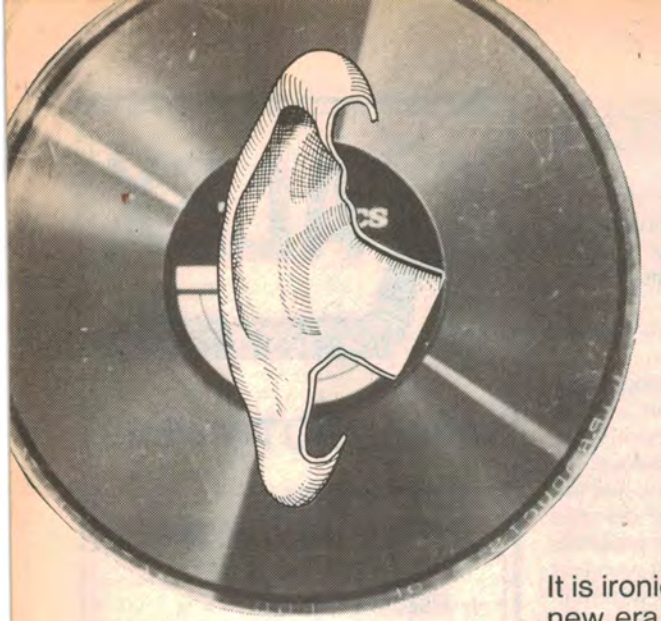


An exasperating human problem . . .

HIFI SOUND . . . BUT LOFI EARS

It is ironic that, at the very time when we are most excited about a new era of high quality sound in the home, we are putting at risk the very organs we need to hear that sound. So look after your ears; they're the only ones you'll ever have!

by Neville Williams

It has taken about 100 years to progress from the primitive phonograph of Thomas A. Edison to the cause of all the present excitement: the laser-read compact disc.

But for all of that time — and longer — we have been working on the gradual destruction of our ears. Years ago, we blasted them with noisy machinery, pneumatic drills and rivet guns. Now we have more fashionable methods.

As if it isn't enough to have ears grow old and sluggish with age, we hasten the process with rock bands and hifi headphones — both capable of creating a sound pressure level, where it matters, of 120dB or more.

And, if ears have grown old and sluggish, whether naturally or prematurely, of what possible interest are those tiny whisps of sound, now exposed by the elimination of recording noise? Both may lie below the threshold of hearing!

And what of the rich overtones on the strings and the oboe? Overtones? What overtones?

NO INSTANT CURES

What makes it worse is that ears are not like eyes. One can suffer with hypermetropia (long sight), myopia (short sight), presbyopia (loss of lens flexibility) or astigmatism (misshapen lens) and yet retain virtually normal vision with the aid of contact lenses or spectacles.

But that very common effect — progressive loss of aural sensitivity — whether natural or aggravated, general or concentrated at the higher frequencies, is normally incurable and irreversible. Nor can it be compensated by artificial aids, at least not to hifi listening standards.

The inherent limitations of diminished hearing and of practical electronic aids make it impossible to recover the frequency response, dynamic range, distortion levels and directional perception of normal hearing. Artificial aids may restore communication but that's about all.

If and when implants are devised to bypass the faulty functions, the position may be more hopeful but, in the meantime, guard the hearing you have as well as you can for as long as you can!

Fig. 1, reproduced from our one-time "HiFi Stereo Annual", illustrates the physical structure of a human ear. It comprises three distinct sections; the outer ear, the middle ear and the inner ear.

The outer ear comprises three main components, of which the most obvious is the outer appendage, known as the auricle or pinna. Apart from its usefulness in supporting spectacles, the auricle or pinna modifies sound wavefronts entering the second component of the outer ear, the ear canal. The brain can ultimately interpret the modified wavefronts as supplementary clues to the source of individual sounds.

The ear canal is a fleshy tube which attains dimensions giving it a broad resonance effect which more than doubles the subjective intensity of sounds in the region 2000 to 5500Hz — the frequency range which we hear best.

At the inner end of the ear canal is a tough, flexible membrane called the eardrum, which seals off the outer ear from the middle ear. The eardrum vibrates in sympathy with the incident sound pressure waves and transfers

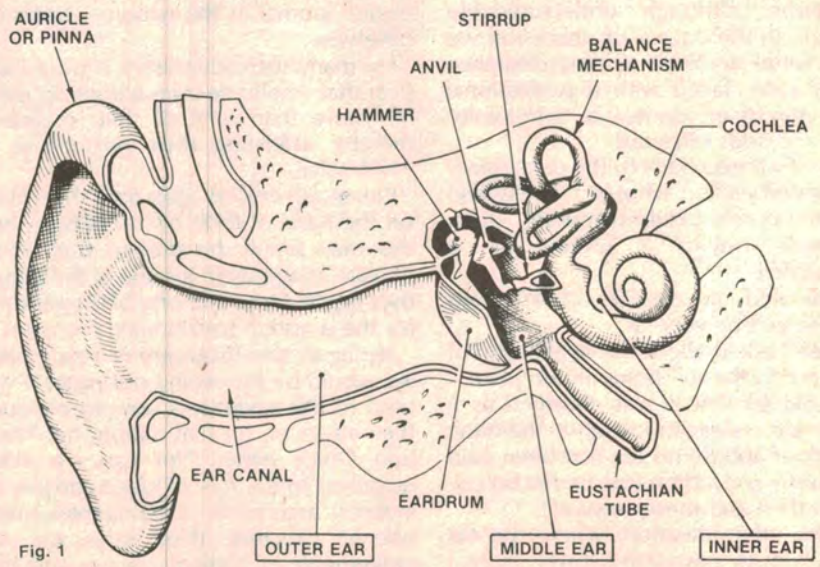


Fig. 1

FIG. 1: Illustrating the structure of the human ear. While part of a remarkable sense, it is nevertheless vulnerable to age, infection and physical damage.

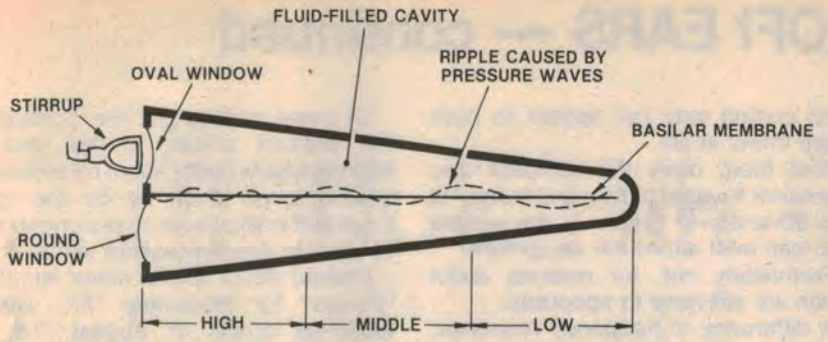


Fig. 2

Fed with sonic impulses via the "stirrup", the cochlea is nature's counterpart of the microphone, transforming physical vibration into electro-chemical nerve impulses. Loss of aural acuity usually occurs first at the higher frequencies.

the vibrations to the smallest bones in the body. The three bones, the hammer, anvil and stirrup, pass the vibrations on to the inner ear, an organ which has to do with both hearing and our sense of body balance.

As the ultimate destination of the sonic energy, the cochlea is nature's own microphone transuducer, turning sonic information into nerve impulses. A tapered, convoluted fluid-filled tube (Figs. 1 and 2) it is divided along its length into two compartments by the basilar membrane.

Sonic impulses are transferred from the stirrup (or stapes) to a small, bony oval-shaped piston at the large end of the Cochlea — the "oval window". The impulses travel through the liquid in one compartment to the small end of the cochlea, then pass through a small aperture and back along the second compartment to the larger end. Here they encounter the so-called "round window", which reflects the sonic energy back the way it came, much as an object will reflect wave energy in water.

"ELECTRICAL" SENSORS

The interaction of the initial and reflected sonic wavefronts sets up "standing wave" effects in the cochlea liquid, causing physical ripples in the central basilar membrane. These ripples trigger responses from an array of something like 24,000 nerve ends distributed along and within the cochlea. In its own mysterious way, the human brain is able to translate the resulting electrical nerve signals — digital rather than analog in character — into separately identifiable signals, each with its own pitch, intensity and phase.

It is, in fact, easy to become quite carried away when extolling the virtues of human ears in prime condition. To quote from our "HiFi Stereo Annual".

"Are our ears so discriminating that we need hundreds of dollars worth of audio equipment to provide the same listening satisfaction as when hearing the real thing?

"The answer to that is an emphatic yes! The human hearing apparatus — the ear, auditory nerves and hearing centres in the brain — make up one of the most discriminating mechanisms in the world of nature.

"Our ears are capable of hearing a tremendous range of frequencies and amplitudes of sound without damage.

"Many people can detect changes in pitch of only one part in 1000, and even an untrained ear can tell the difference when the same note on the musical scale is played on two different kinds of instrument.

"We can hear a mosquito buzzing outside the window screen and the next instant listen to a jet aircraft roar overhead. The difference in intensity of those two sounds is a ratio of about 1 to 10,000,000,000.

"The human ear is capable of hearing sounds within a frequency range of about 20Hz to 20,000Hz" . . . and so on.

Another writer draws attention to the "automatic volume control" mechanisms in the human ear, accounting for its ability to cope with the enormous dynamic range mentioned above, hopefully without suffering permanent damage.

A sudden loud bang, he explains, causes a reflex action in two tiny muscles located in the inner ear. One — the tensor tympani — contracts and stiffens the eardrum, so that it cannot vibrate as freely as it would otherwise do. The other — the stapedius muscle — immobilises the stirrup-shaped stapes, preventing it from delivering excessive input to the inner ear.

Much has been written, too, about the ability of the human auditory system to concentrate on one particular sound source in a noisy environment: on one speaker in a restaurant; one instrument in a group. Indeed, there are occasions when the auditory system may reject all sound turning it into a sonic blur that does not disturb concentration; or something even more remote that does not disturb sleep.

And there's the matter of audio signal phase — the subject of much discussion and argument in recent years. Human hearing is amazingly sensitive to phase, runs the argument, and much of that indefinable satisfaction which is either apparent or not apparent in hifi sound reproduction is traceable to phase discrepancies in the system. So we've had a spate of linear phase loudspeakers and, now, linear phase phono cartridges.

THERE ARE PROBLEMS . . .

Such a recital of the magic of human hearing is likely to induce a warm glow in the reader: "they're talking about me and my ears!" But, unfortunately, that may not be the case, for at least two major reasons:

- If the blush of youth in your cheeks has given way to the mantle of maturity, it is statistically a virtual certainty that the keen edge of your hearing has been perceptably blunted — purely as a function of age.

- If your ears have been subjected to protracted periods of very high level sound, whether in the context of entertainment or employment, there is a strong chance that they will exhibit losses additional to those due to ageing. This, irrespective of other possible physiological trauma.

In respect to ageing, a broad rule of thumb suggests that, if a young child is credited with the ability to hear sounds up to 20,000Hz, they will exhibit a loss of treble response at the rate of about 2000Hz per decade. On this basis, one can draw up a table correlating age with the upper limit of hearing. The assumption is that the aural response will be rolling off through the nominated frequency with a fairly pronounced cut-off beyond it. (See table.)

While these figures may appear to be rather disturbing to hifi conscious listeners, they are in no sense exaggerated. In his book "About Your Hearing", one of hifi's father figures — Gilbert Briggs of Wharfedale — published a set of curves derived by R.

AGE TAKES ITS TOLL!

AGE IN YEARS	UPPER LIMIT OF HEARING
10	18,000Hz
20	16,000Hz
30	14,000Hz
40	12,000Hz
50	10,000Hz
60	8,000Hz
70	6,000Hz
80	4,000Hz

HIFI SOUND BUT LOFI EARS — continued

Hinchcliff, Journal Acustica, 1959. The curves show hearing loss in dB over a range of frequencies from 250Hz to 12,0000Hz for subjects 20 to 70 years of age.

It is noted in the caption that the curves are based on "a random sample population of clinically normal female ears which have not been exposed to the sort of noise levels that are common in industry". It is noted further that female subjects retained a generally better high frequency response than male subjects. Broadly similar information is quoted by a writer in "Audio" magazine (December '82, page 44) from the "Handbook of Noise Measurement".

FAMILIAR FORMAT

Purely to present this information in a more readily recognisable form, we had our draftsman rearrange it into the usual frequency response format. The curves ignore the expectedly superior hearing of children and take, as reference, clinically normal 20-year-old female ears. The derived curves involve a certain amount of freehand extrapolation but they can still be taken as being well "in the ballpark" for typical age/hearing loss relationship.

Two points are obvious from these curves: one is a ready explanation of why ageing grandparents may frequently find it necessary to "beg your pardon". To them, speech is quite muffled.

The other is that, beyond about age 50, your amplifier system is beginning to sound much as it would to a young person, with the tone control turned to minimum treble. To a 70-year-old, the tone control may not appear to have much effect at all!

Well then, does the compact disc represent a waste of time and money to the 50-and-over group — the people who can best afford the equipment?

Fortunately not, for reasons about which we still have to speculate.

A difference in frequency response, as such, may not be all that apparent to the 50-and-overs but the clean, hard transients can still be obvious by contrast to what they have been accustomed to.

And the reduction in harmonic distortion can certainly be evident as an uncanny clarity, which is missing if the compact disc has been remastered from a tape.

As for background noise, the difference may not be as obvious as to a younger person but a difference there can be over the low and middle register, where rumble and acoustic feedback betray the mechanical nature of the conventional phono system.

All is not lost, by any means!

HEARING PROBLEMS

But — and it is a very significant but — the foregoing figures and remarks apply to people with what has been described as "clinically normal" hearing. While this term has to be very broad in its interpretation, there can be little doubt that a significant number of Australians have clinically sub-normal hearing.

In some cases, the problem is congenital, in others traceable to trauma of one kind and another. Such problems should logically be referred to a specialist for whatever treatment may be available.

Of more concern, in the context of the present article, is the kind of hearing loss brought about by avoidable situations, of which by far the most important is exposure to prolonged and excessive sound pressure levels.

I talked about this at some length in "Forum" for November '77, with a follow-up article in August '78. In between, reader support and concern was virtually unanimous: readers, through ignorance, had indeed suffered hearing loss over the years; others were still being subjected, against their will, to objectionable — if not dangerous — sound pressure levels.

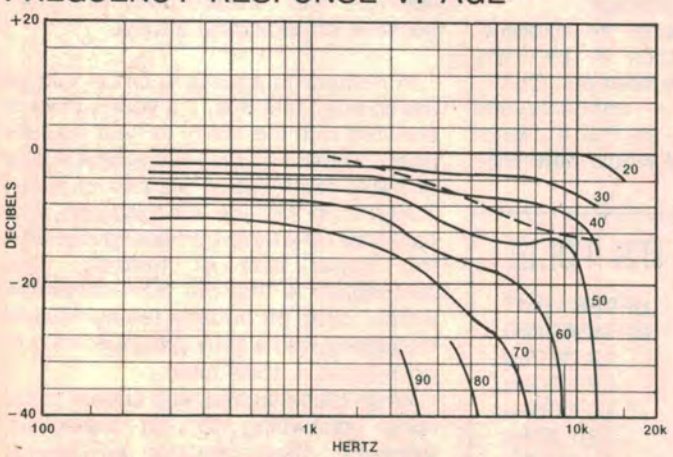
THE NOISE HAZARD

The accompanying noise level table, which quantifies what we are talking about, is reproduced from our August '78 issue.

Looking at this table, the reader may well ask: "What happened to the ear's automatic volume control function", mentioned earlier, and reputed to protect our hearing against exposure to loud noise?

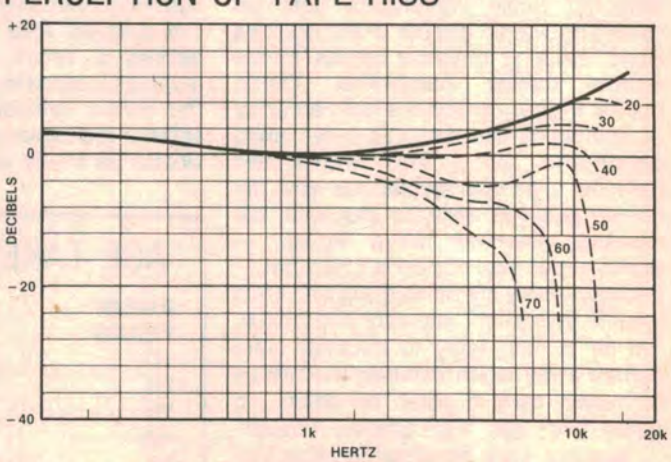
The explanation, it would appear, is that the spontaneous tensioning mechanism in the ear can cope with sound level variations within the "Safe" range and perhaps somewhat beyond it, and it can cope with very loud sounds, provided they are infrequent and of short duration. However, when faced with very loud, sustained sound, the muscles gradually let go, allowing the high level impulses to reach the cochlea. It is then that the damage occurs, with the hair-like nerve ends for the higher frequencies being particularly vulnerable.

FREQUENCY RESPONSE V. AGE



With "clinically normal" hearing of 20-year-old females referenced to 0dB, these curves give some idea of the gradual loss of hearing acuity with advancing age, the loss being particularly apparent at high frequencies.

PERCEPTION OF TAPE HISS



Taken from BASF literature, the heavy curve shows the noise energy distribution of a typical good quality compact cassette tape. High frequency loss with advancing years renders the hiss level progressively less obvious.

Once destroyed, they can never regenerate.

In practical terms, males were at one time more at risk than females, because of their likely exposure to factory noise for much of their adult life and their possible involvement in noisy activities at other times.

Nowadays, we seem to have learned some lessons in these areas, with noise abatement programs operating in factories and the more frequent wearing of earmuffs where high noise level cannot be avoided.

The trouble is that modern technology has now put powerful amplifier systems into everything from rock music venues to theatres, cars and private homes. And with them has come the cult belief that, for sound to turn you on, it has to be at deafening level. How else can it shut out every other stimulus? What's more, if you don't like it that way you must be a bit odd!

As if that's not enough, modern technology has provided us with personal cassette/radio players, and with miniature hifi stereo headphones which, if driven hard enough, can deliver sound pressure levels of 120dB or more — and that is also in the "Injurious" range.

So, if you really want to add further "decibels down" to the inevitable effects of ageing, it is not necessary to take up the trade of a boilermaker or a rivetter. Anyone can achieve the same result by spending a few hours a week at a disco, or playing super-loud music at home, or cultivating high frequency deafness in comparitive isolation with the aid of a powerful headphone stereo system.

What's more, the new deafen-yourself-with-music syndrome is appropriately non-sexist; male and female have equal access to the method. In fact, they often tend to do it in pairs!

Is that all?

No, not quite!

According to our medical correspondent, another effective way of turning down your biological tone control is to swim frequently and dive deeply in polluted water.("Is there any other kind, these days?" he asked!).

Entering the body through the mouth and nose, bacteria from polluted water can travel up the Eustachian tube and set up infection in the middle ear. Too many episodes like that can take their own special toll.

And that brings us right back to where we started:

If the blush of youth in your cheeks has given way to the mantle of maturity, you can still anticipate a pleasurable listening experience from compact discs — provided you've taken reasonable care of the two bits of audio equipment for which no replacements are available — your ears!

But, if you're fortunate enough to be still young, and look forward to the day when even the compact disc will be primitive and obsolete, spare a thought for those tiny nerve ends in your ear which dislike loud sound so much that rather than listen, they lie down quietly and die!

NOISE LEVEL TABLE

INJURIOUS RANGE:	
140dB	Jet engine at 25m
130dB	Rivet gun
	Pain threshold
120dB	Propeller airliner, 50m
DANGER ZONE:	
110dB	Pneumatic rock drill
100dB	Metalworking shop
90dB	Heavy transport truck
SAFE RANGE:	
80dB	Busy street
70dB	Private car
60dB	Ordinary conversation, 1m
50dB	Low conversation, 1m
40dB	Soft music
30dB	Whisper at 1m
20dB	Quiet dwelling
10dB	Rustling leaf
0dB	Threshold of hearing