coupling. In any case, negative feedback is essential, unless the output stage is to consist of a pair of push-pull triodes, a technique almost unthinkable today.

D.C. Coupling. Reference to Fig. 55 will show the essential elements of the two-valve amplifier, which is in fact based on the Mullard 'Twin Three-Three' which has no coupling components between the anode of the first stage and the grid of the output valve; in the absence of any a.c. coupling there cannot be any coupling distortion.

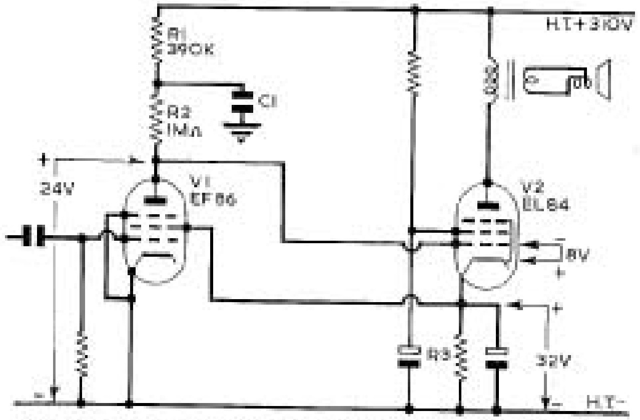

Fig. 55.—A circuit diagram illustrating the principle of d.c. coupling, which obviates any form of coupling distortion.

At first sight it may appear that the h.t. voltage associated with the first stage appears on the grid of the output valve, and whilst this is true, it will be seen that the grid is nevertheless negative in respect to its cathode. It will be desirable to run over the circuit and follow the general voltage distribution.

V_1 is run under what is commonly known as starvation conditions; due to the high value of the decoupling resistor R_1 and the anode resistor R_2, the anode voltage is only 24 V and the anode current of the order of 190 μA. The Mullard EF 86 under these conditions will produce a very high gain, a point which is referred to later. Incidentally, this particular valve is of special low noise construction and also has a screened heater to reduce hum to very small proportions.

Turning now to the output valve V_2, the resistance of the cathode resistor R_3 is 560 Ω which is much higher than would normally be used for this valve, and develops a potential drop across it of 32 volts. Consequently the cathode is 32 volts above chassis, but the grid, which is directly tied to the anode of V_1, is only 24 volts above chassis. It follows, therefore, that the cathode is eight volts more positive than the grid, or expressed more conveniently the other way round, the grid is eight volts negative in respect to the cathode, so it functions normally even though its grid is in direct metallic connection with the anode of the previous valve.

Further reference to Fig. 55 will show that the cathode of V_2 is connected to the screen of V_1 (the normal decoupling resistor is omitted to emphasise the principles involved) an arrangement which provides V_1 with a stabilised screen voltage of about 32 volts. The voltages which appear at various relevant points of the circuit are shown; they were taken when the amplifier was not actually operating and measured

by means of a voltmeter, having a resistance of 20 MΩ on the 1,000 volt range and 2 MΩ on the 100-volt range.

In the circuit under review, a resistor is usually added between the anode of V_1 and the grid of V_2, purely for stability reasons, but has been omitted in the diagram because it is not relevant to the basic principle of d.c. coupling. In the circuit from which this detail was taken, the actual value of the resistor used in this position was 22,000 Ω. The original circuit also uses negative feedback from one side of the output transformer secondary to the cathode of V_1, a resistor being placed between the cathode and chassis for the negative feedback voltage thus derived to develop across, the value being 150 Ω when the usual 3 Ω speaker is used. It is omitted from the diagram because it might appear to be some sort of bias resistor, but since the anode current is only 190 μA and the value of the resistor only 150 Ω the actual bias voltage developed is little more than one-hundredth of a volt (·0125 V). This amplifier will produce an output of 3 W for an input of 100 mV, although the negative feedback is considerable, about 20 dB. Total harmonic distortion does not exceed 1% and the frequency response is essentially flat from 35 c/s to 30,000 c/s. It is a typical example of really solid circuit design, offering as it does remarkable sensitivity for two valves coupled with low distortion, and remarkable frequency characteristics. The hum level incidentally is very low, being 67 dB below 3 W, although the smoothing to V_2 consists only of a 50 μF capacitor. Smoothing to V_1, however, is aided by the decoupling components R_1 C_1.

STEREO REPRODUCTION

In an attempt to introduce more realism into the reproduction of sound, many efforts have been made to imitate the function of the two human ears. As is well known, the human ears give a sense of position to sounds which they hear, i.e. giving preference to sound emanating from a source to the left or right of the hearer. Accordingly two-channel (or stereo, or bi-aural) recording was tried in an attempt to record sounds directionally as the ears would hear them. Two microphones were used, placed each side of a dividing baffle in imitation of the positioning of the human ears, each microphone with its associated recording amplifier, the resulting recording to be played back through separate left- and right-hand channels with the loudspeakers positioned in the same sense as the recording microphones (see Figs. 56 and 57).

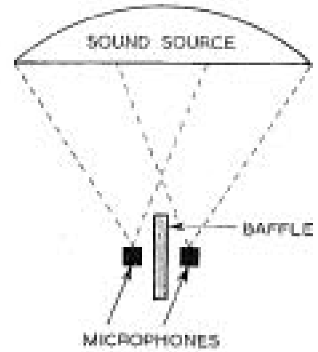

Fig. 56.—A diagram showing the arrangement of microphones to simulate the biaural properties of human hearing.

This undoubtedly gives a positioning or spatial effect, especially to subjects containing movement. A passing train, table tennis, marching feet—all these have been exploited—and even in orchestral recordings the sound of the strings from one side and