The Trouble with Attenuators

by PAUL W. KLIPSCH

MY BRIEF against pads is two-fold: (1) how can a layman adjust them, and (2) why degrade a low-impedance amplifier with inserted dissipation? The first point will be passed with only the comment that without thousands of dollars worth of test equipment and many years intimate experience in the field the layman is handicapped. The second seems to need some support beyond philosophy.*

Experiment

It was reasoned that if a step-down transformer were used, the speaker damping, if aided at all by the amplifier, will be benefited; the use of a pad will degrade it. In the case of heavily loaded horns, it might be assumed that the difference would be negligible. Yet the fact that no available speaker, horn or open type, has ever been made with a perfectly flat response over even a narrow frequency range, means that there remain resonances which are not completely damped.

Anyway, a middle-range speaker (horn type) was set up to be fed through a crossover network and either through a resistive pad or a transformer,

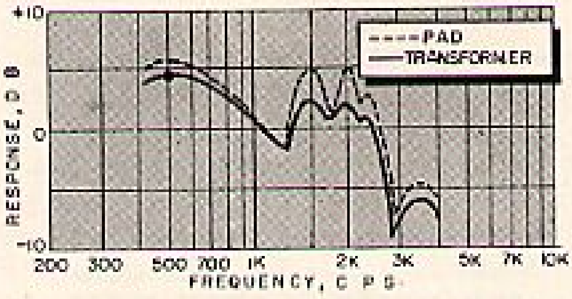


Fig. 1. Effect of pad and transformer.

the loss being adjusted to 6 db in each case and the network constants given values appropriate to the transformed or untransformed impedances.

It was found that the peak-to-trough ratio of output was 4 db in the frequency region of interest with the transformer, and 6.3 db with the pad. That is to say, the pad inserted its 6-db loss in the troughs, but only about 3.7-db loss on the peaks.

Fig. 1 illustrates the effect. The dotted curve shows the frequency response of a horn speaker unit with which a 6-db resistive pad was used to lower the level. The solid curve shows the response using a 2:1 turns ratio transformer.

*George L. Augspurger, "Loudspeakers and Enclosures," AUDIOCRAFT, Dec. 1956 (p. 25), rewords my opinion more forcefully than I would have expressed it: "Mr. Klipsch considers it rather simple-minded to spend money for an amplifier with a high damping factor, and throw away all the benefits . . . by inserting . . . a pad. . . ."

Mr. Klipsch has, for many years, made no secret of his dislike for attenuator pads (level controls) on the individual drivers of multiway speaker systems. He has designed his famous Klipschorn and Shorthorn systems to produce measured balance among outputs of woofer, squawker, and tweeter, thereby eliminating the requirement for level controls under typical listening conditions. Despite sound-pressure measurements, however, recent comparisons with live and reproduced music convinced him that the middle-range output should be reduced for more natural balance. It was not feasible to replace the middle-range driver. The following describes in his own words how he avoided using an attenuator pad, and the measurable superiority of his alternative solution.

Although Mr. Klipsch writes specifically of his own speaker systems, we believe his findings to be of sufficient general interest as to warrant an exception to our rule of not publishing articles on commercial products written by manufacturers or their agents. — ED.

Note that the trough values are about the same for the two cases, but the peaks are higher with the pad. In other words, the response is smoother with the transformer than with the pad.

The explanation is assumed to be that the horn does not apply as much load as required to produce nearly critical damping, so that second-order resonances can show up on the response curve. The added damping of a low-impedance source, therefore, is evidently capable of helping the response even of a highly damped horn speaker.

Now, the 2.3-db error is not large; it is hardly discernible by aural comparison. But if each imperfect system could be compared with a perfect one, then the extra 2.3-db error could well be apparent, whereas the lesser error could pass undetected in many instances.

New Networks

Application of a transformer to a crossover network involves a lot of careful planning. The mere presence of an iron core can produce distortion if the primary inductance is too low.

The networks are shown in Fig. 2. As applied to the Klipschorn, the constants follow fundamental design. The capacitor elements, particularly C2, depend on the actual speaker impedance and the transformation ratio. In the case of the Shorthorn the problem was aggravated by the fact that the woofer is a direct radiator over the upper-bass range, being horn-loaded for only a couple of octaves in the sub-bass range from about 40 to 160 cps, and the region above cone breakup (above 1,000 cps) produces a rising response. Also, the very short middle-range horn acted a little out of character. The C2 value for flattest response turned out to be a value appropriate to a 500-cps crossover frequency; response of the woofer alone suggested a 12-db section. But the values evolved from response adjustment resulted in the simple 6-db network with values shown in Table I.

Table I

	Klipschorn	Shorthorn	Remarks
C3	2 μfd	2	oil
C2	5 μfd	5	oil
L2	0.5 mh	0.5	not over 0.4 ohm DC
L1	5.0 mh	2.5	not over 1.2 ohms DC
T2	Special Autotransformer		

These networks have been evolved, as properly they should have been, as special devices fitted to the particular drive units and horns used. Obviously a substitution of drive unit, or of one of the horns, would probably result in imbal-

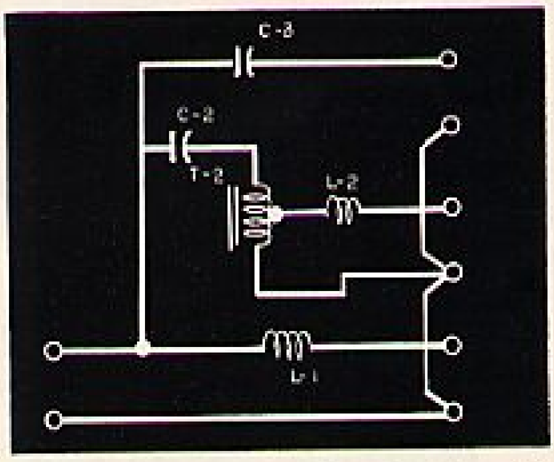
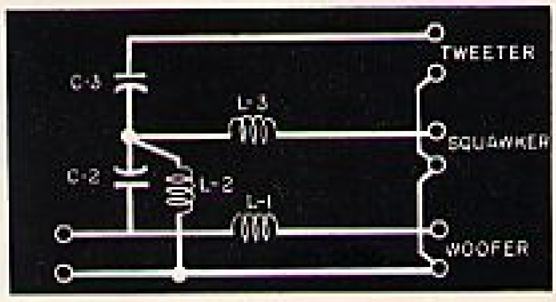


Fig. 2. The new network (above) used by Mr. Klipsch. Contrast this with the old network, which is diagrammed below.



ances. For example, the value of C2 for the Shorthorn network is 5.0 μfd contrasted with a theoretical value of 2.0. The "design center" was used as a point of departure, and the sweep-frequency generator and microphone output used to indicate the direction in which to modify from the design-center values. Design-center and modified values were then given the acid test of hours of listening.

The results are empirical, but were evolved from years of experience, hours of experiment, months of engineering, and weeks of listening to both reproduced and original sound. The recording studio became a laboratory, and vice versa.

Special attention was given the adaptation of the networks for the Rebel series of speaker systems. Because the Rebel III and Shorthorn Model S are identical in acoustic size and function, nothing special was involved. But the less-than-2-cubic-foot size of the Rebel V presented problems.

From microphone-pressure indications it was found, as in the case of the Shorthorn Models S and T, that the capacitor C2 had to be about 2.5 times the calculated value.

The autotransformer is the same for all networks, which is a fortunate thing. The K-1000/5000 W2 network has been arranged to fit into the smallest of the Rebel boxes — hence the shape is trapezoidal, instead of rectangular.

Heretofore the networks involved no iron cores (except the first design of about 1940). In the absence of iron, there is no magnetic saturation and no power limit, except perhaps the kilowatt or so it might take to burn out the No. 17 wire in the inductors. With the introduction of the transformer's iron core, however, a power limit must be established.

Since the network design was specifically for horn speakers of fairly high efficiency, and since the networks would not likely be adaptable to other speaker types, the power requirements for horn speakers were given extended consideration. An extensive series of practical tests shows that 10 w is going to suffice for extremely loud sounds, and power levels exceeding 10 w would produce as much distortion in the ears as in the reproducing system. For sounds of gunfire and rivet hammers, the audiophobes may depend on ear overload before reproducing-system overload. The audiophile, on the other hand, will likely be content with actual volume-power levels of the order of 1 w or less.

The transformer is easily capable of handling its middle-range share of a total power well in excess of 10 system watts, with exciting currents low enough so distortion remains at levels difficult to measure. It is known that all speaker

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Finally, someone usually calls attention to one of the popular brands of amplifier that uses a straight pentode push-pull output, with over-all feedback, and sounds very good. How does this compare? Often this question is asked in the tone, "This amplifier sounds very good — should it?"

Of course, when things sound good there is a reason. At least, there *must* be a reason when they don't! Let me present a hypothetical comparison (and please note, it *is* hypothetical — don't try to fit any actual products to it). One amplifier may consist of a good output stage (tapped-screen, say, with a good output transformer), but then the over-all feedback, including the front end, may not have been engineered to give solid performance to back it up. Another amplifier may use pentodes straight, with a relatively inexpensive output transformer, but a carefully tailored front end and feedback. And the second amplifier may finish up sounding the better of the two, at much lower cost.

What this implies is that you cannot dogmatize about the best output stage, drive stage, phase inverter, etc. A well-designed amplifier will perform better than a badly designed one, though the latter may include the "best" circuits.

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drive units so far tested here produce much more distortion at ¼ w input than the network would introduce at 25 w input.

While on the subject of power, a word should be said about high-fidelity expositions. It seems that every new speaker introduced and a lot of the old ones are demonstrated at hundreds of times as much power as the original sound. Many other exhibitors turn their volume up in self-defense. These loud demonstrations prove little except perhaps that loud playing obscures some of the defects of the reproducing systems. But even at power levels necessary to drown out a nearby dynamicist, electrical power to Klipsch speakers has never exceeded about 2½ w, the gains being set on the tape-playback amplifiers so that this is the output for maximum playback gain setting.

In conclusion, it should be reiterated that the new networks are designed to supplement, fit, qualify, and compensate for a given driver-horn combination. As such, they are no longer of general application.

While it will continue to be company policy to sell these networks separately, it should be understood that they cannot be expected to work with any except driver and horn units of at least closely similar characteristics to the ones for which the network was designed.