can be obtained. In general one rather neglects the treble boost as the falling off of the ear is not so rapid as in the bass. The simple circuit of Fig. 10/13 will afford a degree of bass compensation.

Juggling with the value of C_B will give more or less bass boost, and the value of R_3 relative to C_B will determine the frequency at which boost starts, roughly when $R_3 = xC_B$. The inclusion of the dotted condenser C_T will afford some treble lift if desired. In operation VR_1 is adjusted with VR_2 about halfway, so that comfortable room volume is obtained. Other tone control circuits set the balance, and then as volume is turned down by means of VR_2 extra bass boost is provided.

Compensated attenuators for low level listening are quite difficult to construct. A very useful LF Compensator, made by C. T. Chapman Reproducers Ltd., of Chelsea, S.W.10, is available at a reasonable price. As the general volume level is reduced, the LF attenuation becomes less severe, as indicated in Fig. 10/14.

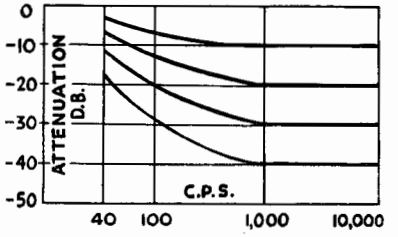

FIG. 10/14.—Response characteristic of Chapman Compensator.

This unit may be installed between the existing volume control of an amplifier and the grid of the next valve, or it could replace the existing control.

NFB LOW LEVEL CONTROL

It is evident from section 3 that NFB circuits could be arranged to provide high and low pass filters to improve realism at low volume levels. Purists will object that the full benefits of NFB are not being obtained at the extremes of the audio range, but as distortion is normally increased by increase of power, the low level case is to some extent self protected. As NFB automatically reduces output from a given voltage input, it is certainly sound economics to use the device for subduing a range of frequencies where necessary. A typical circuit was therefore included at the end of Chapter 7 on NFB.

EXLEY CIRCUIT LOW LEVEL LISTENING

Reference to the design of Dr. Exley will not be out of place here. The basic idea is to increase the impression of bass by deliberate production of harmonics, so that difference tones help to bolster up the funda-

mental frequency. The result, at very low volume levels, gives remarkably good LF response. The writer's impression was that any attempt to obtain more than about half a watt from the 4·5 watt output pentode produced unpleasant effects; but as the system is expressly designed for quiet listening this criticism is rather beside the point.

The reason for this apparent overloading effect is that, whilst the *general* level appears to be about half a watt, there is very considerable power used to drive the loudspeaker at the low frequency harmonics which are deliberately produced. The result is that the output valve may be overloaded at low frequencies before the power level at medium or high frequencies has been increased very much.

It should always be remembered that any attempt to produce heavy bass from, say, an 8-in. speaker on a very small baffle will distress the loudspeaker and generate non-linearity in the cone. Bearing these fundamental principles in mind, the Exley Circuit gives very satisfying results.

In view of the widespread interest which was shown in this rather unorthodox system, we are reproducing Dr. Exley's latest circuit in Fig. 10/15 along with his comments.

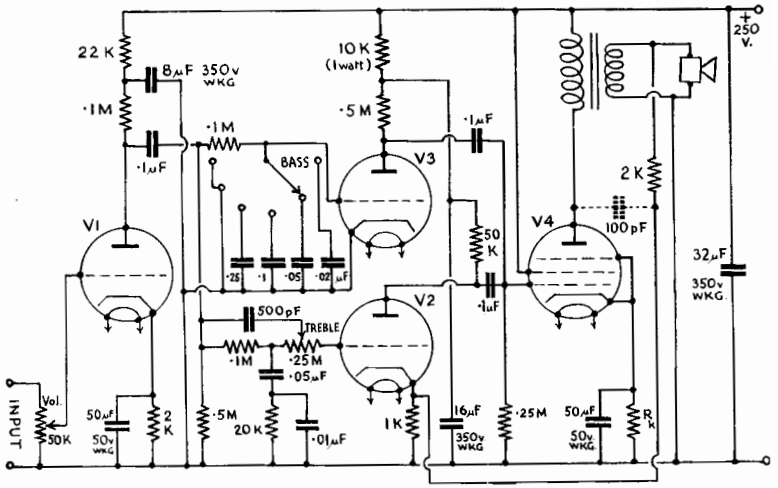

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Fig. 10/15.—Exley circuit.

COMPONENTS

V_1 and V_3, 6F5 *or* H63.
V_2, 6J5 *or* L63.
V_4, 6V6 (R_K=240 ohms, 3 watts).
or EL33 (R_K=180 ohms, 3 watts).

Output transformer; Wharfedale W12 (22 : 1 ratio for 15 ohms speech coil).

Power supply; 250V, 60 mA, heaters, 6·3V.

The condenser shown in dotted lines is optional, but may often help to remove instability (capacity, 0·0001 mfd).

DESIGNER'S REMARKS

The 4-watt negative feedback amplifier shown above (with minor modifications suggested by the designer) was fully described in *Wireless World*, April 1951 issue. It was developed as an approach to the problem of achieving effective bass reproduction in the home without the use of either a large loudspeaker baffle or a high power output.

The lower bass frequencies are converted electrically into their respective harmonics by passage through a variable low-pass filter followed by a non-linear (grid-distorting) stage V_3. The output from this is then mixed with middle and high frequencies which have passed through the linear stage V_2. Since each harmonic is of shorter wavelength than the fundamental, the resultant sound can be radiated more efficiently from a small baffle. The human ear, presented with a combination of harmonics such as these, tends to add the "missing fundamental" subjectively, thus giving a sensation closely simulating the fundamental.

The amplifier is provided with volume, treble and "harmonic bass" controls. The latter should not be turned up too high, otherwise *unpleasant* distortion products may become audible in the final output.

Dr. Exley has very kindly agreed to help experimenters who may have difficulty in obtaining the desired results. His address is 146 Otley Road, Leeds 6. Letters should be brief and to the point and should certainly contain a stamped, addressed envelope for reply!

GENERAL NOTES

It must be admitted that although the use of complex RC networks can produce desired modifications of response, they should be used as little as possible, particularly in feedback circuits, for the following reasons:

(1) Angular phase displacements adversely affect transient response.

(2) Treble boost aggravates harmonic distortion.

(3) Bass boost by reduced feedback, if carried to the point of distortion, loses the cleaning-up effect of the feedback circuit.

(4) Bass boost systems often lead to instability due to phase shift.

It will be generally acknowledged that the best results are obtained when level response can be adhered to throughout the entire system,