A Three-Element Bass Control

GLEN SOUTHWORTH*

One solution to the problem of providing realism in music reproduction is to introduce a controlled amount of "hangover" by means of the circuit described which permits boosting bass at three separate frequencies independently.

The three-element bass tone-control unit designed to obtain power supply from main amplifier.

In the design of conventional tone controls a cut and dried procedure is very often followed. A sine-wave test signal is used and the circuitry adjusted to provide the desired number of decibels boost or cut in reference to 1000 cps, typical steady state response curves being shown in *Fig.* 1. While very useful in many cases, this type of tone control is not very likely to provide adequate compensation for some program sources as well as the listener's speaker system, room acoustics, and individual musical tastes.

The bass-boost circuitry described in this article is an attempt to provide a musical form of bass emphasis similar to the kind generated naturally by good acoustics. To do this, particular attention has been paid to the transient character of most bass sounds as well as some of the significant factors of human hearing. The results obtainable should be highly valued by the listener who desires good, full, audible and "feelable" bass together with a minimum of interaction or apparent distortion of high frequencies.

Figure 2 shows three of the most commonly used methods of bass boost. These are the R-C network, the R-C-L or resonant circuit, and the inverse-feedback method of obtaining bass emphasis. A fourth type of frequency emphasis is obtained by altering the feedback path of a triode or pentode in such a manner that the circuit simulates a resonant inductance-capacitance combination. Though more complicated than the LC circuit of (B) in *Fig.* 2, This circuit has a number of distinct advantages. It requires no expensive high-Q inductances, and is therefore not susceptible to hum pickup from stray magnetic fields. Likewise, it is a high-impedance device with essentially zero insertion loss and as such is easily adapted to, or combined with, other audio circuitry. In addition, control of the circuit is very flexible and apparent Q's from zero to near infinity may be obtained by varying the setting of a single potentiometer.[1]

Fig. 1. Comparative steady-rate response curves of conventional bass-boost circuit (A) and resonant bass boost (B).

The steady-state response curves of a simulated resonant circuit are shown in *Fig.* 1 in comparison with those of a conventional tone control. Two factors are worth noting: First, that the curve obtained is such that added accentuation is obtained in the low-bass region where it is frequently needed to compensate for poor speaker and baffle efficiency, inferior acoustics, and possible defects in original program material. Secondly, the response can be made to drop off quite sharply below a chosen frequency in order to reduce the possibility of amplifier or speaker overload by very-low-frequency components, or in some cases to attenuate serious hum

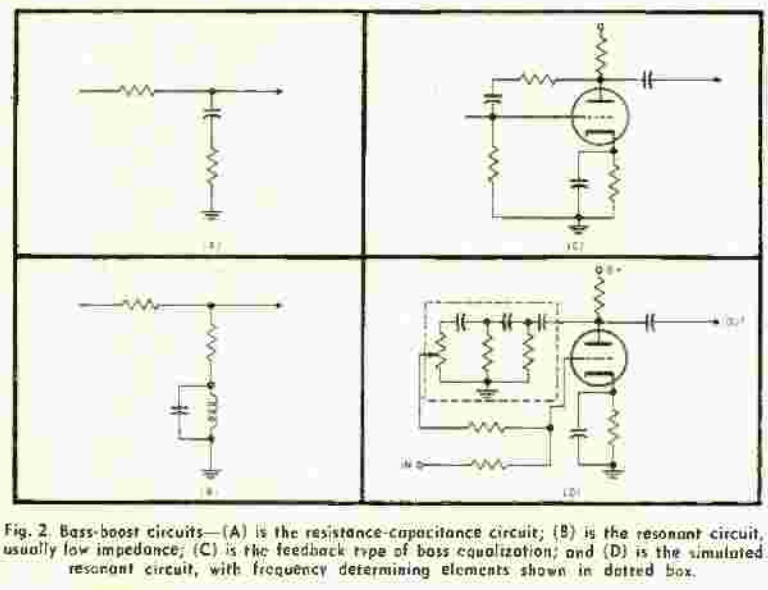

Fig. 2. Bass-boost circuits—(A) is the resistance-capacitance circuit; (B) is the resonant circuit, usually low impedance; (C) is the feedback type of bass equalization; and (D) is the simulated resonant circuit, with frequency determining elements shown in dotted box.

* *Box 284, Moscow, Idaho.*

[1] "Artificial hangover." *Radio and Television News*, January, 1952.

in the program material.

Steady-state measurements tell only part of the story, and in many cases the transient response characteristics will be more important in determining what the reproduced bass sounds like. *Figure* 3 shows a series of scope photos illustrating the effects of various types of bass circuits on transient pulses. In the case of the synthetic resonant circuit, nearly pure bass fundamentals are generated from the transient pulses not only at the main resonance frequency, but for an appreciable range on either side.

The synthetic construction of fundamental tones from transient pulses may be considered to give the following benefits. It tends to duplicate effects produced naturally by good acoustics, it tends to provide a signal more easily reproduced by present day speakers, and—rather paradoxically—it can result in better apparent highs. This last characteristic is a psycho-acoustic effect resulting from the fact that the masking characteristics of the low-frequency reproduction are radically changed. As a result, more bass boost can be used without drowning out the highs with strongly masking pulses or noise components. At the same time it may be found that certain transients become semi-audible that were not reproduced at all previously and these give a soft-

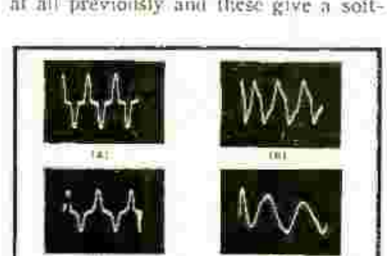

Fig. 3. Oscilloscope photos showing pulse series with repetition rate of 100 cps. (A) shows initial pulse shape; (B) shows output of R-C bass-boost network such as that of (A) in Fig. 2; (C) illustrates output from feedback type of boost circuit; and (D) is 'scope trace of output of the three-element bass-boost circuit.

ening and more musical effect to what might otherwise be strident highs.

In addition to its pulse-forming characteristics, the resonant circuit has another aspect that has suffered considerable misunderstanding. This is the fact that a high-Q circuit will generate "hangover" when shock excited. Unfortunately, hangover has come to be associated with a host of undesirable distortions in bass reproduction, and as a result, resonant circuits have been little used in recent years. Actually, a thumpy or boomy reproducing system is apt to be suffering from too little hangover rather than too much. The reason for this is that rapidly damped wave trains produce strong "side-bands," or adjacent frequencies, and the ear tends to hear and be irritated by the spurious high-frequency components of a too-rapidly damped bass note. Similarly, adjacent resonances in the speaker, baffle, or acoustics tend to be strongly

Fig. 4. Three-element bass-boost circuit with self-contained power supply.

stimulated and consequently may produce disagreeable beats.

The introduction of artifical hangover before the loudspeaker means several things. Short duration wave trains are lengthened and non-symmetrical components are largely eliminated, with the result that an objectionably pitched speaker or cabinet resonance is much less apt to be stimulated. Similarly, fewer spurious sidebands are produced, with the result that the listener hears deeper and clearer bass. This last may be considered of definite importance when listening at low levels due to nonlinearity of the ear which gives the effect of heavily damped wave trains. However, certain precautions should be taken to secure optimum results with resonant bass boost circuits. In the average phonograph, there are apt to be three major sources of mechanical resonance in the bass region. These are the loudspeaker, the speaker cabinet, and the phonograph pickup arm, and sometimes the proper combination of these elements can result in a system with warm, vibrant, bass without electrical boost. However, if the electronic resonance is peaked at or near the frequency of one of the mechanical resonances very disproportionate response may occur.

Practical Circuit

Figure 5 shows the schematic of a bass-boost circuit which employs three different resonant elements. By using two or more resonant elements in the bass region the over-all response may be more closely compensated for and tendencies toward "one-note" reproduction are greatly reduced. In the circuit shown, each control serves a dual purpose, acting as a means of controlling the "Q" of the resonant element as well as an attenuator of that particular channel. Thus, when the three bass controls are turned all of the way down, no bass boost occurs. When the controls are turned part way up, a low "Q" resonance is simulated and pulse forming occurs. When the controls are turned all the way up, a high "Q" resonance is simulated and artificial hangover occurs. The fourth control shown is the input level to what is called a "side amplifier," a channel which introduces no frequency discrimination, and which

(Continued on page 97)

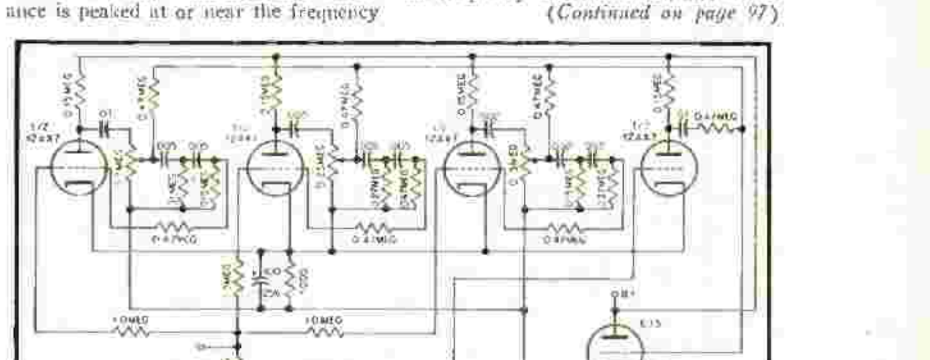

Fig. 5. Schematic of tone control system using three different simulated resonant elements, a side amplifier, and a cathode-follower output. Note that no over-all volume control is included. Resonant frequencies are 45, 80, and 120 cps.

BASS CONTROL

(from page 25)

is used to set the level of the high-frequency response in comparison to the bass. In some respects, this part of the circuit is worthy of special attention in itself, inasmuch as the slope of the high-frequency response curve is not changed, but merely the relative amplitude of all of the highs. This means that it is possible to achieve emphasis of clarity giving middle highs without adding excessive high-frequency noise to the reproduction.

While the unit shown in *Fig.* 5 obtains power from the main amplifier, the system shown in *Fig.* 4 is completely self contained, and is designed for easy insertion between a crystal pickup or a preamplifier and the main power amplifier. The self-contained power supply, shown in *Fig.* 6, furnishes a B+ voltage of about 150, which is adequate for most purposes. This supply can be incorporated into a single chassis, as in *Fig.* 4, and will mount readily in a 3½ × 6 × 2 in. chassis. In a compact, self contained, unit, care should be taken that the two dual triodes are located in the minimum field from the power transformer. This position can usually be located by means of a small pickup coil—such as a magnetic phono cartridge—and a high-gain amplifier, the best procedure being to determine the point of minimum field intensity from the power transformer before any of the components are mounted. This may be done by connecting the primary leads of the transformer and moving the exploring coil about it until the region of minimum field is established.

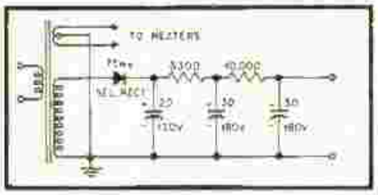

Fig. 6. Power supply incorporated in unit shown

Performance

The frequency of each resonant circuit is determined by the values of the three resistors and capacitors in the feedback loop. Increasing the value of any of these components will lower the resonant frequency, while decreasing the values will raise the point of resonance. Suggested values for specific frequencies are shown on the diagram, but superior performance with a given audio installation may likely be obtained with a different group of frequencies selected to match the resonances of the system.

Bass tone is likewise strongly influenced by the amount of low-frequency distortion present in the signal source or reproducing equipment. In the construction of the three-way bass circuit, the use of different components tend to alter the character of the resonant decay curve due to changed linearity characteristics. For example, the substitution of pentodes for the triodes shown in the schematic may produce significant, though not necessarily undesirable, changes in tone color. Likewise, when using larger values of capacitance in the feedback loops, such as .01 μf or greater, the effect of dielectric hysteresis may alter the resultant sound, but in some cases this may be beneficial.

Aside from the benefits of deeper and more musical bass, the use of the three-element bass control seems almost to add a new dimension to radio broadcasts and the various elements of a station's technical personality seem to stand out more clearly due to the superior reproduction of low-frequency transients. For example a control room microphone that is poorly shock mounted may exhibit an interesting serious of thumps and bumps while the operator is reading news or changing records in the middle of an announcement. Similarly, matters like hum in different audio channels, microphonics, turntable or record rumble, air conditioner noises, and so on, tend to show up more clearly. Of course, if these sounds become too distracting they can easily be eliminated by proper setting of the bass controls, a procedure somewhat easier than getting out the hammer and saw to modify the acoustic resonances of the room or cabinet.

In conclusion, the use of multiple resonance bass circuits should appeal to many listeners who desire fullness in the lower registers. To date, the only detrimental effects that have been noted when using circuits of this nature are found when the electronic resonance is set too closely to one of the mechanical resonances of the system, or when excessive distortion elsewhere has tended to counteract the benefits derived. Particular attention might be paid to the elimination of cabinet or room rattles which may be generated by the fundamental bass tones. Similarly, amplifiers such as the "Ultra-Linear" are recommended.

EVERYMAN'S AMPLIFIER

(from page 40)

Control. We realize, of course, that the loudness control is a much disputed subject at the present time and that there are those who prefer such a control and those who prefer the standard bass and treble controls. Consequently, we provided what we felt was the best compromise—a bass and treble compensated volume control whose compensation is effective mainly at low volume, plus separate bass and treble controls capable of either completely nullifying the effect of the volume control compensation or adding to it for a higher degree of bass and treble boost or cut.

By actual measurement, the volume control adds 2.4 db bass boost at 50 cps, 0.3