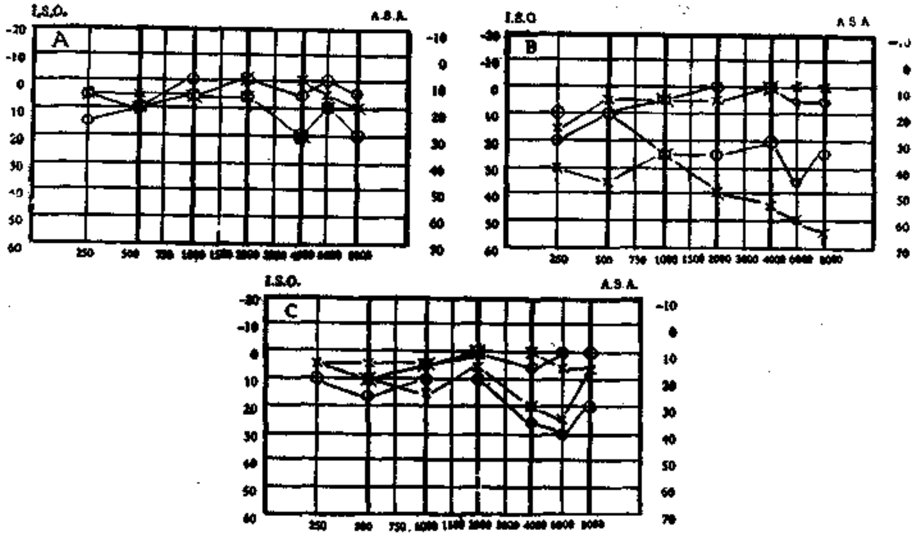
TABLE 1 showing the comparison of the average intensity of noise at different frequencies, produced by the Bulldozer with damage risk criteria given by Glorig, Ward and Nixon (1961)

Experiment 2

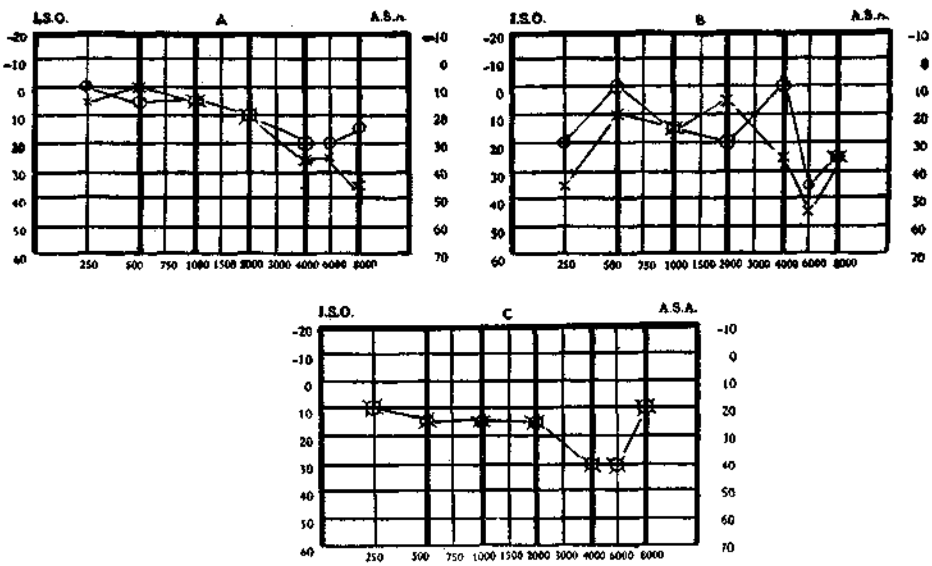
To study the effect of this noise on hearing three normal hearing adult males, who volunteered themselves were taken for the study. All the hearing measurements, on these subjects were carried out in three audiometric rooms, which satisfied ISO standards. A. C, B. C. and SRT measurements were done by three qualified audiologists on these three subjects using three audiometers (Beltone-12D, 15 CX and Arphi) which were calibrated to ISO standards, by standard procedures. Each subject was tested by the same tester on the same audiometer in the same situation throughout the study.

After the initial measurements of hearing were made the subjects were made to sit in the driver's cabin of the bulldozer, which was levelling the ground. They were exposed to noise for 1 hour and 2 hours, with an interval of 11/2 hours. In both the instances, immediately after the exposure to noise pure tone thresholds were measured, to see possible shifts in thresholds. There was a lapse of less than 2 minutes before these measurements could be made as the subjects had to cover a short distance from the bulldozer to the test rooms.

There was a definite shift in thresholds for pure tone in all the three subjects. The maximum shifts were observed, as usual, at 4 KHz and at 6 KHz in all of them in both the conditions. Graph 1 and 2 show the results. There was a shift ranging from 15 dB to 45 dB at 4 KHz, with ±5 dB difference between the two ears



Graph 1 showing shift in threshold after one hour of exposure to the noise



Graph 2 showing shift in threshold after two hours of exposure to the noise

of the same subject, except in case of subject B, who showed a difference of 25 dB between two ears. A similar shift was observed at 6 KHz with a range of 5 dB to 50 dB. Again, there was only a difference of ±5 dB between the two ears of the same subject except in the case of subject B, who showed a difference of 20 dB between the two ears. And he also showed a shift of 60 dB at 8 KHz, in left ear only.

The shift in threshold was expected to grow logarithmically with time (Ward, W. D., 1963), that is, more shift in threshold was expected after two hours of exposure than in one hour exposure. Only in case of subjects A and C more shift in threshold was observed, but in the case of subject B the shift was less than the shift that was seen in one hour exposure, by 5 dB. And a lesser shift of 35 dB at 8 KHz. To check this variation from the rule, the experiment was repeated. But again, the same results were observed. This may be because of inconsistent responses given by the subject, as reported by the tester or there may be some other explanation for this variation. From this experiment it was evident that the noise of the bulldozer, which was above the Damage Risk Criteria, would cause a shift in threshold in higher frequencies (at 4 and 6 KHz) even for an exposure for one hour.

Experiment 3

After the initial measurements for shifts in thresholds, after both the exposures, the subjects were tested once in 1 hour to study the complete recovery pattern. The recovery was faster in first \ hour of rest period than in second ***i*** hour of rest, in case of subjects A and C. And they took one hour to recover completely, after both the exposures. Whereas subject B again as an exception, took one and a half hours to recover completely and only in case of one hour exposure he showed a gradual recovery. But in two hour exposure recovery study he did not show any recovery in first two *k* hours, that is one hour after exposure, but a sudden recovery was seen when his thresholds were measured at the end of the third 1/2 hour rest after exposure. Thus shifts seen in the thresholds for pure tones after one hour and two hours of exposure to bulldozer noise, was only temporary. The recovery pattern for all the subjects have been shown in Table 2.

Experiment 4

This experiment was conducted to find out an effective means of attenuating the (intensity of) noise that was reaching the ears and thus to stop or to reduce the shifts in thresholds that were observed in experiment 2.

Guild (1958)'records the attenuation provided by A. F. ear muffs, and A. F. ear plugs and by the two worn together. The results show that the combination of the two types provides the greatest amount of attenuation and that the total attenuation of the two together is far less than the simple addition of the attenuation provided by each of them.

Studebaker and Brandy (1971) while discussing the methods of ear protection say that "other sound transmission pathways limit the total amount of attenuation that can be achieved by simple covering and plugging the ears. . . . Sound

(a) Recovery after 1 hour of exposure

	sub	4KH2		6KH2	
		Rt.	Lt	Rt	Lt
after 30 minutes of rest	A	15	10	5	10
	B	15	45	15	15
	C	5	15	5	10
after 1 hour of rest	A	5	10	0	5
	B	5	0	10	10
	C	5	5	5	5

TABLE 2. Showing the recovery patterns after one hour and two hours of exposure to noise

energy may pass through the ear plug material, it may move the ear plug as a whole and set up pressure waves within the ear canal, or it may enter the ear canal through air leaks around the edge of the ear plug. In order to reduce transmission through the ear plug itself, it should be made of material with low compliance and high mass. However, a complaint material is needed for good fit and comfort, this makes compromises in ear plug construction necessary. A substantial increase in mass above that currently used is required in order to produce a significant effect. Furthermore, greater mass increases discomfort and creates a problem in keeping the devices in the ear. An ear leak can cause a significant reduction in attenuation at all frequencies but, particularly in the lower frequencies (Zwislocki, J., 1951). For this reason, a flexible material that conforms to the shape of the individual ear canal, a good initial selection of ear plug size, and the proper use of the ear plug by the employee are all required" (p. 458).

Several other methods, for this purpose have been tried and suggested and yet no satisfactory method has been evolved (Zwislocki, 1957; USASI, 1957; Mass, R. B., 1961.)

To achieve this purpose, ear moulds using acrylic material were prepared for each individual and using free field testing the effect of these moulds in attenuating sound was determined for each individual. It gave only an attenuation of 20 to 40 dB and in high frequencies only. Even when the ears were covered with head phones (of speech trainers) with these ear moulds there was no attenuation in low frequencies. Hence, ear moulds using typing metal (an alloy of lead),

(b) Recovery after 2 hours of exposure

after 1 hour

SUBJECTS	4KHz		6KHz	
	Rt	Lt	Rt	Lt.
A	15	5	10	10
B	0	10	10	40
C	10	15	5	25

after 1 hour

A	0	10	5	5
B	0	10	10	40
C	5	10	5	5

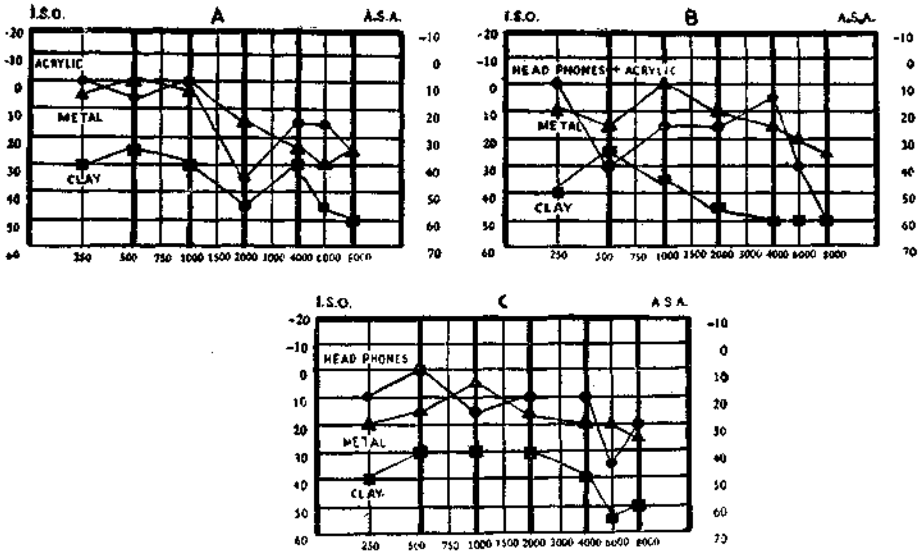
after 1J hour rest

A	-	-	-	-
B	0	5	10	0
C	-	-	-	-

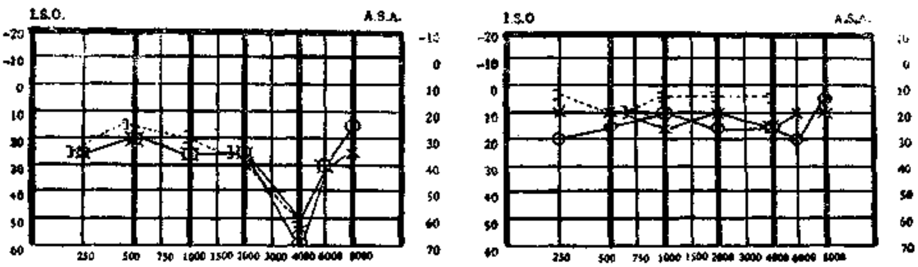
were prepared for each individual. Again this also showed an attenuation of high frequency sound and not of low frequency sounds. And the subjects reported difficulty in wearing these moulds because of their weight. Ears were packed with modelling clay and its effectiveness in attenuating sound was determined using free field testing. This packing gave an attenuation of 15 to 40 dB in low frequencies and 30 to 60 dB in high frequencies. Graph—3 shows the thresholds for pure tones under free field testing, with different ear moulds. Again the subjects were exposed to noise for one hour with the packings of clay in the ears. After one hour exposure their pure tone thresholds were measured. And no threshold shifts were observed in each case, proving the effectiveness of plasticine modelling clay in attenuating the noise of the bulldozer and protecting the ears.

However, the process of packing the ears is cumbersome and therefore this cannot be taken for routine use to protect the ears of the drivers.

Audiograms of the two drivers, who had been working for a duration of 22 years, and 2 years, respectively, have also been given in graph—4. The driver who



GRAPH 3. Showing the thresholds for pure tones under free field testing with different ear moulds



GRAPH 4. Showing the audiograms of the drivers

had been exposed to this noise for 22 years showed a loss of 55 dB and 30 dB at 4 and 6 KHz. The driver who had been exposed to this noise for 2 years responded to 15 dB and 20 dB at 4 and 6 KHz.

Summary and Conclusions

The noise produced by bulldozer, which was levelling the ground, was predominent in low frequencies and it exceeded the Damage Risk Criteria. An hour of exposure to noise showed a threshold shift of 5 to 50 dB at 6 KHz and 15 to 45 dB at 4 KHz, in the subjects under study. After one hour of rest there was complete recovery. Packing the ears with plasticine modelling clay has been found to be useful in protecting the ears from this noise. An exposure to this noise, for a long time, will cause a 'Noise Induced Hearing Loss'.

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