"HI-FI! Who needs it?" said the experts in 1945 —

but one experiment proved them wrong

A "high-quality" radiogram of the 1940s.

It seems incredible today that in 1945 audio and electronics engineers were advocating that the public did not want high fidelity sound in broadcasts and gramophone records, and produced evidence that most people preferred a bandwidth of not more than 4 to 5KHz. Fortunately, some leading audio engineers were not convinced, and put forward a counter-theory to explain why people voted for narrow band sound.

by David W. Weems

By the time World War II ended in 1945, the wartime shortage of home radio and phonograph products had become acute. Even radio experimenters were hampered by the shortage of parts, but that didn't stop some of them from tinkering with a concept they called "high fidelity". What could have stopped them cold didn't happen until a month after the war ended.

That was a report[1] by Chinn and Eisenberg in the "Proceedings of the IRE", describing the results of a study to investigate the tonal spectrum preference of radio listeners. An audience had been given a choice of three frequency ranges to choose from: narrow (150-3500Hz), medium (100-5000Hz), and wide (50-10,000Hz). Surprisingly, most of the listeners chose the narrowest band. In fact, they continued to choose narrow-range sound even after they were told that it was "low fidelity".

Professional musicians listening to classical music picked the low-fi sound by an even greater margin than the average listener. Among the musicians, 73% chose narrow range, while only 5% liked the wide range and 22% were undecided.

For hi-fi fans, that report was a double whammy. The study purported to fix the "ideal" frequency range for the recording and broadcasting industries. What good was it to build wide-range hi-fi amplifiers and speaker systems if the frequency response of records and radio broadcasts were to be restricted?

However, there wasn't much to be criticised in the experiment. The qualifications of the investigators were impeccable. One, a consultant to the Office of Scientific Research and Development, with extensive experience in broadcasting, had been associated with the Massachusetts Institute of Technology and Harvard. His colleague was a professor of psychology. Their audio equipment was the best available – flat from 40 to 10,000Hz with "supposedly" low measurable distortion. The speaker system used was coaxial with a multi-cellular horn for highs; folded horn for lows.

The investigators had kept record noise to a negligible level by using original master recordings and playing each only one time. To double check the results with records, a live network broadcast of a 29-piece orchestra with a 14-voice female chorus was monitored in the listening room for some of the tests. Again, the frequency range for the medium and narrow bands was altered by an electronic (single-section band-pass) filter inserted in the system. And the listeners liked the filter.

If the study threw a wet blanket over hi-fi, it wasn't the first one. In 1944, O. J. Hanson, chief engineer for one of the major broadcasting networks questioned the desirability of high fidelity.[2] He suggested that frequencies above 10KHz were good only for sound effects: non-musical noises such as key jingling, hand-clapping, and resin squeaks. Anyway, he said, the jokes of a favourite comedian were just as funny when heard on a radio with a 200-to-3000Hz range as on a wide-range system.

Those who argued against a wide response on the grounds that it was impractical had many reasons to cite. They said that a listener would have to sit directly in front of his speaker because if he were 45° off the axis, the response would be inadequate at frequencies as low as 3000Hz. Critics also noted that background noise increased along with bandwidth and that the extension of high-frequency response beyond 5000Hz on AM radios would only result in "monkey chatter" due to the 10KHz spacing of radio stations.

Such were the views of the "establishment". It was hardly surprising, then, that many of the first post-war radio receivers were built on the same chassis layouts as the last of the pre-war models. The economic climate of war-time price fixing and high demand was also partly to blame. But a scientific study which showed a one-sided preference for low-fi music discouraged all but the most adventurous manufacturers.

And so the console AM radio was still king of the mountain, or at least of the American living room. Eighteen million had been manufactured, the latest of them being superhets with a pair of push-pull pentodes in the output stage. The power output may have been listed in the valve manual at 8 to 10 watts, but it was usually considerably less than that, depending on how much distortion one would tolerate. A small output transformer coupled the output valves to a 10 or 12-inch electromagnetic stiffconed speaker, mounted in the lower section of the open-back cabinet. That arrangement produced a booming resonance in the 200Hz region that almost masked the absence of fundamental bass response under about 100Hz. The almost total lack of either electrical or mechanical damping on the speaker permitted the cone to vibrate after a signal had ended and added the word "hangover" to our audio vocabulary.

Sometimes the radio amplifier was fed by a 78rpm record player whose massive tone arm carried a crystal pick-up. At the end of the cartridge was a "chuck" or set screw that held the stylus, which was called a needle but looked like a brad nail. People who were fussy about record wear could substitute a cactus needle, which killed what little high-frequency response might have escaped the other equipment.

Those were the "components" of a home music system; commercial sound systems were not much better. An investigation by Eagleson and Eagleson in 1946[3] showed that, when listeners tried to identify musical instruments heard over a PA system, the results were wild guesses. In a test involving 35 listeners, 22 of them musicians, the one who got the best score identified the instrument correctly less than 40% of the time. And he wasn't one of the musicians. In fact, he'd had no musical training at all.

The Chinn-Eisenberg study clearly backed up the engineers who had argued for a "sensible" frequency range, and against hi-fi. But when the paper was read carefully, some odd comparisons emerged. For example, when the professional musicians listened to male speech, they showed a preference for wide-range reproduction. Another curiosity: Why did listeners prefer a higher sound intensity for speech than for music? This was a suspicious reversal of the normal difference in sound intensity for live speech and live music.

Fortunately for the future of hi-fi, some readers were sceptical of the results. One of these was Harry F. Olson. Born in Mt Pleasant, Iowa, Olson had received his PhD at the University of Iowa in 1928 and had gone to work for RCA that year. Six years later he was placed in charge of acoustical research for RCA.

As Olson analysed the conclusions of the controversial paper, he decided that there could be three possible explanations for the results. The first two were: People

> were so conditioned to a narrow frequency range from listening to the radio that they accepted it as natural.
>
> Musical instruments are improperly designed. They should be redesigned to eliminate the undesirable overtones.

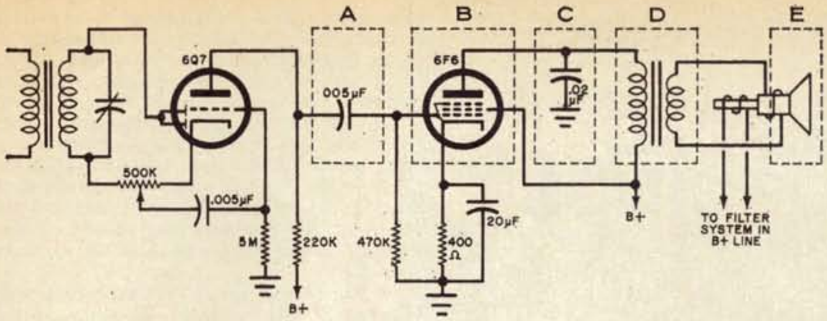
Olson was offering these suggestions to cover all the possibilities. He knew that the professional musicians should have had no difficulty choosing what was the most natural sound. And as for recognising musical instruments, stripping the overtones would rob each instrument of its individuality. A violin, for example, would lose its gutty string tone and sound somewhat like a flute. One might as well write music for a battery of sine-wave generators!

The third possibility, Olson said, was "the distortions and deviations from true reproduction of the original sound are less objectionable with a restricted frequency range".

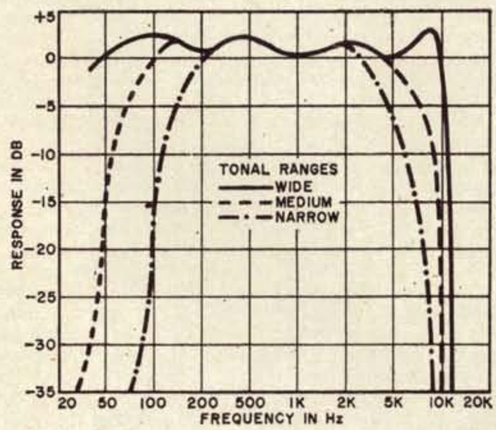
But how could he prove his suspicion? If distortion were the demon, his problem was to design an experiment that would eliminate distortion. His solution was simple.

If distortion in amplifiers and speakers could not be eliminated, he would bypass 1945 electronics and use live music. This time "live music" would mean exactly that – no microphone, no amplifiers, and no speaker system.

Olson's background in acoustics served him and the cause of high fidelity well. He and John Preston, a member of the technical staff at RCA Laboratories, designed an acoustical filter to place



Audio section of a typical radio built in the immediate post-war period. The lettered sections indicate where frequency response was restricted: A – the small coupling capacitor reduced hum by rolling off the bass. B – pentode output stage without feedback produced distortion and inadequate loudspeaker damping. C – anode capacitor maintained correct load on the output valve but cut high frequency response. D – small transformer limited low frequency response, while its leakage inductance cut highs. E – electro-magnetic loudspeaker had limited response and its stiff cone and poor baffling restricted the lows; the large straight cone gave poor high frequency response and spread.



Frequency responses used in the Chinn and Eisenburg tests. Most people preferred the narrow band which rolled off at 3500Hz.

between a live orchestra and an audience. The filter was made by properly spacing 3 sheets of perforated metal. The holes in the metal sheets provided a reactance (or inertance) to the vibrating air particles that increased with the frequency of vibration. The trapped air volumes in the two sections of the filter, on the other hand, provided a reactance that decreased with frequency, tending to absorb the vibration of the particles. By careful choice of hole size in the metal sheets and air volumes (by spacing the sheets) Olson was able to obtain a cutoff at the desired frequency. He selected the cutoff point to correspond to the high-frequency response of "very good" radios and phonographs of that time. The cutoff point was 4000Hz; however, as defined by radio and phonograph terminology, the filter was called a 5000Hz low-pass filter.

Olson designed the filter mathematically, then checked its performance by actual measurements. The result was a sharp cutoff filter that worked the way he had hoped. "A snare drum", said Olson, "seemed to be an entirely different instrument". 4And the cymbals, instead of having the usual shimmering resonance of thin discs, sounded as if they were "1/8 inch in thickness".

But Olson was an unusually keen listener, with years of experience in the science of acoustics. Which sound would the average buyer of records and radios prefer? To answer that question, Olson conducted an experiment involving 1000 listeners.

He installed the filter across the corner of a room that was 24ft square with a 9ft 6in high ceiling. The dimensions of the room were no accident. They were selected to approximate the size of a typical living room, since the results would be used by engineers to design equipment for use in living rooms.

Behind the filter, a small orchestra – piano, trumpet, violin, clarinet, contrabass, drums, and traps – was assembled. A sound-transparent curtain prevented the audience from seeing the position of the filter. Then Olson assembled his listeners: chemists and gardeners, doctors and farmers, secretaries and electricians – anyone who was available as worker or visitor at RCA Laboratories. The orchestra played and A-B tests were made, the filter changed every 15 seconds during each number. For different tests, the letters A and B were reversed to prevent the results from being skewed by letter preference. The listeners made their choice, and added comments if they desired.

The results of the experiment produced a reversal of all previous studies. It was a striking victory for the concept of high fidelity. A strong majority, 69% of the listeners, preferred full-frequency-range hi-fi, compared to 31% who voted for the low-fi music.

But there was a suspicion that even some of the minority who didn't like the full-frequency range may have been reacting to something other than sound quality. Because of the small room, Olson could not supply classical music devotees with a full symphony orchestra. Some of them added negative remarks about

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High Fidelity Experiment . . . continued from page 81

popular music to their votes for narrow-range sound.

Olson also disproved another belief held by the broadcasting industry: that the product of the upper and lower limits of the reproduced frequency range should always equal about 500,000 in order to ensure proper balance between highs and lows. He found that his listeners did not approve when he cut off the bass at 100Hz to balance the high-frequency cut-off at 5000Hz.

Tests on speech produced comments that the restricted frequency range produced "muffed" speech that was not as intelligible as the full-range speech.

Olson's experiment showed that previous workers who had attempted to find the "ideal" frequency range for music reproduction had been working in the dark. Evidently his third suggestion, that distortion was less objectionable with a narrow frequency range, was correct.

"Distortion was inherent in the phonographs and radio receivers of that day", Dr Olson said recently. "The engineers cut back the frequency range until the performance was satisfactory".

But the fact that listeners preferred full-range sound, if undistorted, had now been proved. It gave a solid foundation for hi-fi development work that had once been conducted on faith alone. The hi-fi or stereo fan of today owes much to Dr Olson and to the men who kept building better amplifiers and speaker systems when no one else seemed to care enough to listen.

If you ever find that your ears and your test equipment disagree, trust your ears until they are proven to be wrong. The listeners who chose the narrow range for reproduced music were reacting to the high-order distortion in the wide-range equipment of the 1940s. In that respect their low-fi choice was the correct one and explains why the professional musicians objected more than the average listener to the distortion. And it was the ears of Dr Olson's listeners that proved the desirability of a full-frequency range.

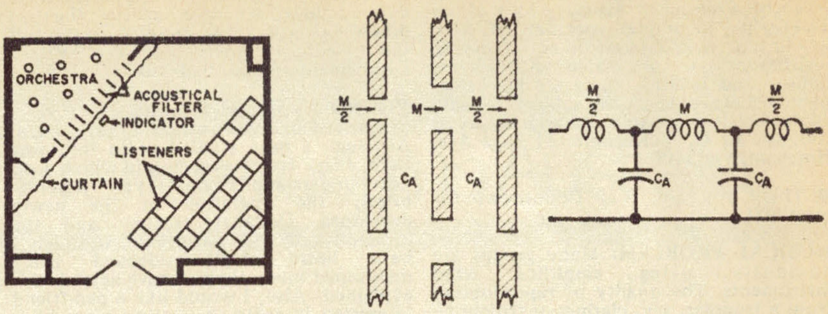
Perhaps there should be a minority report from the people who chose the narrow band with live music. Even today there are people who apparently prefer narrow band sound. One such reaction came from a lady in Texas when the local radio-TV shop returned a repaired console radio to her. "Oh good", she said. "I'll be glad to listen to a radio with a good tone again. And the records you get today just don't sound like the old ones".

1 CHINN, H. A., and EISENBERG, P. "Tonal Range and Sound Intensity Preferences of Broadcast Listeners", *Proceedings of the IRE*, Vol 33, September, 1945, p. 571,

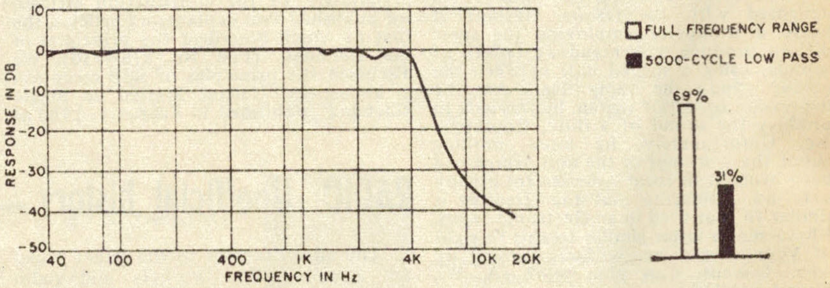
2 HANSON, O. J., "Comments on High Fidelity", *Electronics*, Vol 17, August, 1944, p. 130.

3 EAGLESON, H. V., and EAGLESON, O. R. "Identification of Musical Instruments when Heard Directly Over a Public Address System", *Journal of the Acoustical Society of America*, March, 1947.

4 OLSON, H. F., "Frequency Range Preference for Speech and Music", *Journal of the Acoustical Society of America*, July 1947, p. 41.



LEFT: The floor plan for the experiment. RIGHT: Sectional view of high pass acoustic filter, with its electrical network equivalent.



LEFT: Frequency response characteristic for the acoustic filter. RIGHT: The bars indicate the frequency range preferences of the listeners.

FUEL INJECTION

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also reduces harmful exhaust emissions, such as hydrocarbons, carbon monoxide, and oxides of nitrogen, substantially.

Other attractions that the company claims for its electronic fuel-injection system are: the elimination of "dieseling" after shutdown, a simple starting procedure that is the same for all temperatures and conditions, and a throttle body that can be less than 1½ inches high so that designers can lower the engine profile and hoodline to conform to customers' styling preferences.

The Bendix electronic fuel-injection system has no adjustments other than the idle air flow. This reduces maintenance requirements and helps ensure that low levels of harmful emissions will be more easily maintained throughout the life of the vehicle. If a component should become faulty, it is replaced rather than repaired.

In summary, the owner of an electronic fuel-injection-equipped car will benefit from significant improvements in power and fuel economy, greatly reduced exhaust emissions, and easier starting under all weather conditions. ("Electronics World", September 1970.)

ANSWERS — continued

DOLBY "B" SYSTEM. Are you considering developing a noise reduction circuit along the lines of the now famous device developed by Ray Dolby? I realise that there are many problems associated with this project, not the least of which is the sophistication of the circuit and also the fact that the original design is patented. However, the Advent Corporation in the USA is marketing a home version (called the "B" type) selling at around $130, which puts the price range in line with most of your audio projects. I am sure the interest in this device would be tremendous. We have been hearing a lot lately in your magazine and others about demonstrations where as Dolby-raised 15ips production master of Decca's "Der Rosenkavalier" recording was compared with a tape reprocessed at 1-7/8ips, and nobody could spot the difference. I am sure there must be thousands of home constructors like myself heating up their soldering irons in ancitipation of this one. **(M. R., Bellevue Hill, NSW.)**

O The original Dolby system is a very complex multichannel compression and expansion arrangement used in the production of master tapes by the recording industry. This has no relevance to the domestic scene. The very much simpler Dolby "B" system has been in the news a fair amount recently, but whether this will prove to be any more acceptable and successful than numerous other compression and expansion devices for amateur recordists which have been played around with over the years has yet to be demonstrated. On the other hand, if you are referring to the expansion device only, for use with tapes which have already been subjected to a compression treatment, it would have to provide the exact expansion complement of the compression provided by the manufacturer. If and when tapes incorporating compression appear in quantity on the market in Australia, we might be prepared to look at the matter again, but at present we can see no point in getting steamed up.