Enquiry into the effects of loud sounds upon the hearing of boilermakers and others who work amid noisy surroundings / by Thomas Barr.

Enquiry into the effects of Loud Sounds upon the Hearing of Boilermakers and others who work amid noisy surroundings.

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It is familiarly known that boilermakers and others who work amid very noisy surroundings are extremely liable to dulness of hearing. In Glasgow we would have little difficulty in finding hundreds whose sense of hearing has thus been irremediably damaged by the noisy character of their work. We have, therefore, in our city ample materials at hand for the investigation of this subject.

In the process of boilermaking, as most of you are aware, four different classes of men are engaged—riveters, caulkers, platers, and "holders-on." The riveter drives in with a large hammer the red-hot iron rivets for binding the plates together; the caulker hammers with a chisel the edges of the plates so as to ensure complete tightness; the plater forms the iron plates and arranges them accurately in position; while the "holder-on," stands inside the boiler holding a large hammer, the head of which he presses against the inner end of a rivet. These are not all equally exposed to loud sounds, and they differ, therefore, in the extent to which their ears are affected. The men who work inside the boiler, such as the "holders-on," are, of course, exposed to the loudest and most damaging sounds. Their ears are near to the rivet which is being hammered in by the riveter outside. The iron on which they stand is vibrating intensely under the blows of perhaps twenty hammers wielded by twenty powerful men. Confined by the walls of the boiler, the waves of sound are vastly intensified, and strike the tympanum with appalling force, while the vibrations from the iron pass directly through the bodies of the men to the delicate nerve structures in the inner ear. If, in such circumstances, we venture into the interior of a boiler, our first

impulse is to hurry out, or to stop our ears with our fingers. We are conscious not merely of the sound waves, like blows, producing their terrible effects upon our ears, exciting therein sharp, painful, intolerable sensations, but our bodies seem to be enveloped in invisible, yet tangible waves which we actually feel striking against our heads and our hands. When I underwent this experience, I fortunately furnished myself with a couple of India-rubber plugs, and by carefully withdrawing and inserting them in the canals of my ears, I was able at pleasure to admit or shut out the fearful sound. Let no one who values his hearing perform such an experiment without similar precautions. After such an experience one is surprised that the delicate mechanism in the interior of the ears can retain its integrity for a single day under the action of these blows of compressed air. In order to experience the full effects of the noises in boilermaking, one must ensconce himself in one of the smaller interior chambers such as a "superheater," or flue, where the air-space is still more confined, while the plates which are being hammered are thin, and therefore give forth notes not only intensely loud but extremely shrill. Even men whose hearing has been blunted by years of exposure to the sounds of boilermaking are, I am told, forced in such circumstances to protect their ears with cotton-waste or such-like stopping. Amid the overpowering din, communications have generally to be made by pantomimic gestures, and when the foreman wishes to attract the attention of the men, he employs a shrill whistle like a policeman's. When my conductor at one moment, in the loudest and shrillest voice, spoke closely into the passage of my ear, the effect was not that of spoken intelligible words but that of acute pain as the sharp tones pierced my ear. No doubt this necessity for occasionally speaking loudly close into the ear must tend also to injure the hearing of these men.

I had the curiosity to take a phonograph into the interior of a flue while the riveters and caulkers were hard at work without and within. The manipulation of the phonograph in that situation was a somewhat difficult proceeding. The results were not very satisfactory, for, while quite distinct indentations were produced upon the tinfoil, the reproduction of the sound was not effective. The indentations were small and closely arranged, indicating the great height of pitch of the notes, and contrasting with the large widely separated indentations caused by the human voice.

My enquiry included the examination of 120 men who were

employed in boilermakers' sheds, but 20 of these being labourers who were not constantly working at the trade, I have excluded them, and have based my conclusions only on the examination of the 100 men who were directly engaged in the process of boiler-making. For the facilities kindly granted to me in the course of my investigations, I have to express my gratitude to my friend Mr. Kinghorn of the London and Glasgow Shipbuilding Company, to Mr. Kirk of Messrs. R. Napier & Sons, and to Mr. Jeffrey of Messrs. J. & J. Thomson.

The 100 men examined represented all ages, from 17 years, the youngest, to 67, the oldest. The average age was 34·93. The most serious results were found, as might have been expected, in the older men. The following shows the relative numbers at the various periods of life:—

Under 20 years, - - - - -	10
From 20 to 30, - - - - -	27
,, 30 to 40, - - - - -	21
,, 40 to 50, - - - - -	28
,, 50 to 60, - - - - -	10
,, 60 to 70, - - - - -	4
	100

The average number of years during which they had been exposed to the sounds of boilermaking was $17\frac{1}{2}$; the oldest had been at the trade for 54 years, and the youngest for three years.

The range of the enquiry embraced the four following points:—

1st.—Extent of the loss of hearing.
2nd.—Region of the Ear affected.
3rd.—Course of the deafness.
4th.—Prevention of the deafness.

I.—The Extent of the Loss of Hearing.

This was determined by testing the air-conduction of sound, as in ordinary hearing, that is, when the waves of sound enter the outer canal of the ear, and are transmitted by way of the tympanum to the fluid of the labyrinth in the inner ear.

The following points were investigated:—

1. The power of hearing a simple tone such as the tick of a watch.

2. The power of hearing speech.
   (a.) Whisper at a yard distance.
   (b.) Moderately loud voice at a yard distance.
   (c.) Voice of a public speaker.

1. *The power of hearing a simple tone, such as the tick of a watch.*

I first tested the distance at which the tick of a watch was heard, the watch in question being heard when the hearing is normal 36 inches from the ear. The distance was accurately measured in each case with a measuring rule. The following table presents a view of the various results of this enquiry:—

15 did not hear the watch in either ear on pressure.
13 heard on pressure in one ear and not at all in the other ear.
21 heard when the watch was in contact with, or pressed upon the ears.
15 heard in one ear only on pressure or contact, and in the other at a distance varying in different men from half an inch to 20 inches.
25 heard the watch on both sides at distances varying from half an inch to 10 inches.
11 heard at varying distances of from 5 to 34 inches from the ear.

100

In no single instance was the hearing normal so far as the tick of a watch was concerned. In about half the number of men, the watch was either not heard at all, or only on pressure or contact. The nearest to the normal was 34 inches and that was limited to one man and to one ear. Perhaps a more striking way of representing the extent of the loss of hearing in these 100 men, is to sum up the total number of inches at which the watch was heard by all the men, and then compare the result with the total number at which it should be heard by 100 men having perfectly normal hearing. The total number in normal hearing is found by multiplying the double of 36 inches (for the 2 ears) that is 72 by 100; this gives 7,200, which we shall regard as the standard number of inches at which the watch should be heard by 100 men with normal hearing. The total number heard by the 100 boilermakers was 704 inches, or only 9·36 per cent. of the normal hearing.

In order to draw a comparison between the hearing of these men and that of some other classes of the community, I have examined also 100 ironmoulders and 100 letter-carriers with reference to their powers of hearing.

Through the kindness of Mr. Campbell of the Hyde Park Foundry, and of Mr. Dawson of the General Post Office, I have been enabled to carry out these examinations. The ironmoulders are not especially exposed to very loud sounds, but their ears are menaced from another direction—namely, through the nasal passages. The middle ear which is the seat of most of the diseases of the ear, is really an offshoot from the nasal passage, the lining of which, in ironmoulders must almost constantly be coated with irritating dust and dirt. Besides, their exposure to great extremes of temperature must, by exciting nasal catarrhs, still further contribute to an unhealthy state of their nasal mucous membrane. Such an unhealthy state is very ready to invade the middle ear. We would therefore expect a small sum total of hearing for ironmoulders. Letter-carriers, on the other hand, from the comparatively healthy nature of their employment, enjoying, as they do, so much of the fresh open air, may be looked upon as living under circumstances pretty favourable to a healthy state of the organ of hearing. The following numbers give the results of the application of the hearing test with the watch to these 300 letter-carriers, ironmoulders, and boilermakers, including 600 ears :—

Total number of inches at which the tick of a watch should be heard by
100 Men having normal hearing, 7,200.
100 Letter-carriers (average age 30 yrs.) heard 5,694 or 79% of normal hearing.
100 Ironmoulders (,, 37½ ,,) heard 3,291 ,, 45¾% ,, ,,
100 Boilermakers (,, 35 ,,) heard 704 ,, 9⅘% ,, ,,

2. *The power of hearing speech :—*

In addition to the watch I also tested the hearing of these 100 boilermakers, with the voice. It is important, in order to form an accurate notion of the state of the hearing, not to limit oneself to such a test as the tick of a watch, or other such simple mechanical sound. There is not unfrequently in deafness a strange disparity between the power of hearing a watch and the power of hearing the voice. We meet with persons who hear the watch very badly, perhaps no farther off than an inch from either ear, and yet they hear quiet conversation so well, that their friends do not observe any defect of the hearing. We meet with others, on the contrary, who hear the watch as far as 20 inches

from the ear, and yet they require a loud voice pretty near to the ear in order to hear so as to understand. One of the iron-moulders whom I examined presented this peculiarity very markedly. When I proceeded to apply the test of the watch, he said, "You need not try the left ear, for the hearing is quite gone on that side, I only hear with the right ear." On testing with the watch, however, I found, to the man's surprise that he heard its tick 3 inches from the left ear where he said there was no hearing, while on the right side, to which he believed his hearing was entirely limited, the watch was not heard at all even on pressure. When I tried him by means of speech, however, his first statement was found to be quite correct; he could hear speech only with the ear which did not hear the tick of a watch. In testing by speech I employed—

(a) A whisper at a yard distance, using such words as "twenty," "brother," "America," "forty," "house," "garden."—The use of isolated words is a more reliable method than that of complete sentences, as in the latter, the element of guessing disturbs the result.

In normal hearing, a whisper should be heard about 22 yards from the ear. At a yard distant from the ear it was found that *fifty-nine* men could not hear a whisper with either ear, or heard it very indistinctly; that *thirty-three* men heard it on both sides; while *eight* men heard it with one ear, but not with the other.

(*b*) A loud-spoken voice at a yard distance.—In normal hearing such a voice should probably be heard about 100 yards from the ear. *Thirteen* men did not hear so as to understand with either ear. *Ten* men heard on one side, but not on the other. *Seventy-seven* men heard such a voice at a yard's distance with both ears.

(*c*) A public speaker.—This particular form of enquiry, namely, as to their power of hearing a public speaker, seemed to me a pretty reliable way of ascertaining the extent to which the deafness of these men interfered practically with their social comfort or usefulness. *Twenty-one* men stated that they could not hear so as to understand any public speaker, however near they placed themselves to the platform or pulpit, hence they rarely or never entered a church or public meeting. *Fifty-four* men stated that they heard with difficulty in a church or at a public meeting, requiring to be near to the speaker, who must also be clear and distinct. Even in these favourable circumstances, they missed

much of what was said. Only *twenty-five* asserted that they had no difficulty in hearing in whatever part of the hall or church they were placed.

Of the hundred ironmoulders whom I examined, *twelve* stated that they had difficulty in hearing in church or public meeting; while of the hundred letter-carriers, *eight* assured me that they heard with difficulty in church or public meeting.

I think these facts should be considered by those interested in the religious and social welfare of the people, and especially by public speakers and clergymen. I have been informed that two thousand five hundred men are probably actually engaged in this trade in Glasgow and its neighbourhood, besides those who may have left the trade, after having had their ears injured by the noise, and those labourers who are more or less associated with the same noisy work. Twenty-one per cent. of these are, as we have seen, practically debarred from church or public meeting; and although, no doubt, some excellent men, notwithstanding that they themselves hear nothing, attend church regularly for the sake of example to others, yet such are, I fear, few; while fifty-four per cent. are very much hampered in their enjoyment of church or public meeting owing to defective hearing. It might be worthy of consideration whether there should not be some arrangement made in the interests of boilermakers, so that this serious defect might be met by providing them with small places of worship, having good acoustic qualities, and supplied with speakers possessed of a strong voice and clear articulation. In the large, lofty ecclesiastical edifices which adorn our city, in the design or construction of which the question of hearing is, I fear, sometimes neglected in the calculations of the architect, the poor deaf boilermaker has no chance. Apart, however, from boiler-makers, the results of my examination of ironmoulders and letter-carriers—and these results bear out my observations of other classes—show that in the community there is a surprisingly large number who are more or less dull of hearing. Probably we are not far off the mark when we say that in every congregation or public meeting numbering 500 persons, 50 of these have some impairment of hearing. And of these 50 it may be said that if the speaker has not a clear and distinct mode of articulation, if he is not possessed of a fairly strong voice, they hear with difficulty, and do not follow the speaker with ease and advantage. When we consider that, owing to the strain of listening and the feeling

that they are missing portions of what is said by the speaker, they soon become tired and discouraged in their efforts, and are apt to fall into a state of listlessness and inattention, it is not surprising that such persons are much tempted to remain at home. If my words reach any one destined for the clerical profession, or aspiring to success as a public speaker, I would urge him, in addition to his mental training, not to omit attention to the medium by which his mind has to communicate with the minds of his hearers —namely, the mechanical act of speech—I would urge him to cultivate such qualities as strength of voice, slowness, clearness, and distinctness of articulation, to avoid slurring over the consonant sounds, and the bad habit of lowering the voice at certain parts to an almost inaudible tone, last of all, to eschew, if possible, moustache and beard. These appendages are, I assure him, serious hindrances to the efforts which all persons who are dull of hearing instinctively make to read the facial movements of a speaker. Deaf ladies who wish to conceal their infirmity shun the society of moustached and bearded men. The reading of the lip and facial movements is universally practised by deaf people, and is a great help to them in understanding speech. I know persons who, when they visit the theatre, understand nothing of what is said on the stage until they have the face of the actor well in the field of an opera-glass. Hence, good vision is a great help to a deaf person—hence, also, the face of a public speaker should be well illuminated. In many pulpits there should be more light. Deaf persons hardly know their dependence upon their vision, and complain that their deafness is worse at twilight, not observing that their deficiency is aggravated by their imperfect vision.

A clergyman, therefore, cannot ignore the members of his congregation who are dull of hearing with safety to his reputation or popularity. I find that persons dull of hearing generally attribute their difficulty in hearing to the defects of the speaker's voice and articulation. In the privacy of my consulting room they often dilate very bitterly on the subject of "poor speakers." On the other hand, when they do make out fairly well what a speaker says, they are profuse and cordial in their expression of praise of the speaker. I may say, in this connection, that it is frequently the chief regret of a deaf patient that he or she cannot now hear the minister. I trust the minister will co-operate with the surgeon in assisting the deaf to hear.

II.—Region of the Ear Affected.

We now come to the consideration of what region of the organ of hearing is affected in persons exposed to loud noises. This necessitated the study of the following points :—

1. Bone-conduction of sound (when a sounding body is applied to the head).
   - (*a*) Watch on temple.
   - (*b*) Tuning-fork behind ear.
2. The power of perceiving notes of high pitch.
3. Hearing better in a noise.
4. Noises in the ear.
5. Giddiness.

1. *Bone-conduction of Sound.*—Supposing the ears were sealed up so that sound could not find admission by these channels, if a tuning-fork were made to vibrate, no sound would be heard, provided a space of air, however small, existed between the head and the fork. The waves of sound falling upon the head from the air would not be sufficient to throw the cranial bones into vibration, they would in great part be reflected from the surface of the head. But place the vibrating tuning-fork in contact with the head and its note would be heard resounding even more loudly than if the ears were open. In this case the vibrations of the tuning-fork are communicated to the bones of the head, and are transmitted to the osseous casing of the cavities of the ears, from which they pass to the endings of the auditory nerve in the labyrinth—this is what is termed *bone-conduction of sound.*

With the ears open, this mode of conduction is somewhat feebler than the ordinary method of hearing through the air. For we find that after a vibrating tuning-fork placed in contact with any part of the head has ceased to be heard, it will again become audible if transferred to a point opposite to, but not touching, the orifice of the ear. In a normal state of the hearing, therefore, sound waves conducted to the nerve of hearing by the bones produce a less effect than when conducted by the air. But, curiously, with many deaf people this is often reversed, and they hear much better by the bone-conduction. Without entering upon the more exact details of this matter, which would divert us too far from our proper subject, I will just say that as a general rule, liable, however, to exceptions, when in a deaf person the

bone-conduction excites the nerve more readily than the air-conduction, we conclude that the obstacle to hearing exists in the parts of the ear external to the labyrinth—that is, in the outer ear or middle ear, the so-called conducting apparatus of the ear. When, on the other hand, in a deaf person, the air-conduction produces a greater effect on the nerve than the bone-conduction (the condition in health) we infer, although this is subject to more numerous exceptions than the other, that the labyrinth or nervous apparatus is the seat of the mischief.

In each of these hundred men, therefore, I tested the relationship between the bone-conduction and the air-conduction of sound.

For this purpose I employed a loudly ticking watch and a tuning-fork. In testing with the former, the watch was pressed upon both temples. The watch is only suitable where the deafness is very decided, otherwise it is heard by air-conduction as well as by bone-conduction, although placed on the bone, and this disturbs the result. It was thus applicable in 133 ears. In only 13 of these ears was it heard by bone-conduction, and thus in 120 ears the presumption was that some obstacle to hearing existed in the nerve structures. But the use of the vibrating tuning-fork yields the best results. In the case of each man I applied the vibrating tuning-fork (C) to the mastoid process, that is, the smooth bulging behind the ear; and when the sound had completely died away on that part, I instantly transferred it to a point opposite to, but not touching, the orifice of the ear. In 90 of the men the sound was audible for some time in the latter position after it had died away in the former. In these 90 deaf men, therefore, the bone-conduction was feeble as compared with the air-conduction, thus pointing to the nerve structures as the seat of the lesion. I employed likewise a second experiment as a confirmatory test. In each of these 90 men, after the sound had ceased on the mastoid process, I quickly transferred the tuning-fork to my own mastoid process (and I may say that I have reason to believe that my auditory apparatus is normal), and found that in every case the sound was heard by me for some time after it had ceased to be heard by the man under examination. This again proved defective bone-conduction, pointing still to diminished nerve perception. In the remaining 10 persons, representing 12 ears, the opposite results were found, the tuning-fork being heard for a longer time by bone—than by air—conduction. In these exceptional cases, both with reference to the tuning-fork and the watch, there was

probably, in addition to the nerve lesion, some morbid state of the conducting apparatus, which, by intensifying the bone-conduction, compensated for the diminished perception of the nerve.

2. *Power of perceiving notes of high pitch.*—In connection with tests applied to the nervous structures of the ear, I examined twenty of the men with special reference to their power of perceiving tones of high pitch. The sounds in boilermaking which are probably most injurious to the ears are the notes which are extremely shrill, and which act with most damaging effect upon the short fibres of the basilar membrane in the cochlea—these short fibres being concerned especially in the perception of high pitch. For producing varieties of pitch, I employed a Galton's whistle, which consists of a silver tube about 2 cm. long, with a bore of 1 mm. Notes of various pitches are produced by altering the length of the tube by means of a piston which can slide in the tube. The more deeply the piston is pressed, the shorter the tube and the higher the notes. Notes from about 9,000 (9 mm.) vibrations to 28,000 (3 mm.) vibrations may be sounded in this way. Of the twenty men examined with the whistle I found the power of perceiving high notes strikingly diminished in every case. Above 9,000 vibrations per second the hearing gradually diminished, and few could hear 20,000, and then only very faintly. In health, it may be mentioned, the power of perceiving tones of high pitch is greater, as a rule, within limits, than that of perceiving tones of low pitch. In persons with normal hearing, notes as high as from 40,000 to 50,000 vibrations per second may be perceived.

3. *Hearing better in a noise.*—Another interesting point was made the subject of enquiry in these 100 men, namely, whether they heard speech better in the midst of a loud noise or during perfect quietness. It is a remarkable fact that many persons with very defective hearing hear better in a great noise, such as in a railway carriage, or in the presence of noisy machinery, than in a quiet place. The instance of this peculiarity first described was that of a husband who could be heard by his deaf wife only while the servant was beating a drum. Some try to explain such an apparent paradox, by pointing out that in a railway carriage the confined space, the nearness to the speaker, the elevation of the voice, and the close attention of the listener, may account for the apparently better hearing. The elevation of the speaker's voice must be taken in conjunction with the important fact that the general noise is not impeding the deaf

person's hearing as it is that of the normal subject. He is, so to speak, profiting by the loudness of the voice while he is not disturbed or distracted by the din around him. While I was travelling lately along with a friend afflicted with deafness, in a steamboat on the Clyde, my friend remarked that he rejoiced when the steamboat whistle brayed forth, because then the speaker raised his voice and his deafness was hardly detected. Nevertheless, it is unquestionable that, apart from these modifying influences, the hearing, in the case of some deaf persons, is actually improved in the presence of loud noises. The explanation, probably, is that in such cases the three small bones of the ear have become stiff and rigid, and have lost their wonderfully delicate powers of vibration in response to waves of sound, of moderate intensity, striking upon the tympanic membrane. When, however, they are shaken by strong coarse vibrations entering the ears, they are thereby, it may be conceived, rendered fit for the time being for transmitting ordinary vibrations from the human voice.

In regard to the men under examination, with a few exceptions, they reported that they heard better in *quietness*. On questioning carefully the few who asserted that they heard better in a noise I was satisfied that the peculiarity could be explained by the circumstances already mentioned, especially by the loudness of the voice, and the proximity of the speaker. If the explanation just offered of the cause of hearing better in a noise is a correct one, the absence of this phenomenon noticed in these men still further corroborates the view that the nerve structures are the seat of the lesion.

4. *Noises in the Ears.*—This is a very common symptom in the various diseases of the ear, in many of which indeed it is the main feature, and in a small number the only symptom for which relief is sought. I have been surprised at its comparative infrequency in these men. Only 8 men seemed to suffer permanently from these noises, and even in these the sensations were not of a distressing character. Thirty-four men, however, mentioned that they had at times noises in the ears; they were experienced chiefly after getting home at night, but were gone in the morning, or they were only present when they suffered from a cold. For a time after joining the trade, most apprentices are troubled with a sounding in the ears every evening for a few hours after leaving work. This comparative absence of persistent noises in the ears

of these men is in marked contrast with any 100 cases of ear disease which are treated at our Hospitals. For example, of 100 consecutive cases of ear disease affecting the conducting apparatus of hearing, treated at the Glasgow Ear Hospital, 78 were attended by a constant noise in the ear. Noises in the ear are probably in most cases due to pressure exerted directly or indirectly upon the terminal nerve structures in the labyrinth from causes external to the nerve, while the mischief in the boilermakers is probably of the nature of a degeneration of the nerve structures themselves.

5. *Giddiness* is now well recognised as a pretty frequent symptom of ear disease, being probably due, as in the case of noises in the ear, to pressure upon the nerve structures. Only one man stated that he had such severe giddiness as to amount to attacks of staggering, the attacks, not continuing for any length of time, and separated from one another by considerable intervals. In other fourteen men there seemed to be occasionally when stooping, or in the morning, when rising out of bed, some sensation of giddiness. But I attributed little importance to these sensations in their bearing upon the state of their ears. It may be said, then, that noises in the ear and giddiness have not been met with in anything like the frequency found in cases of ear disease attended by a like amount of impairment of hearing, when due to disease of the conducting apparatus of the ear.

In regard, therefore, to the question of the region of the ear affected when the organ is exposed to loud sounds, such as in boilermaking, the great preponderance of evidence (derived from the state of the bone-conduction, the diminished power of perceiving high notes, and the study of certain other symptoms) points to the *terminal nerve structures, probably in connection with the basilar membrane of the cochlea*, as essentially the seat of the mischief. There is no doubt, however, that in a certain proportion of cases, disease likewise exists in the middle and external ears, modifying the symptoms, just as disease of these parts exists in a certain number of all classes of the community.

III.—The Course of the Deafness.

In regard to the length of time intervening between their entrance upon the noisy employment and the commencement of the disturbance of hearing it was not easy to obtain accurate information. The statements of the men as to the duration of their deafness generally refer only to the time during which the loss of hearing had

markedly attracted their attention. When closely questioned, most of them admitted that a certain degree of disturbance of their hearing began almost immediately after entering upon this kind of work, advancing in many cases slowly, but in some much more speedily to very decided deafness. When apprentice lads, with the keen sensitiveness of hearing which often characterises the young, are first put into these boilers, they are quite "stunned." The following descriptive terms were used in answer to the question how the noise first affected their ears:—"Bad," "very bad," "awfully bad," "fearful," "could hardly stand it;" and I am not surprised, from my own experience of the sound, to be informed that a number who enter upon this trade cannot stand it, and have to abandon it in favour of some other kind of employment. These apprentices said that even from the first they feel dull of hearing at night, and have a sensation of buzzing or confused din in their ears; these feelings, however, usually pass away in the course of a few hours, and on the following morning they feel quite well again. A few hours of absence from the noise apparently suffice at first to enable the irritated nerve structures to recover themselves. After a few weeks, or it may be months, if they are able to continue at the work, they appear to get accustomed, as they express it, to the noise; more correctly they have now diminished perception, probably due to partial paralysis of the nerve structures in the cochlea, and they become gradually less and less painfully and disagreeably affected by the noise. Some of the men went the length of asserting that they had reached such a state of torpidity to the sound as to be able to sleep in the interior of a boiler while all the riveters and caulkers were at work. Some, on the other hand, never reached the happy stage of being indifferent to the noises, and always felt it very unpleasant, even painful, when they had to work in the interior of a boiler, and they tried to avoid it. A number of the men mentioned how doubly painful the sensation was when, in consequence of the plates being thin, the sounds were of an extremely shrill character. I have mentioned that at first the dulness and noises in the ears pass off after a few hours of quietness. I found also, that even in after years when their hearing was markedly impaired, many of them thought that it improved when they were idle for a week or two, as at a holiday time. There seemed to be truth in these statements, for in a few cases where I was surprised at the comparatively small loss of hearing in men who had

been long at the trade, I discovered, on enquiry, that they had at some time been absent from the trade for a year or two, perhaps away on a long voyage working on board ship. A number, however, stated that their hearing was not improved in the least by a period of absence from the noise.

The changes, therefore, which are produced upon the ear by the action of these loud noises seem always to tend at the earlier periods to pass away simply under the influence of rest to the organ; and even in the advanced stages there is frequently a tendency to distinct improvement on the removal of the irritating cause.

IV.—Prevention of the Deafness.

The only other subject embraced in this investigation was as to the use by the men of means for shutting out the sound and protecting the ear. In answer to my enquiries, 28 men stated that they occasionally stopped up their ears with cotton or some such substance. Most of these only used such a preventive when they were working in the interior of a boiler while riveters were hammering outside, especially when they were put into a smaller cavity, such as a flue or "superheater." It was used in these circumstances, not with the object of preventing deafness, but to diminish the painful sensation experienced at the time in their ears. When severe dulness of hearing comes on, and the sensation is neither so painful nor so disagreeable, they usually discard the cotton plug. Most of the men seemed to be prejudiced against cotton plugs, chiefly owing to the notion that the use of cotton might make them liable to catch cold when they removed it at night; some, however, objected to this precaution because it interfered with their hearing, and others because it excited a disagreeable itchiness in the ear. But the main reasons for the neglect of such precautions were, I fear, want of appreciation of the value of hearing, want of forethought, and the conviction that dulness of hearing is an inevitable consequence of this kind of work. Speaking for myself, the interior of a boiler was quite intolerable unless my ears were plugged with India-rubber plugs, such as I show you here. When they were inserted in the orifices of my ears I was able with impunity to remain inside a flue while using the phonograph, although the noise was at its very worst. I observed, while the plugs were in my ears, that I was able to hear the voice of a speaker better than when the ears were open. Apparently, the

dulling effects of closing the ears were more than compensated by the shutting out of the terrible and deafening clang. These plugs, which are hollow, and made of various shapes and sizes to suit various ears, were introduced by Mr. Cousins, of Southsea, and were originally intended for bathers in order to protect the drums of their ears when diving, and for this purpose they are very useful. As prepared by Mr. Cousins they are round, but I have, with his sanction, had such plugs made elliptical and oval in shape, which accords better with the form of the lumen of the orifice of the ear. I tried these plugs with some of the men both in the works of Messrs. Napier and of the London and Glasgow Shipbuilding Co. and they have so far reported favourably. They agree with me that they rather favour the hearing of speech than otherwise. In order to avoid irritating the canal of the ear, they should not be too large, and should be smeared with vaseline, which renders them effective in keeping out the sound without the necessity for very tight plugging. A plug of cotton well smeared with vaseline was, at my suggestion, also tried by some of the men. When the cotton is in the ear I found the sharp painful character of the sound was materially modified, giving place to a dull thud not particularly disagreeable. The India-rubber plugs are, however, more handy and effective. It would be well if apprentices when entering upon this kind of work were advised by the foreman to use such simple precautions for protecting the ears, for by these means it is probable that the injurious effects produced upon the ears by the intensely shrill notes would be materially obviated, while the protection which they would afford against the actually painful influences of the terrible din would prove a great comfort to the men.

Let me, in concluding, recapitulate the chief results of these enquiries:—

1. No one engaged in boilermaking for any length of time escapes injury to the hearing.
2. In about half the number of boilermakers the hearing power is so defective that the tick of a watch, which should be heard 36 inches from the ear, is either not heard at all or only on contact with the ear.
3. As compared with the normal standard, they possess only about $9\frac{1}{3}$ per cent. of hearing power.
4. As compared with men engaged in other occupations, their hearing power is extremely defective—for example, letter-

carriers have 79 per cent., and even ironmoulders 45 per cent. of the normal hearing power.

5. The extent of their defective hearing is also strikingly shown by the fact that three-fourths of their number could either not hear at all at a public meeting, or heard with difficulty.
6. In regard to the ironmoulders, 12 per cent. admitted difficulty in hearing in a public meeting, while of the letter-carriers 8 per cent. admitted the same difficulty.
7. In view of the fact that probably of those who attend church or public meeting 10 per cent. hear with some difficulty, it is of great importance that clergymen and public speakers should cultivate clearness and distinctness of articulation.
8. There is almost decisive evidence in favour of the view that the nervous structures of the inner ear are essentially the seat of the mischief in boilermakers' deafness. This evidence is derived mainly from the weak conduction of sound by the bones and the defective perception of tones of high pitch; but other peculiarities in regard to such symptoms as hearing better in a noise, noises in the ear, and giddiness, also support this view.
9. Lads when they join the business experience very painful sensations in the ear, and there is little doubt that the hearing power begins to suffer very soon after.
10. There is a tendency, at all events in the earlier stages, for the disturbance of hearing to diminish or pass away simply under the influence of absence from the noise, and even in the advanced stages there is sometimes a similar tendency.
11. The men have hitherto employed preventives in the form of cotton plugs, mainly in special and temporary circumstances.
12. Men who have recently joined the trade, and also many older men in whom the noises produce painful symptoms, would gladly employ some simple and efficient preventive or sound-deadener.
13. The india-rubber hollow cushion or plug promises to be useful, both for alleviating the painful effects of the noises, especially inside the boilers, and preventing the ultimate deafness.