

## FULL-RANGE ELECTROSTATIC SPEAKER

(from page 20)

enclosure. Do not place it too near to a wall (no closer than four inches). The sound emanating from it is best when the membrane can move freely.

### The Amplifier

The schematic is given in Fig. 12. It should be noted that other amplifiers might also do under certain conditions, but the main advantage of this one is that it provides sufficient audio voltage without the use of a step-up transformer. The author has found it impossible to design a step-up transformer capable of producing 2000-volts audio peak voltage over the entire audible frequency band without considerable phase and harmonic distortion, as well as poor transient response. The audio voltage is first amplified by  $V_{1A}$ . One-tenth volt is enough to drive it to full output. The negative feedback loop  $P_1-C_1$  serves to boost the output voltage below 130 cps. This loop is necessary only with a speaker length of under two yards. The signal is then split up in the phase inverter,  $V_{1B}$ , and fed through the driver,  $V_{2A,B}$ , into the grids of the final. So far, it is rather conventional. The signal then goes directly into the speakers. The feedback loop actually consists of the voltage dividers,  $R_1$  and  $R_2$ , fed through  $C_7$  back into the cathode of the driver, and  $R_{11}$ ,  $R_{22}$  and  $C_8$ , respectively. Resistors  $R_1$  and  $R_{11}$  each consist of five 50,000-ohm 2-watt units. The author has mounted the entire feedback network  $R_1$ ,  $R_2$ ,  $R_{11}$ ,  $R_{22}$ ,  $C_7$ , and  $C_8$  on one terminal board, above the chassis. The resistors near the plates of the finals do handle very high voltages. Keep them far from the input wiring, and especially far from your fingers!!! The negative feedback is about 26 db. The choke,  $Ch_1$ , only serves to supply the finals with d.c., as they operate in pure A1 amplification. It needs only high reactance at low frequencies (200 Hz will give enough). Of course, the insulation must withstand up to 2400 volts peak-to-ground for each half of the winding. For best symmetry it should be wound on two discs. The iron core need not be of highest quality, because, as we mentioned before, the amplifier works class A1, and thus every output tube provides its full half of the cycle.

Some notes on the power amplifier tubes. They are in reality nearly voltage amplifiers, because the electrostatic speakers have such a high efficiency that you need mainly voltage to drive them. For this reason the tubes work with 1200 volts on the plates. New sets of operating conditions had to be designed for the purpose. At the suggested plate voltage (the screens are at 150 volts, regulated), a negative bias of 17 volts is required to measure 20 mA at the cathodes of each 807. As the applied plate voltage

varies with different power transformers and rectifiers, it is wise to adjust  $R_3$  and  $R_{33}$  at the cathodes to the right value while measuring the cathode current with a milliammeter. Both tubes should draw the same current. The 807, now sometimes called QE 06/50, should be of newer production, because war-surplus types may contain too much gas for such high plate voltage. Newer types work correctly even at more than 2000 volts. In any case the product of plate voltage and cathode current should not exceed 24 watts. The amplifier is designed to feed the impedance of one to three yards of speaker length. It is clear enough that proper phasing between the speaker elements is of importance here, too.

### Power Supply

The power transformer secondary may range from 1000 to 1400 volts (for example 500-0-500). Although the amplifier only draws 60 mA altogether, the winding must permit a current of at least double that amount, because in this circuit it must provide all the required power in only one half of the cycle. A full-wave doubler could be used with success, but then one would need a voltage source of about 1200 volts a.c. to feed the voltage doublers,  $D_7$  and  $D_8$ ,

which provide the necessary high negative bias to the membrane. The one-megohm bias resistor should be placed close to the membrane of the individual speaker. Diodes  $D_1$  through  $D_6$  first load up the three electrolytic capacitors in series. This is less expensive than oil-filled capacitors, and smaller, too. The three resistors in parallel to them help to divide the plate voltage equally between them. From here we also take the plate voltage for the preamplifier tubes, through  $R_4$ . As soon as the voltage across the loading capacitors exceeds 450 volts, the three voltage regulator tubes, VR 150/30, ignite, and provide the screens of the 807's with the necessary 150 volts, and through the RC ripple filter, the entire preamplifier. If you use other than 1200 volts on the plate of the 807, you should calculate a new value for  $R_4$ , in order to keep the current through the VR-tubes near 20 mA.

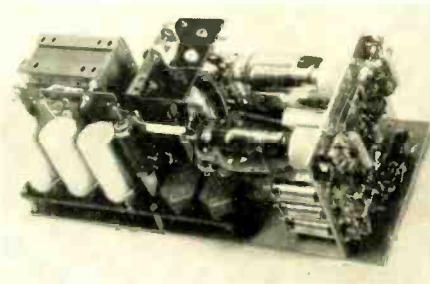


Fig. 13. View of the complete amplifier.

"Wanna  
hear my  
Stereo recording  
of Handel's  
'Water Music'?"

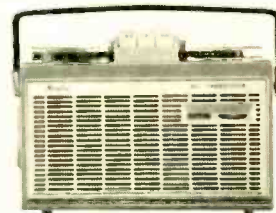


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