The Flewelling Audio System*

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This is the system about which so many rumors have been current during the past few months—an authentic description by the inventor.

This description of the author's unconventional system is presented to AE readers because of the wide interest already engendered. Since the material is somewhat controversial, it is carried on the following pages exactly as written by its author. AE's opinion is carried on page twelve in the Editor's Report.

Chassis of amplifier used in the Flewelling System.

I CANNOT BEGIN TO COVER my entire subject in one article, but I am going to describe in that space, as completely as I can, a system of sound reproduction that comes closer to being a musical instrument than anything you have yet heard. Some of the best engineers in the country have said so, and, if you build one, you can prove to your own satisfaction that it is capable of real performance by the following simple test:

Connect a good signal generator that will produce a clean sine wave at 25 to 50 cps into the input circuit of the amplifier. Then with a good mike, a clean amplifier, and a 'scope, you should be able to pick up *out of the air* a clean 25 to 50 cps sine wave such as you put into the outfit. How low, in frequency response, you can go will depend upon factors that we are not yet sure of. We have seen outfits that would go down to 20–25 cps without any trouble at all. This system will give the experimenter plenty of opportunity. Later on I shall cover this in more detail.

The above statement points out, vaguely perhaps, that you are not at all interested now in the linearity or the intermodulation of the amplifier, or whether you use triodes, pentodes, magnetic, or by-roads. We've had all we need of this bunk for 20 years. It's very necessary in its place and time, but 20 years is a long time. We are fed up on it for "one". What we want is a musical instrument that will sing to us and not blast our ears off while we kid ourselves with "that bass is good". Remember, remember—the bass range is the very foundation upon which music is built.

Let's stop talking about high fidelity because it has not yet been achieved. Let's stop raving about magnetic, reluctance, or crystal pick-ups. Let's not be foolish about FM reception. The point is to be stressed and stressed again is that if your reproducing system—note that I said system not amplifier—is good, bad, or indifferent, what comes out in the air will be good, bad, or indifferent, exactly as your system is able to handle what is put into it. It's what comes out of the hat that counts, not that he says he'll produce a rabbit. Imagine the beautiful FM reception that you would get, with the finest reproducing system in the world, if you tuned in an FM station whose program was a transcription, received over a few miles

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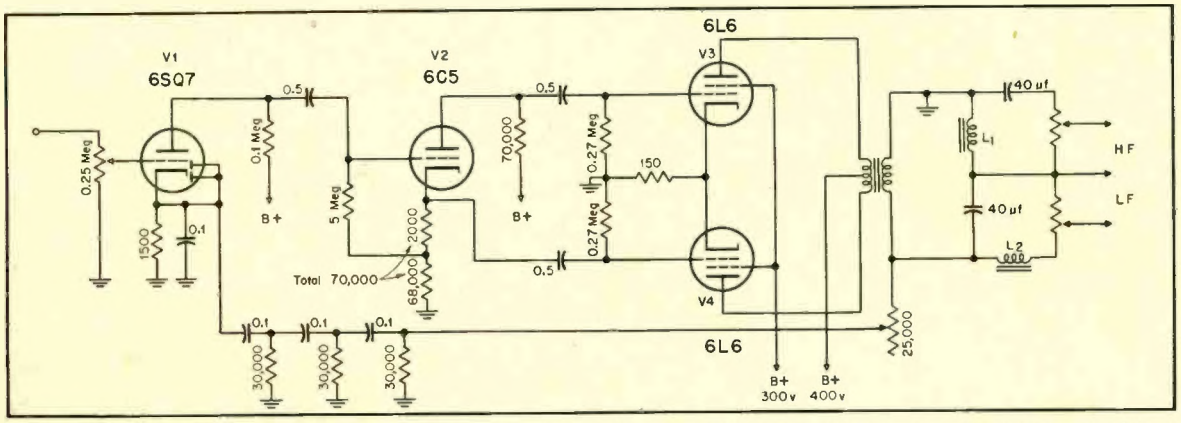


Fig. 1. Schematic of two-stage amplifier which is the electrical section of the Flewelling system. Note the use of large coupling capacitors, and the unique feedback circuit. Other than this, the circuit is reasonably conventional.

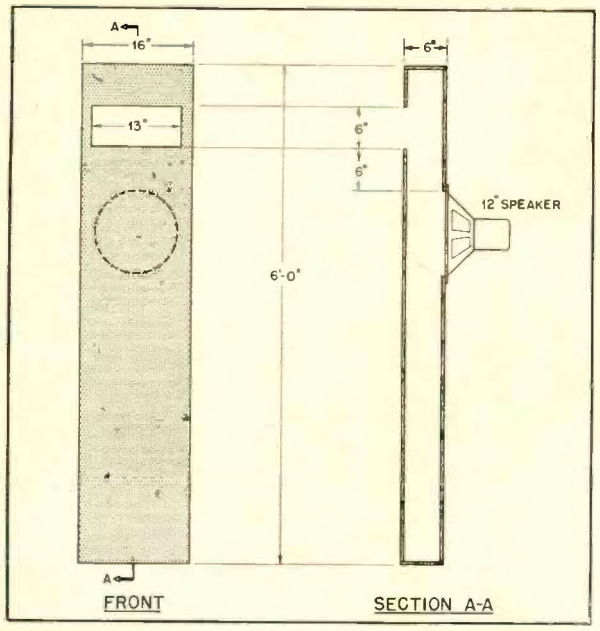


Fig. 2. Elevation and section of the low-frequency reproducer unit, which differs appreciably from standard types of reflexed cabinets, infinite baffles, or exponential horns.

of 5000-cps line, and then put through —well, what's the use? You get the point, there's no use in getting childish about it.

The outfit to be described has been designed for residence music only. It is not a dance hall instrument. The circuit diagram shown in *Fig.* 1 is a standard two-stage amplifier, with the addition of a trick feedback circuit. We will leave it to the "X square Y square" boys to prove that this is wrong. We haven't the time and besides we've been told that we were wrong so many times, that we are fed up on this; "two".

Circuit Description

We have two stages because as you know (or do you?) the phase inverter produces no gain. This phase inverter is a cathode follower, and really does a job. Be *sure* to put your scope on both outputs, the plate and the cathode, and check for distortion. When the stage is right, both outputs will be clean and equal. You should have no trouble here, for it is not at all hard to set up. 6SN7 or double-triode phase inverters are absolutely out. To use such a phase inverter generally means three stages of amplification and distortion. Feedback over three stages is something one had best stay far away from. We want only two stages and we want feedback that we can control. The more amplification we have, the more chances we have for distortion, and the less chance we have for decent control of our feedback.

The feedback control shown in the diagram is a variable only because no two amplifiers or speaker systems are exactly alike. You'll come close enough, unless you are fussy, if you use a fixed 15,000-ohm resistor. Now remember, many times an audio amplifier can oscillate without making an audible sound. Of course, oscillation will mean distortion that you might not be aware of. If you doubt this statement, hook up the outfit strictly according to direction. Then watch the output with a 'scope while you listen to the speakers and do things to the volume control. Maybe you'll be surprised.

I am tempted many times, as I write this article, to branch out with a dissertation on sound reproduction. I feel that I could easily write a book on the subject. May I, while I am off the track a bit, say that years ago when I was writing about my super-regenerative circuit, I formed a habit that, as far as I know, I seldom break. I formed the habit of being able to prove practically any statement that I make. Not being a saint, I'm not claiming perfection.

To go on—that 0.1-μf capacitor across the cathode of the 6SQ7 had better not be changed, and of course you know that the feedback take-off will have to be taken from the right side of the voice coil. I can't show the right side in a diagram.

The output transformer must be the best obtainable. The taps used on the secondary should give you a correct impendance match through your dividing network and speakers.

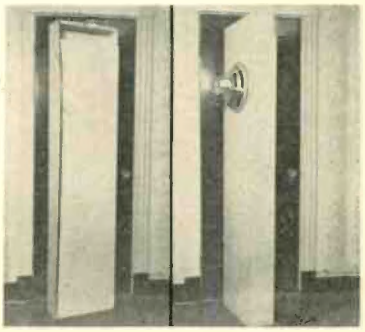
Dividing Network

In the dividing network, the choke coils are wound on the core of old transformers such as are used as output transformers for 50L6's in table models. It is preferable to use slightly larger cores, but we are not trying to show how accurate we can be because we have had so much experience over the years with this system that we know where accuracy is or is not needed. You may wind these coils in one, two, or three layers, putting on 100 turns of wire and using a piece of wrapping paper for an air gap. If you want to know if they are working, start up the system leaving the laminations a bit loose. You'll see.

Before we leave the network, we must not forget to speak about the capacitors. If you make the mistake about these condensers that several $10,000–$15,000 a year engineers have made and have had to retract, you'll just be out of pocket, gained nothing, and kidded yourself. The statement that these capacitors cannot be used, is something else that I am fed up on: "three". The capacitors, without any further beating around the bush, are common ordinary 20-20 μf 150-volt electrolytics such as are used in table model a.c. d.c. jobs, although any of the small electrolytic capacitors may be used if their rated capacitance is in the 20-μf class, and the voltage rating is not exceeded by the peak output voltage of your outfit. Your dividing point will be around 400 cps. Do you care if it is 350 or 450 cps? Certainly not, unless you have a specific reason. Put a d.c. meter with a rectifier across this network, run an oscillator over the range, and you'll see that you have hit it in about that frequency.

The Speaker System

It seems that 10,000 years ago (more or less) Confucius kept goats, and, of course, daily had occasion to call them home. As the goats wandered farther away, old Con soon found that he could be heard at a greater distance if he made a sort of horn out of his cupped hands, or by rolling up a copy of AUDIO ENGINEERING. Con was a pretty wise old duck, you remember, and he at once saw that the thing was getting over his head, so he called in all the audio experts in his realm and told them to get busy, be-



External appearance of low-frequency speaker cabinet used with this system.

Left, the author at the controls of an early version of his home reproducing system. Right, later model of the system, with three changers for 78, 45, and 33 1/3 r.p.m. records.

cause it looked to him as if he had stumbled onto something pretty big.

Well, the engineers went to work on it, and they tried out everything they could think of. They even tried out the goat pen in the corner of Con's living room, and after yahs and yahs, they came up with what we now call the exponential horn. It wasn't just what Con wanted because he found that while he could attract the attention of his goats at great distances, they often just looked up and went back to cropping his neighbors corn. Thus he discovered that while the goats heard him, they did not recognize his voice. Today horn distortion is still with us, children.

Let us refer to pages 104–107 of *Motion Picture Sound Engineering*.[1] Here we have the horn that the motion picture boys came up with in an effort to give us the best. It is one of the reasons why so many raving maniacs are created by listening to musical movies. Confucius found it out 10,000 years ago. I wouldn't dare say that I can improve upon it. You use your own judgment, but in the meantime, note that the response curve of the thing gives up at 50 cps, evidently in disgust. The unit has a mouth area of 50 square feet, an axial length of 40 inches. The mouth is also mounted on a flat baffle 10 feet by 12 feet. You'd look well trying to get down to 50-cps with anything less than this movie horn, for those boys knew what they were doing. In horns it's the horn. Your wife would also, no doubt, be pleased with such a horn in the living room.

In laying out my system of reproduction I tried to reason the thing out and finally came up with this answer. No matter what the job was, whether a $300 combination record player or a so-called high-fidelity outfit, there was, generally speaking, no substantial difference in the quality of the output. All reproducing jobs ran smack up against what might be called "the state of the art." There has been no basic improvement for years. What one man knew was certainly available to the other. What difference there was, it seemed to me, depended almost entirely upon the output transformer or upon the space that was available for the outfit. In other words, what size horn or baffle could be used. This led me to wondering if we were connecting our speakers to the air in an acoustically correct manner.

The answer is a bit involved, but it seems evident that our greatest weakness is in the speaker end of our outfits. To go into the matter in more detail, we must point out that a loudspeaker, of the type in ordinary use, is not only a motor, but it is a generator. I think the "brains" will agree with me that its performance as a generator might very well exceed its performance as a motor. This is because as a motor, it cannot be properly loaded at low frequencies (acoustically coupled to the air) and hence under a varying drive it is bound to "fly wheel" and go off on excursions of its own. There are bound to be small high-frequency voltages generated, which, if we desire, we can feed back, and to some extent affect with our feedback circuit.

An infinite baffle has a limited use, and a horn cannot properly load a loudspeaker. The more we try to load our speakers, the larger our speaker and horn become, and we run up against the law of diminishing returns. We cannot do it with $300 or $400 precision speakers or with horns, but if it is done correctly—that is, if we could succeed in coupling our low-frequency speakers to the air in an acoustically correct manner—we should be able to use the 10- or 12-inch speakers of the common garden variety which cost around $8 or $10. We might even be able to do it with 6-inch speakers, although I've not seen it done. Furthermore we would succeed in producing lower frequencies, in generating less fly-wheel excursions, in clarifying the very apparent distortion that is evident in the high-frequency end of all systems, due to the generation of these fly-wheel parasites, and should, to top it off, increase the speaker efficiency many fold.

A horn seems to offer much better performance than just the air in front of a speaker. A horn is a form of air column, so the question naturally comes up—what is the best form of air column, and how should it be used? Is the exponential horn, after all, the best manner in which we can use an air column? I finally came up with a type of air column that seems to help considerably. Instead of playing a speaker *through* an air column, as in a horn, the idea is to build a non-resonant air column and play the speaker *across* the air column. See *Fig. 2*. It is made of plain pine boards ¾ inch thick, and must be assembled with screws.

Space does not allow me to do more than give the inside dimensions of an air column that we have used successfully. There is much promise in this approach to air columns. We know very little about it except that over five-hundred lay persons, musicians, and top flight engineers have said that they have never heard such reproduction as that given by this system. We know too, that it created enough interest in the indus-

[1] D. Van Nostrand Co., Inc. New York.

try for one of the big companies to part with many, many bucks.

Conclusions

To sum up: The system consists of the amplifier as described, the air column, and six loud speakers. These speakers are to be of the cheap or garden variety, and are to be placed as follows. In the high side of the dividing network use a tweeter, a 6-inch, and a 12-inch speaker; most anything will do as a baffle for these speakers. In the low side of the network use a 12-inch speaker in the air column, hide the column behind a divan or such, and connect with it two 8-inch speakers mounted on any convenient baffle. All speakers are standard 6- or 8-ohm speakers, and must make some sort of an impedance match with the output circuit.

In the low side we run afoul of our theory, but, as I have said, we know very little about the air column. It is well known that the impedance of a loaded speaker is quite different from that of a free wheeling speaker, and that these columns do load the speaker. We need to know lots more about the columns.

All of the speakers are concealed, for the psycological effect of a speaker opening is bad. Remember, of course, that the high-frequency speakers will show directional effects, and should be placed with that in mind.

It may well be that another article could be written on the subject of pitfalls in sound reproduction, with particular reference to this system.