

Toward a More Realistic Audio

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A complete, frank discussion of the trend in equipment development which is necessary to provide the discriminating listener with optimum reproduction in the home, if the consumers' demand is to guide the engineers.

THIS IS, FIRST, a report on the attitudes Consumers' Research has found commonest among those interested in high-fidelity in the home. CR receives more inquiries on this subject than on any other except automobiles, so we believe we are dealing by no means with an insignificant minority. Common factors in these inquiries have importance to those in the profession.

Assemblies of high-fidelity components have been well received by consumers. We are much impressed with the willingness they show to make substantial investment in their equipment. It is surprising that so many are asking, not for the "best low-cost equipment," but for the "best available." Encouraging as this may be, there are widespread danger signals of consequence to everyone in audio.

The amount of misinformation reflected in our inquiries is appalling. Some of what passes for quantitative data in advertising is, we believe, downright misleading. Some of it may be written by people who are, themselves, misled, but much of it appears to be deliberately misinforming, composed with full understanding that however ambiguous the impressive figures may be, even professionals are enormously influenced by graphs and charts that appear to be derived from measurements on equipment too complex and expensive to be familiar.

Aside from the advertisements, the dealer himself too often sponsors confusion in the buyer. There seem to be two common types: the one who first feels out the customers' prejudices, and then feeds on them; and the type which assumes an Olympian attitude toward all mere customers—an attitude whose loftiness is the best measure of its ignorance. There are, of course, the honored few who offer respect and seek

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to inform: we owe them a profound debt of gratitude.

Nature of Unfilled Demand for Audio Systems

Non-professional high-fidelity enthusiasts, we find, are more interested in good record-playing equipment than in anything else. Radio is most often regarded as an accessory, to be used for incidental listening, but not as a primary source of serious musical entertainment.

There is an important minority of non-technician consumers which is interested in home recording. These are almost exclusively concerned today with magnetic apparatus, with tape commanding most inquiries.

Another matter of wide concern is the consumers' inability to hear and see the equipment before purchase. Many still are unaware that well-equipped sound salons are maintained by dealers in the larger metropolitan areas.

Many purchasers of assemblies inform us that they experience difficulty in

making the necessary interconnections in their assemblies. Much hum, and most reports of unreliable performance are traceable to this difficulty. Often when the supplier has not volunteered full information on the necessary wiring, the non-technician is at a complete loss.

A fourth too-common complaint is made over the difficulty of laying out an assembly so that the controls come out symmetrically and at one central point, so that duplication among them is avoided, and so that convenience of operation is optimum. The physical configuration of the equipment is blamed.

Related to this objection is the series of inquiries on how to arrange the equipment in either built-in or cabinet set-up so that the final assembly looks neat and professional. It is said that expensive arrays of fine equipment should look well enough to justify their cost. Nobody, it is suggested, short of a combination architect and electronic engineer could assemble, re-arrange, and alter some of the components on the market,

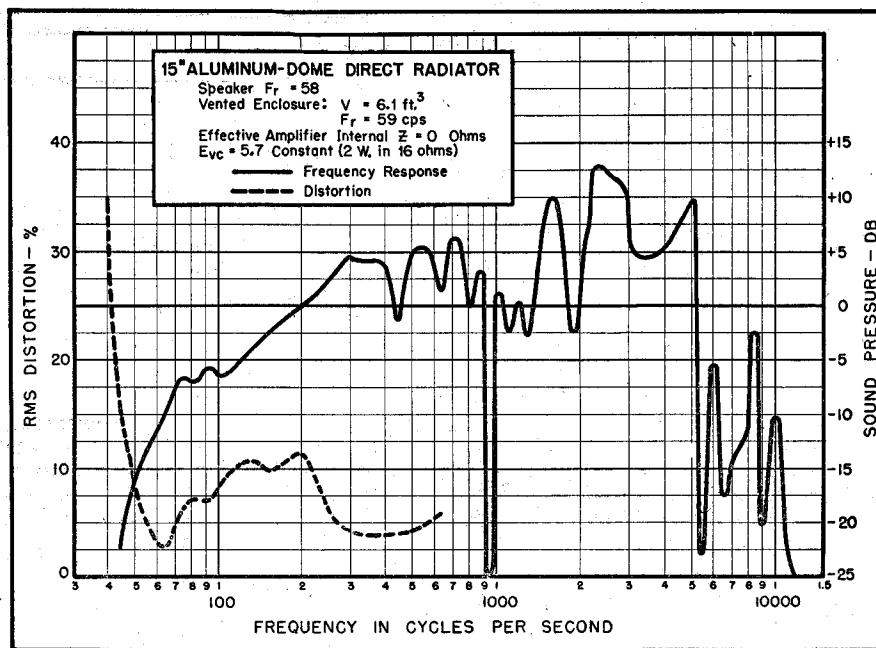


Fig. 1. By no means a "horrible example," this is one of the most highly-regarded of contemporary loudspeaker systems. The measurement was made outdoors from the top of a high building in a silent location. It should be noted that the amplifier source impedance was artificially reduced to absolute zero (constant-voltage) conditions. The bass characteristic assumes somewhat more normal proportions when the source has some, if little, effective internal impedance. The 1000-cps dip may be due to rim resonance or to a cancellation arising out of cabinet conditions.

so as to avoid ugly cabinet proportions, eccentric lumpy shapes, and trailing wires.

To most of us here the most important objection raised by non-technical people is this: many expensive assemblies *don't sound good enough*. The specific complaints most often received are with respect to *noise, shrillness, and weak or dirty bass response*. This is not with reference to users of faulty equipment, either.

Now, presumably, the reason we make measurements in designing and building equipment is in order to *predict*, in the scientific sense, the *end result* to be obtained, namely listener satisfaction. If we refuse to recognize a listener's objections on the ground that *he* is incompetent, we are ignoring a serious discrepancy in the accuracy of our predictions. A refusal to admit that the experimental results disagree with the predictions is an inexcusable violation of scientific method, and can't be tolerated. Before we conclude that the listeners are mainly tin-ears, and retire to the laboratories to please no one but ourselves, we had better re-examine our measuring methods and their interpretations. It is suggested that the trouble lies with simple and attractive, but unrealistic, interpretations of our evidence. We're not relating the physics and the psychology of the problems before us in an adequate way. Our engineering, it is suspected, is excellent, but our psychology needs an overhaul. We are pre-occupied with the glamorous means we are using to the point that we're forgetting the ends toward which we should be working.

Listener Preference

Our findings indicate that listener satisfaction increases with increasing frequency-range *only* when *noise, distortion, and raggedness of frequency response* are all greatly reduced simultaneously. To be sure, there is nothing new about such a theory. Many investigators feel these are the culprits in the public's notorious distaste for wide-range systems. Yet, many of us continue to display attitudes—and equipment—which over-emphasize wide range to such a degree that, *by comparison*, noise, distortion, and raggedness are ignored. Equipment is commonly designed to pass 30 to 15,000, or even 20 to 20,000 cps—the very limits of human hearing—yet how miserably short are we still of getting *noise* down to the threshold of hearing, of reducing distortion to the point where it's undetectable, or of reducing *acoustic* output that is free of dips and peaks. Extending *range* is easy, and therefore tempting. But extending range without correspondingly improving noise, distortion, and smoothness characteristics, is costing us listeners. We think it cannot be overemphasized that in a system of *any* range—wide or narrow—noise, distortion, and raggedness are *not* sufficiently reduced if the listeners don't like the sound. Sometimes a *reduction*

Fig. 2. A high-quality home system in which control complexity has been reduced to a minimum.



of frequency-range will improve the listeners' reactions. Still better listener-reaction is observed if, instead, further reductions are made in noise, distortion, and raggedness. We think that in *this* direction, laboratory predictions and listener reactions may be brought to coincide.

Suggestions for Improvements of Acoustic Quality

These, then, are our impressions of the most significant needs of the home user, and a theory from which we think better satisfaction of those needs can grow. On the basis of these needs we suggest expanded criteria for judging components and assemblies, to include not only (1) highest possible acoustic quality, defined in terms of listener satisfaction, but also (2) convenience of installation, maintenance and operation, (3) appearance matching or excelling that of comparable-cost production consoles, and (4) reliability and safety above any reproach.

Noise Level Limits

To evaluate audio quality realistically by means of physical measurements, we have to *integrate* them together at every point. Quantitative standards are necessarily arbitrary, so it is best to make them marginally more exacting than the majority of cases requires. To illustrate how much electrical noise is tolerable, we find that listeners are displeased if such noise, in the absence of signal, is audible a few feet from the speaker. In our tests the electrical output, in tube-noise and hum, that was just audible varied between 0.1 and 5.0 microwatts, depending upon the level and character of ambient noise and upon the efficiency

of the speaker system. This amounts to between -23 and -40 dbm, representing performance which, with a nominal 10-watt amplifier, would be described as "Noise 63 to 80 db below full output." The first figure is not hard to attain, but the latter, when high-gain magnetic pickup preamps are in the circuit, is rarely achieved, representing noise corresponding to a noise-input level of -118 dbm. The listener who wants quietness enough to pay two or three hundred dollars for his amplifier expects to have this demand *met*. Lower-cost installations will, presumably, involve speakers of lower efficiency, especially at the hum frequencies, and will meet the requirement with the higher noise figure.

Record Scratch Limits

Take another example: how much record-scratch is tolerable? When we integrate *several* factors together at once, we find that the *character* of the scratch is at least as important as its relative level. If the sound-pressure response of a *whole system* is full of dips and peaks, scratch causes objections out of all proportion to its level. But if the system is *smooth* throughout its range, and that range does not include much more than the cleanly-recorded frequencies, the silky character of the hiss is tolerable when its measured level is as little as 25 db below peak recorded signal; with modern recording means it can be reduced much more than this—and it should be.

The Pickup Cartridge

A common source of gross distortion and intolerable raggedness is the alignment of the cartridge relative to the record, especially in changers as they are installed by dealers, some of whom

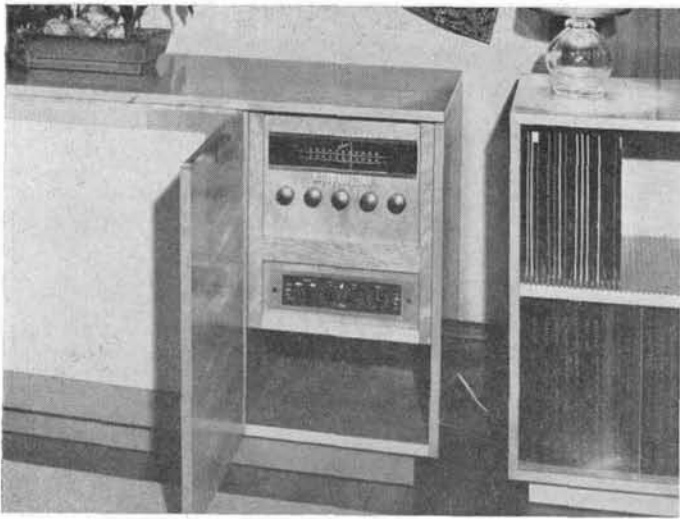


Fig. 3. A high-quality home system in which the necessities of component construction have led to duplication and complexity in control functions.

seem to have the impression that the cartridge is properly installed if its stylus manages to contact the record surface once each revolution. If gross disorders of this kind are relieved, the loudspeaker becomes the limiting factor. As response-smoothness improves, the upper tolerable range, we find, can be extended.

Distortion Limits

When we consider *distortion* limits we have to integrate them with *power* requirements. At the risk of extended argument, we report that oscilloscopic observations at the final grids of a number of amplifiers in actual home service, using musical transmissions with low-efficiency speakers, showed *no* peaks driving the amplifiers beyond 5 watts, even when uncomfortably high sound-levels were developed. With high-efficiency speakers the signals were considerably lower. Furthermore, when peaks of this power, transient or otherwise, drive virtually all our tested speakers into violent distortion, we feel that a 10-watt amplifier which is uncritical of its load at any usable frequency, is generous, and that expense incurred for greater power is extravagance. We find that such an amplifier contributes no audible unpleasantness if the following conditions are met: distortion must decline with power, and at the 10-watt level must not exceed 2 per cent r.m.s. at any frequency from 40 to 7000 cps. IM distortion of 8 per cent is alternately acceptable if the frequencies are 40 and 7000 cps separated by 12 db.¹ Pre-amplifier and tone-control stages must be included, and must not, except in treble-boost or bass-cut positions, increase these figures.

Distortion in AM receivers is, we

¹ It has been shown elsewhere, by C. J. LeBel and others, that the relation between total r.m.s. and IM distortion is by no means a simple or a constant proportion. To the conditions defined here needs to be added only the condition that distortion-content shall decline regularly with its harmonic number in order to make the meaning of the 2 per cent r.m.s. figure coincide with that of the 8 per cent IM distortion figure.

think, inadequately measured at the low percentage-modulation used in standard test procedures. With the high modulations routinely maintained nowadays, there is need for drastic improvement in detectors. FM distortion may be expected to be below 1 per cent with ± 75 kc swing and 50-microvolt signal, at which 40 db of quieting should be observed. Such a standard is attainable and is, we find, required in many locations to satisfy critical listeners.

We come last to the question of frequency-range because we are so firmly convinced that this is the *last* place where improvement should be sought. It will appear sheer heresy to speak of a high-fidelity system whose range is good only from perhaps 70 to 6000, or 60 to 8000 cps. BUT IF WE MEASURE IN TERMS OF ACOUSTIC OUTPUT, ACCORDING TO THE SAME STANDARDS WE APPLY TO FILTERS AND OTHER ELECTRICAL ELEMENTS, THE LOUSPEAKER IMPOSES SUCH LIMITATIONS. That this is due to no form of carelessness or lack of research by loudspeaker makers does not obviate the necessity that we recognize the problem is enormously complex and difficult. For this reason we feel required to consider the limitations of the *best speaker which the economics of any given installation will permit* when we select every other component. We believe the profession owes the speaker-makers the compliment of recognizing the magnitude of their problem, and that we ought to discredit the misconception that such a range as 30 to 15,000, or 20 to 20,000 cps is now expectable with *anything resembling* the smoothness and low distortion we realize routinely from the electrical components. We can find *no* evidence that *any* speaker or system accomplishes such a standard. See Fig. 1. Only the costliest systems we have examined produce a *recognizable* 40- or 50-cps tone, much less one of low distortion. The hash which most speakers make of the range above 4000 or 5000 cps may best be judged by the jaggedness of their response-curves in that region. Even the vital mid-range is full of points of violent disturbance. Where frequency-response range is concerned, no engineer would rate the "upper cutoff" of a filter

or an amplifier at the point where response is just measurable, on the tail-end of an 18-db-per-octave declination, but the practice is apparently common in rating loudspeakers. We think the industry is sufficiently grown-up today that it can afford to apply the same rigorous standards to speakers that it does to other components.

If the speakers merely cut off the top and bottom, it wouldn't be so bad. But the distortion that results in the middle-range when a cone is driven out of the linear portion of its magnetic gap by boosted 40-cps fundamentals makes a strong argument for electrically restricting the bass range. The same holds for the top, when the ragged residue of response goes to work on the harmonic structure. Horns help a great deal in the top range, of course, but if they are to begin handling power at 800 or 1200 cps their diaphragm-mass forces a fast roll-off from 6000 or 7000 cps. The value of adding a miniature third unit for the extreme top is questionable, since in our experience its function is largely to make a fine display of the hash to be found there from *almost* all program sources. Provision for cutting off the top electrically should be provided in every quality installation. If our listeners set the cutoff lower than we do, we might inquire what distortion products and jagged responses up there drove them away. Control of the high frequencies presents more complexities than the usual controls allow for. If horn speakers, or others of good distribution and smoothness, are used, sharp cutoff points are needed to minimize program-source irritations. If ragged speakers are dictated by economics, gentle roll-off of the whole upper range is demanded, we find, by listeners. Very sharp cut-offs, or, worse, peaks followed by sharp declination, produce the same sort of listener-irritation as does excessive raggedness.

Where bass response is concerned, we find once more a widespread engineering reluctance to take the listener seriously. If he prefers a loud one-note-thump to electrically-measured flatness, there is entirely too much tendency to charge off the trouble to the listener's tin ear. Reconsideration indicates that many electrically flat systems are acoustically decidedly weak at the bass end. We customarily drive speakers from extremely low source-impedance amplifiers, so that the power expressed into the speakers at their high-impedance bass frequencies, is low. Furthermore, loudspeakers work into living-rooms whose dimensions do not encourage excitation at long wavelengths. Because higher source impedances involve us in serious damping problems, some provision is needed to lift the voltage output approximately with speaker impedance. Further boosting will be needed to overcome the living-room's unfriendliness to low frequencies. The boost should not be extended too far down, of course, or the amplitudes involved will drive the

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REALISTIC AUDIO

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voice-coils out of their magnetic gaps, with attendant uproar.

We're getting better speakers all the time, but until the problem is much better solved we'll make more friends by allowing realistically for necessary speaker shortcomings. Our present speaker systems, if kept within their power and frequency capabilities, and properly baffled, will produce great satisfaction—even though it's within a range of 60 to 8000 cps.

Suggestions for Improvements in System Design

So much for the audible characteristics of systems. The weight and spatial requirements of some of the best quality components impose difficulties. The problem of interconnections among components is vexing, and indicates that it is surely time for an industry conference on standard plugs, at least for inputs and outputs. Fortunately many audio houses are willing to make up the necessary intercables, and to code them clearly. That doesn't help much when the healthy curiosity of the owner leads to his changing amplifiers or tuners or what not.

The difficulty of arranging controls into a compact and attractive center are formidable. *Figure 2* illustrates an electrically and acoustically fine instrument, marred by duplication and excessive complexity of controls. Consumers want the knobs to come out symmetrically, with none duplicated or useless as they are in *Fig. 3*. It seems to them a reasonable request. This may involve alterations in wiring and chassis arrangement which non-technicians cannot be expected to make. Some of the best amplifiers cannot, for this reason, be used attractively. Long steps in the direction of solving this problem are being made in the various remote-control amplifiers. Such a technique as the use of removable lock-in shafts could be applied both to tuners and to amplifiers, so that duplicated controls could simply be pre-set, and removed when their function can be served by an adjacent knob on another chassis. Some tuners are so designed that removal of one, two, or more shafts, whose function may be duplicated at the amplifier, leaves a symmetrical panel. This is admirable, and could and should be adopted with amplifier-control panels. Most of these will be mounted in cabinets, and that fact should be considered in their design. Great flexibility in provisions for the connection of antennas to tuners can and should be provided. Tuners which are designed to serve also as control-centers need flexible arrangements for the connection of external inputs, like tape-recorders and TV sound. These

are only *some* of the means available to meet listeners' needs. The important thing is that these needs *exist*, and for the sake of survival of the profession deserve attention.

It seems to us that some of the problems of high-fidelity are in an admirable state of solution, and that time can be spared from them to pursue the acoustical rodents that still plague us. Among the best-solved problems in all electronics is that of the amplifier output stage. What we emphatically do *not* need is more good engineering talent devoted to yet another variation of the push-pull feedback power amplifier. At their best, tape and disc recording means have reached a degree of excellence that far outstrips our ability to display it acoustically. The finest of existing pick-up cartridges, arms, and turntables leave little to be desired except cost-reduction. May we not hope for concentration, then, on those elements that are still giving trouble? The biggest problem, of course, is the loudspeaker system. But there are others: record-changers, for all the low esteem in which they are held by the professional, are seriously wanted by most consumers, and their wishes deserve more than our disapproval. The techniques that have made separate turntable-and-arm combinations so satisfactory, are applicable to changers. Tone-control systems designed to meet real needs, instead of to fill graph-paper prettily, are not beyond reach, technically or economically. AM radio receivers are not hopeless: we have recently seen demonstrated an AM detector circuit whose distortion did not exceed $\frac{3}{4}$ of 1 per cent at 99 per cent modulation. A tuner with performance approaching this should be available.

Realism toward high-fidelity in the home requires our taking the non-professional listener seriously. It may be that he cannot *define* exactly what he wants, in our terms, but his approval ultimately determines the success of our efforts. We hold that it is the audio professionals' deepest responsibility, not only to understand and to meet, but to *anticipate* the needs of those whose interest lies in the *program*, not in the equipment. More realistic and respectful attitudes toward the *listener*, we are sure, will result, in the end, in more realistic sound reproduction.



EVERYBODY

But everybody is planning to visit the Annual Convention of The Audio Engineering Society, and The Audio Fair. Why not you?

November 1, 2, 3
Hotel New Yorker
New York City