HUGO GERNSBACK, *Editor*

RADIO CRAFT

IMPROVING SOUND EQUIPMENT

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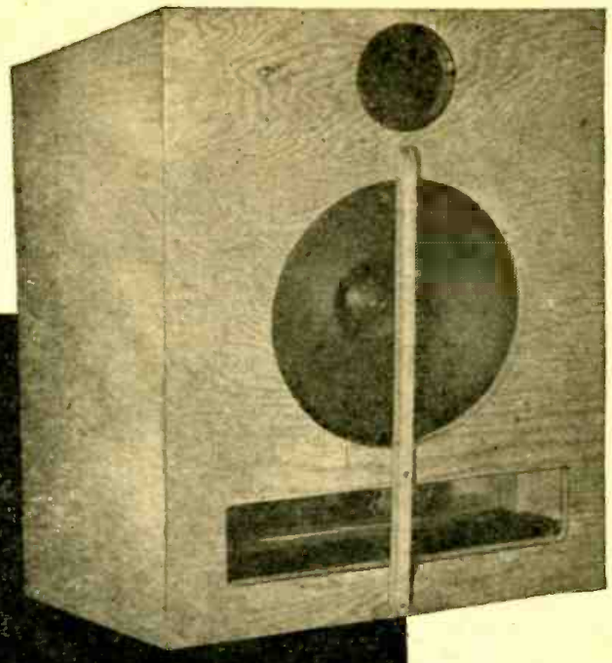
By J. CARLISLE HOADLEY

SOUND SYSTEM IMPROVEMENT



The speaker cabinet. Position and comparative sizes of vent and speaker hole are clearly shown here.

Excellent reproduction of recorded music depends on three factors: compensation for recording characteristics, a good amplifier, with special attention to the output transformer, and a speaker and baffle system which turns the output to sound with a minimum of distortion

A NUMBER of years' experience building maximum-fidelity amplifiers and sound systems have led to the formulation of a set of rules, which, if followed, will enable the listener to realize the best from any sound system.

First and foremost, the psychological factor must be considered. People are definitely different in their tastes and desires, and these desires change with the type of program they are listening to. Your amplifier should be equipped with some means of varying its response curve, preferably with independent treble and bass controls.

It is often stated (and rightly so, if the statement is qualified) that a *flat amplifier* is ideal. If we had a flat microphone, a flat amplifier and a flat speaker, located in a perfect acoustic chamber, and if the speaker output were exactly as loud as the sound source, the system would indeed be ideal.

Even with this theoretically perfect sound system, if we turned the volume down to one-half the loudness of the sound source, it would no longer sound like the original, because we have introduced a new variable, our ears. The human ear's response curve varies with loudness. The lower the volume the less ability there is to hear very low and very high frequencies.

Room acoustics have a profound effect on the ultimate sound of a system, and as there are few ideal rooms outside of broadcasting stations or laboratories, this is another item to be reckoned with. In addition to these things, few pickups, speakers and microphones are flat.

FREQUENCY RESPONSE

Now that we have an idea of what we have to contend with, let's get down to cases. Though the frequency response of a system is important, the most disturbing element in any system is distortion. This will be more apparent at the higher frequencies, so we limit the frequency response of the system till it is just sufficient to reproduce the material on hand. There is no advantage in using a system flat from 20 to 20,000 cycles to reproduce a shellac pressing. The high frequency noise and distortion would be unbearable. Neither could we use an inexpensive phono motor with this wide-range system without the rumble in the motor being very apparent. So-called permanent needles when worn cause a particularly annoying type of distortion, in addition to causing permanent damage to the records.

The response of an AM receiver need not be any wider than 40 to 5000 cycles for the average station when broadcasting network programs, and 30 to 9500 cycles is entirely satisfactory for the best AM stations when broadcasting local programs. Limiting the response to 9500 cycles is to suppress any 10-kc beats between other stations located 10 kc apart. For FM reception or transcription reproduction we can go the limit and provide response from 30 to 15,000 cycles, for only in these sources is the distortion low enough or the range wide enough to warrant this wide range.

In the reproduction of any record we must take into account the various recording characteristics and compensate the pickup accordingly. Standard shellac phonograph records are recorded with a "modified" velocity characteristic. Amplitude of the cutting stylus is held constant from the lower frequency limit to between three and eight hundred cycles, and modified constant-velocity above this crossover frequency provides a five to ten decibel boost at 8000 cycles. See Fig. 1.

This is done for the following reasons:

1. Due to widespread use of crystal type pickups, the manufacturers of records insert a high frequency boost to reduce the compensation necessary to flatten the playback equipment's response. This boost effects a considerable improvement in signal to noise ratio.

2. A large majority of the users of shellac pressings have equipment with serious attenuation of the higher frequencies and no means for the compensation thereof. As the figure shows, there is a falling-off at the low-frequency end of the audio spectrum. If the low frequency amplitude were not restricted, either overcutting would result or the level of the high frequencies would be below the noise level.

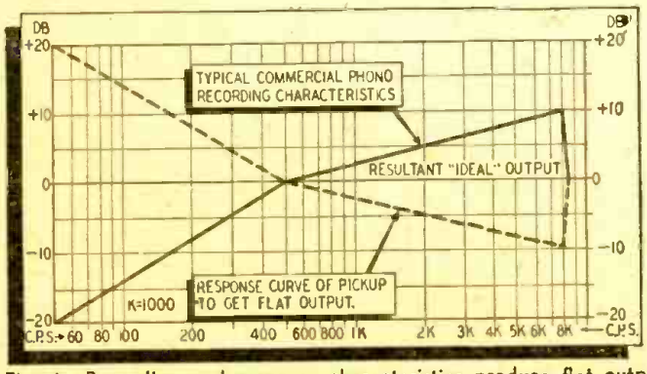


Fig. 1—Recording and response characteristics produce flat output.

PICKUP CHARACTERISTICS

If constant velocity records (without treble boost) are played back with a magnetic pickup the output will be flat with decreasing frequency down to the crossover frequency where constant amplitude begins. Since the magnetic pickup requires successively greater stylus motion at the low frequencies to maintain its output flat, and since the amplitude is held constant below the crossover frequency (300 to 800 cycles) we must provide an equalizer to compensate for this condition. Since practically all commercial records made in the last six or seven years have a treble boost, the magnetic pickup must be further compensated to *reduce* its high frequency response. Otherwise response from commercial records will be excessively brilliant. Fig. 2 shows the

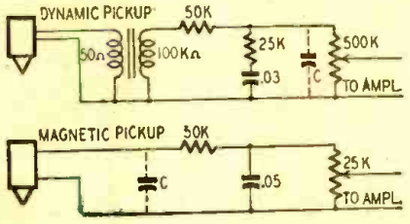


Fig. 2—Two suggested equalization circuits.

usual method of equalization. Constants are approximate and depend on the pickup and transformer, as well as the recording characteristic of the records being played. Condenser C is for treble attenuation. Its value may be anywhere from .002 to .02 μf, depending on the pickup and transformer.

A crystal pickup has a *constant amplitude* characteristic. Its output voltage is a direct function of stylus motion independent of frequency up to its high-frequency cutoff point. For constant velocity recording (without treble boost) above the crossover frequency we would have to compensate for the decrease in stylus amplitude with frequency. This is in the order of six db per octave above the crossover fre-

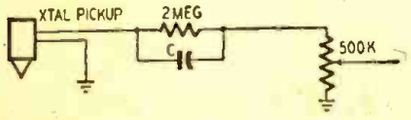


Fig. 3—Equalizer circuit for crystal pickup.

quency. To compensate the pickup for this would require considerable boost at 7000 cycles. However, commercial records insert treble boost at a rate of from two to about five db per octave above the crossover frequency, depending on the record. Thus for some records no high-frequency equalization is required and for others only a small amount. The customary method of compensating crystal pickups for commercial records is shown in Fig. 3. Reducing the value of C will reduce the amount of treble boost. For maximum boost C should be about .002 μf. When playing records having considerable treble boost, C should be reduced in value to as low as 50 μμf. Transcriptions are recorded with more involved response characteristics (generally they have considerably more treble boost than records) and the manufacturer of the pickup should be consulted for information on equalizers for Orthacoustic, NAB Standard, Columbia or other transcription characteristics.

THE AMPLIFIER

Now that we have a suitable flat source of music we wish to amplify it with as low distortion as possible. The easiest way to do so is to build a straightforward amplifier using triode tubes throughout. We can choose between 6A3, 6B4, 2A3, 45 for the output stage. These tubes should be arranged in push-pull, as the attendant cancellation of second harmonic distortion and supply-voltage hum is worthwhile, and reduces the first filter section requirements. Of course, beam tubes (6L6-6V6) can be used with feedback.

The most important purchase in connection with this amplifier is a good output transformer. It will make more difference than any other component. An output transformer may have a power rating of ten watts. This is somewhat deceptive as it is usually measured at some middle frequency, usually 400 or 1000 cycles. The same transformer may only be capable of transferring four watts at 30, and six watts at 12,000 cycles. This is a serious drawback particularly when we wish to boost the high and low frequencies. High-quality units are relatively inexpensive in comparison to the results they will produce.

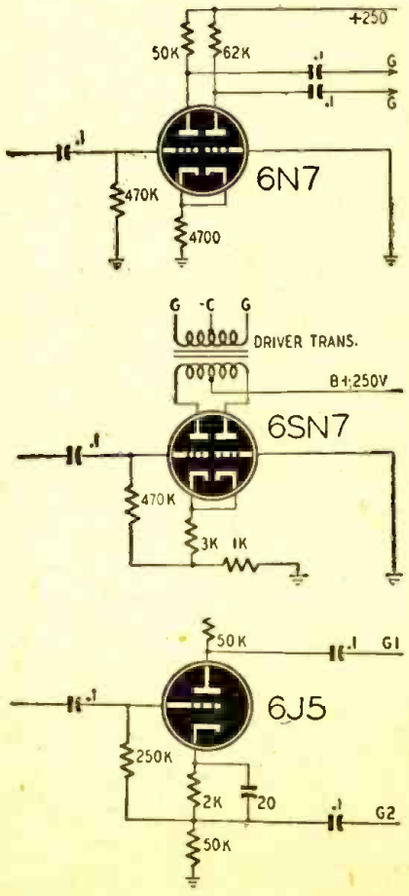


Fig. 4—Three self-balancing phase inverters.

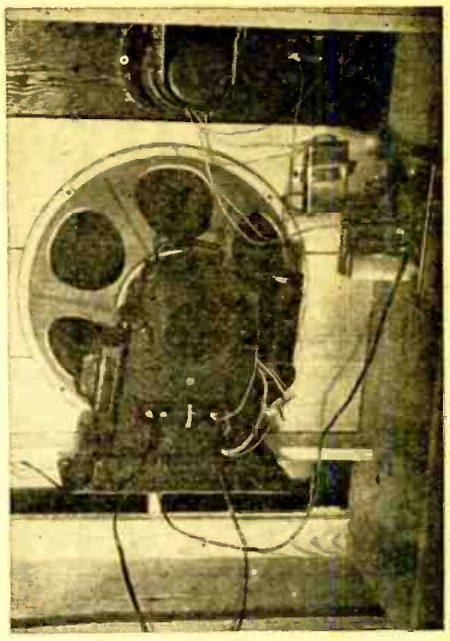


Photo B—Inside view of the speaker cabinet.

A high-quality output transformer for a 15-watt 6B4 amplifier can be obtained for $15.00 or so.

An input transformer need not be used if class-A operation is desired, as a phase inverter is adequate. Fig. 4 shows several inverters which are degenerative and consequently self-balancing and of the low-distortion type. If class AB or AB_2 operation to obtain maximum power output is desired, an input transformer is needed to keep the resistance in the grid circuits of these tubes low in the case of a small amount of grid current being drawn.

Fixed bias is desirable as it allows greater power output with lower distortion. Fig. 5 shows a simple way to obtain it when your power transformer does not have a bias tap. A separate transformer winding is required. The rectifier may be a triode similar to those in the amplifier.

If you use an input transformer it is wise in the case of an inexpensive unit and essential for a high quality unit, to shunt feed the primary from the driver tube. This does not hold for push-pull drivers, as their d.c. plate current balances out in the output transformer.

Be sure to bypass all cathodes with large enough condensers to eliminate degeneration at low frequencies. It is wise to decouple every stage, both in the interest of low hum level and to eliminate the possibility of motor boating or unwanted interstage coupling.

One should, of course, use as good a speaker as possible and it should be baffled efficiently.

A bass reflex baffle offers many advantages, among which are improved bass response, higher sensitivity and cleaner high-frequency response. The distortion at low frequencies may be reduced greatly over the conventional open-back enclosure.

When a speaker is placed in an en-

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closure of this type, the back wave of the speaker is added in phase with the front wave through the port in the cabinet, which adds to the acoustic power obtainable at low frequencies. As a matter of fact, the radiation from the port exceeds the radiation from the cone at very low frequencies. This increases the low-frequency response, extending it approximately an octave lower, while at the same time more heavily damping the frequencies above this point. This tends to smooth out the response from the lower limit up.

Damping material is placed in the baffle behind the speaker to absorb the back wave. If this were not done, it would reflect from the back and cancel some of the higher frequencies emerging from the cone. This would give rise to very uneven high-frequency response. The overall effect is an enormous improvement in the bass and a clean high frequency response.

The baffle in Photos A and B was built for an 18-inch speaker, but this type of baffle works its wonders on any size speaker. Fig. 6 gives the dimensions for all standard size speakers. The enclosure should match your individual speaker. The dimensions given are approximate and there are two ways to vary the box's resonant frequency.

The easiest method is to vary the port size by placing a book over part of it while feeding several volts of 60-cycle a.c. into the speaker voice coil from a filament transformer. When the proper size is arrived at, a piece of wood may be screwed over part of the port inside the box. The right position is where the greatest amplitude appears at 60 cycles.

The more difficult method is to move the back of the baffle in or out of the box until the desired result is obtained. For the 15 and 18-inch speakers it would be desirable to use a 30 or 40-cycle source for adjusting the baffle. The source should be a high-quality audio oscillator, with low distortion.

For AM or shellac pressing reproduction, a single speaker with response up to 5000 or 7500 cycles will be adequate. For FM or transcription reproduction, better results can be obtained with a dual speaker system, with a small high-frequency speaker added to extend the range of the larger unit. Several coaxial units are available, ranging in price from $30 to over $250.

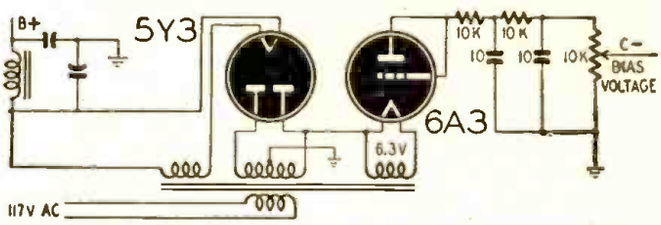


Fig. 5—Simple bias supply which works from the power transformer.

Photo C shows a Jensen 18-inch low frequency speaker, a 14-inch speaker and a Jensen C3 tweeter. This combination is capable of reproducing the entire range from 30 to over 15,000 cycles.

The best place for a speaker in any room is in a corner facing the longest diagonal of the room. In this position

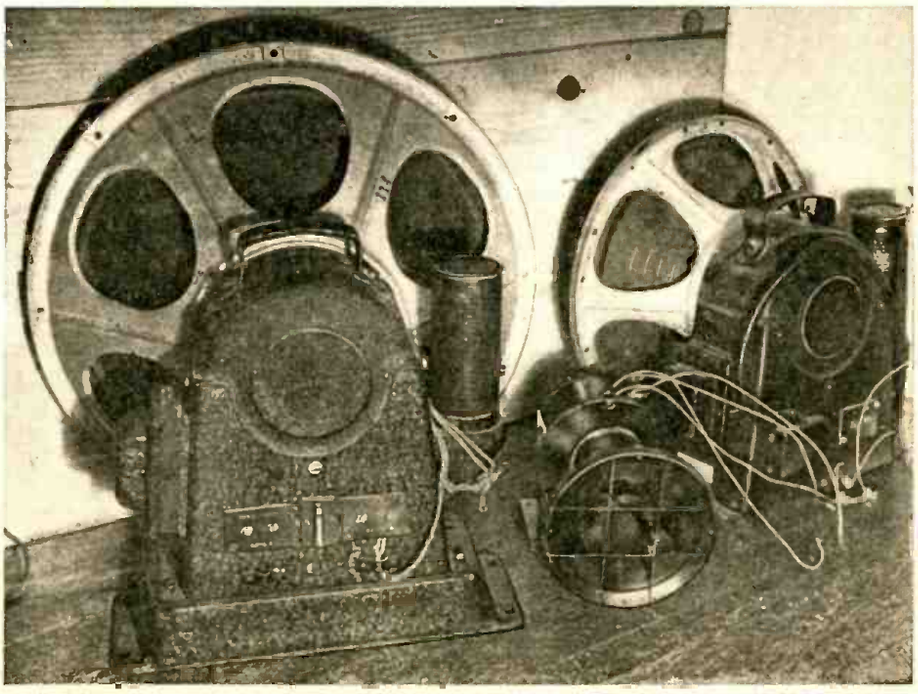
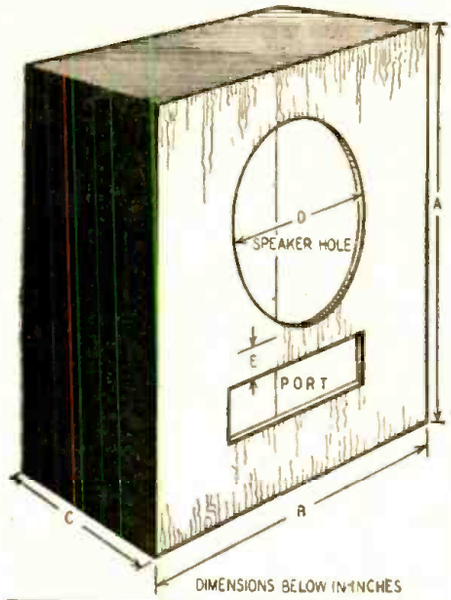


Photo C—A combination of speakers to provide high fidelity from 30 to 15,000 cycles.

the enclosure is best able to match the room's acoustic impedance. Remember to place the speaker far enough from the turntable so acoustic feedback will not occur from mechanical coupling at low frequencies.

Don't ruin records with worn needles. A regular steel needle will play one side of a 12-inch disc and should not be used further, as it will develop a pronounced flat spot with a sharp cutting edge which will tear up the next record.



DIMENSIONS BELOW IN INCHES

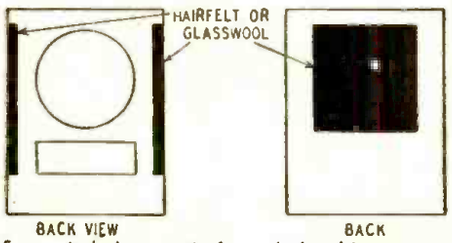
S	A	B	C	D	E	PORT
8	24	18	11	7	3	1/2 AREA OF SPEAKER HOLE "D"
10	28	22	12	9.5	3	" " " " "
12	31	24	13	11	3.5	" " " " "
15	34	26	14	13.5	4	9/16 " " " "
18	40	27	14	16	4.5	5/8 " " " "

"S" COLUMN SHOW SPEAKER DIAMETERS

Fig. 6—Correct dimensions of speaker baffle (The first column "S" is diameter of speaker).

It will also allow the pickup to chatter in the groove, giving rise to a particularly obnoxious type of distortion.

It is a good investment to purchase a pickup with a built-in permanent stylus. The pressure on the record of these units is usually less than the replaceable-needle types. There is much less acoustical chatter, the hiss is lower and the sapphire stylus is kinder to your records.



Suggested placement of sound-absorbing areas.

In the case of transcriptions, it is necessary to use a light-weight pickup, preferably with sapphire or diamond needles. The one greatest cause of surface noise on records is dust. They should be stored in dustless envelopes. If they get dusty, wash them in water. A dusting brush, which can be purchased in any record shop, is a good investment.