SIMPLE TONE CONTROL CIRCUIT

Bass and Treble, Cut and Lift

By E. J. JAMES, B.Sc.

THE tone control system described here has the merit of requiring only resistors and capacitors. As a result it is unusually easy to fit to an existing amplifier, particularly as the absence of an inductance reduces the likelihood of trouble from hum pick-up.

While the circuit does not give the large amounts of lift which can be obtained by more complicated designs or by the use of resonating circuits, it is sufficient for normal requirements. The bass lift is not intended to compensate for the falling record characteristic below 300 c/s. This

Fig. 1. The basic bass lift circuit is shown at (a). The lift is controllable by a variable resistor (b).

should be dealt with separately, so allowing the tone control to give extra lift for records abnormally deficient in bass or for listening at low volume. If required, however, a fair measure of compensation can be obtained.

It is not always realized that large amounts of bass lift cannot be achieved in a simple single-stage non-resonating circuit without lifting the lower middle register as well. The maximum rate of lift is fixed and it is only by starting at a higher frequency that greater lifts can be obtained. The amount of top lift which can be satisfactorily used is limited by amplitude distortion. Since this

distortion consists of the introduction of frequencies 2, 3, 4, etc., times the fundamental frequency, a rising frequency characteristic emphasizes any which is present in the signal prior to the tone-control stage. The higher order harmonics, which are the most disturbing to the ear, are the ones which receive the greatest amplification. This limit to the useful degree of top lift applies to all forms of top lift circuit, and is inherent.

The basic bass-lift circuit is shown in Fig. 1(a). The capacitor C_1, has a reactance which increases as the frequency decreases, so that the output increases at lower frequencies. By shunting it with a variable resistor, Fig. 1(b), the degree of bass lift can be controlled. In the same way Fig. 2(a) shows the circuit for bass cut, and in Fig. 2(b) a variable resistor controls the amount of bass cut.

The two circuits of Figs. 1(b) and 2(b) can now be combined to give that of Fig. 3, where bass lift
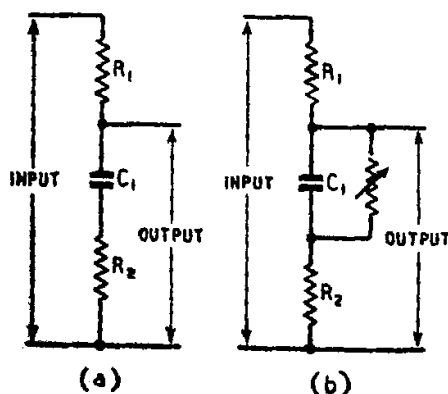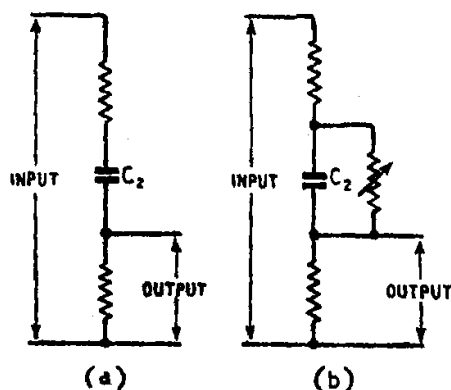
Fig. 2. Bass cut can be obtained with this circuit (a) and is controllable by a variable resistor (b).

and cut are controlled by the potentiometer R_3.

Fig. 4(a) shows a circuit giving top lift. Here the reactance of the capacitor C_3 decreases as frequency increases, so that the output rises with frequency. In this case a variable resistor in
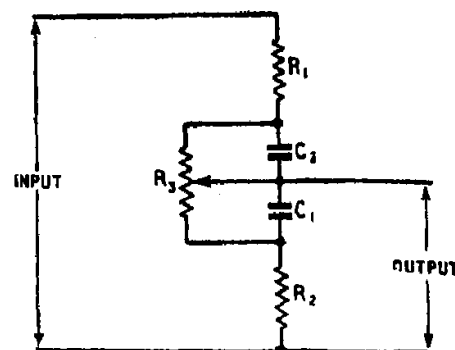
Fig. 3. This diagram shows the bass cut and lift circuits combined and controlled by the potentiometer R_3.

series with C_3, as shown in Fig. 4(b) gives control of top lift.

Similarly Figs. 5(a) and 5(b) show top cut and controlled top cut respectively. Once more the two circuits can be combined, Fig. 6, to give control of top lift and top cut by means of the potentiometer R_4.

The treble and bass controls can now be combined into the circuit shown in Fig. 7, and will normally be used as part of the coupling between two valves. For signal current the resistance, $R_1 + R_2$, is in parallel with the anode load resistance of the previous valve. R_1 and R_2 should therefore be as high as possible so that the valve does not work into too low a load. The minimum load should be about twice the valve impedance. On the other hand they must not be too high or the valve output capacitance and stray capacitances will affect response at high frequencies.
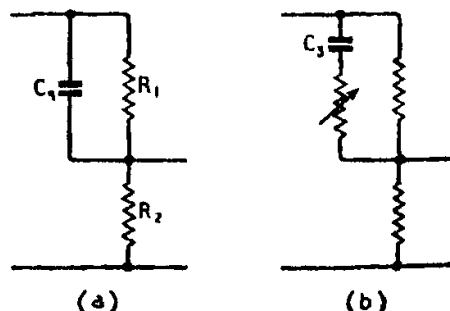
A simple method of finding

Fig. 4. Top lift is given by this basic arrangement (a) and can be varied by a series resistor (b).

suitable values is to use an anode resistor of at least 4–5 times the valve impedance and to make the sum of R_1 and R_2 rather larger than this. A ratio for R_1/R_2 of 10/1 is suitable for normal tone control requirements. For a medium resistance triode of 7,000–10,000 ohms impedance, an anode resistor of 56,000 ohms could be used with R_1 and R_2 100,000 and 10,000 ohms respectively. The total anode load will then be about 35,000 ohms. This will vary, of course, as the controls are used to give lift or cut, but the only time any appreciable drop will occur in anode load will be at high frequencies when maximum top lift is used.

This type of tone control circuit should always be placed as far forward in the amplifier as possible so that the input to the valve preceding the control is low. There is then little chance of distortion being introduced by
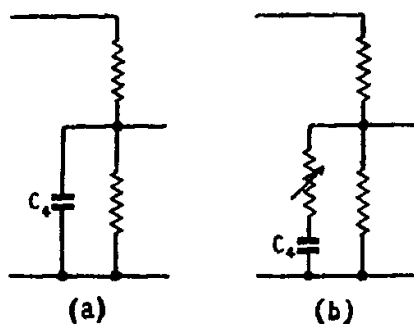

Fig. 5. Top cut is obtained from circuit (a) and controlled by a variable resistor as in (b).

the valve on account of the possible low load resistance. A smaller bias voltage than that normally employed will help to reduce distortion to a minimum. If the input to the valve is x volts, the optimum bias is $(1 + x)$ volts since this is the least bias which will safeguard us from grid current. Thus, a bias of 1.3 volts is required if the input is 0.3 volts. The value of the cathode resistor required for this bias is best determined by trial and error, using a high-resistance voltmeter for measuring bias voltage, or measuring the anode current I, and calculating the bias voltage from IR, where R is the cathode resistance. A 1,000-ohm wire-wound potentiometer of the preset type is easily and cheaply obtainable these days and

would be a very suitable cathode resistor. The resistance in circuit can be estimated with sufficient accuracy from the degree of rotation.

A complete circuit suitable for feeding from a medium impedance triode such as the MHL4 is shown in Fig. 8. The values given provide a satisfactory degree of control. On test a similar circuit gave the following results :—

Bass control :— + 10 db to — 12 db at 50 c/s. Treble control :— + 10 db to — 16 db at 6,000 c/s.

If it is felt that more or less change would be an advantage, it is easy to alter the characteristics of the circuit by using different capacitor values. In-
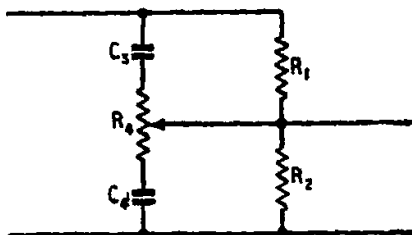

Fig. 6. Here the top cut and lift circuits are combined and controlled by R_4.

creasing the values of C_3 and C_4, Fig. 7, will increase the amounts of top lift and top cut respectively, while a decrease in their values will reduce the amounts of control. Bass lift and bass cut can be increased by decreasing the values of C_1 and C_2, and vice-versa. For example, if a greater bass lift is required, so that it can be used as compensation for the falling bass characteristic of gramophone records, the value of C_1 should be reduced from $0.02\,\mu F$ to $0.01\,\mu F$. The great ease with which the circuit characteristics can be altered in this way is one of the outstanding merits of the design.

The variable cathode resistor need only be used if it is required to introduce the very minimum of distortion, such as before one of the modern low-distortion amplifiers.

There is little point in reducing the distortion of the main amplifier to less than 0.1% and then introducing anything up to 0.5% or possibly more in a previous stage. In fact, some tone control stages using normal bias for the valve can introduce from 3% to 5% harmonic distortion. Where the variable re-
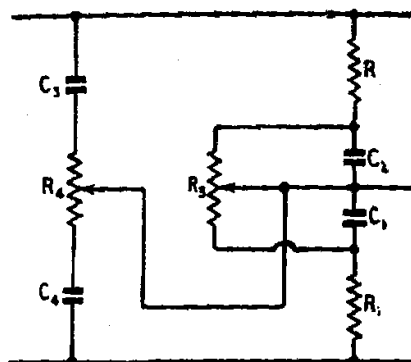

Fig. 7. The combination of the bass and top circuits is shown here.

sistor is not used a bias resistor of $100\,\Omega$–$1,000\,\Omega$ is suitable. In either case care should be taken to see that anode current does not exceed the manufacturer's stated maximum.

The amplification of the valve before the tone control circuit is reduced by the ratio $\dfrac{R_2}{R_1 + R_2}$ so that little gain is obtained from the valve. This generally means that another valve must be added to an amplifier unless there is some reserve gain. If there is no room on an existing chassis for another valve, or if a compact lay-out is required, one of the double triodes such as the 6SN7 or ECC32 can take the place of one of the present valves and the
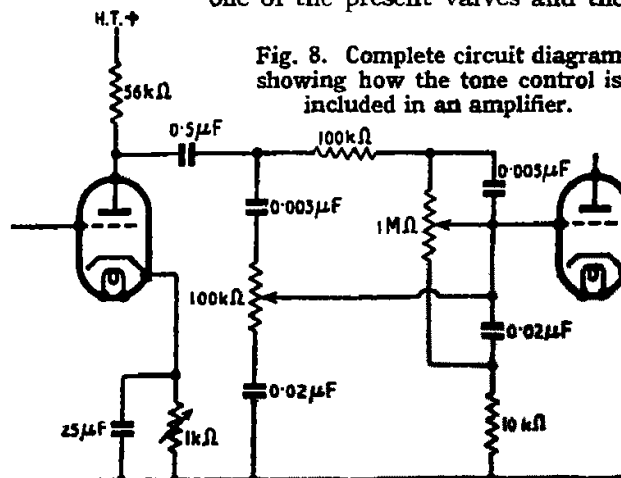

Fig. 8. Complete circuit diagram showing how the tone control is included in an amplifier.

Simple Tone Control Circuit—
tone control circuit used as the coupling between the two halves of the double triode. Where 6-volt heaters are used this provides an easy method of introducing the tone control with the minimum of interference with the rest of the amplifier. If 4-volt heaters are used and there is a spare 4-volt winding on the mains

transformer, it is possible to obtain a 6-volt supply by connecting half the spare winding, giving 2 volts, in series with a 4-volt winding already in use. The two must be connected so as to give 6 volts and not 2 volts, as will be the case if the extra half-secondary is connected so as to oppose the 4-volt secondary. The right connection is most easily found by

trial, using the glow of the valve heater as an indicator. There is no difficulty whatsoever in determining by this means the correct coupling between the two secondaries.

If a double triode is used in place of a normal medium impedance triode it will generally be found that gain is about double that of the original.

From the Correspondence section,
Wireless World, April 1949, pp. 156-7.

" *Simple Tone Control Circuit* "

I SHOULD like to draw your attention to the fact that a tone-control circuit exactly similar to that described by E. J. James in your February issue, except for the slight differences in values of elements, was designed by our engineer Michael Volkoff as early as July, 1939, when the first amplifier embodying this circuit was built. We have used this circuit ever since then, and there are now over one thousand amplifiers in Belgium with this tone control built in.

<div align="center">WILLY L'HOEST,
Rocke International, Ltd.
Brussels.</div>