Research Department. REPORT NO. L.011. 18th November, 1938

Serial No. 1938/29

Job No. 8.009.-

Work Carried out by: Drawing No. L.011.1

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The Technical Design of O.B. Loudspeaker Amplifier and Baffle

SUMMARY

This report describes the circuit design of the O.B. Loudspeaker Amplifier and the work leading to the first model loudspeaker baffle. The Amplifier delivers a power of $1\frac{1}{2}$ watts and forms a part of the folding type baffle, the whole assembly when closed being of convenient size for handling.

REPORT ON O.B. L.S.M.

Use of AC/SP3 Valve

As a result of extensive tests on the AC/SP3, which are summarised in Report H.008, it was found that this valve could deliver up to 800 mw. with 5% distortion. Two valves in push-pull will therefore give 1.5 watts, and with sufficient negative feedback the harmonic can be reduced to less than 2%. When a large amount of feedback is employed it is no longer beneficial to design for the output load which gives minimum second harmonic, but it is better to design for maximum power output and leave the feedback to reduce the harmonic content. Tests on these lines showed that the output could be increased to 2 watts with favourable loading and with 2% harmonic content.

Paraphase Push-Pull Circuit

In order to avoid the 6 db. loss entailed by centre-tapping the input transformer to feed the push-pull stage, a paraphasing circuit was developed which feeds one valve from the output of the other. In addition this circuit, which has been provisionally patented, is self-compensating and any necessity for matched valves or preset adjustments is avoided.

The outputs of the two valves are arranged in push-pull in the conventional manner, but an impedance is included in the common anode supply. The signal potentials developed across this resistance are fed up to the grid of the second valve while the grid of the first is fed with signal in the normal manner. The operation of the circuit is then as follows.

Signal on the grid of valve 1 causes anode current to flow which passes through the common impedance mentioned and tends to produce large signal potentials across it. These potentials are, however, fed to the grid of valve 2 in such a phase that the anode current which therefore flows tends to cancel the effect of the current from valve 1. This cancellation is not complete, but is just sufficient to maintain a potential across the common impedance nearly equal to the input potential to the grid of valve 1. The higher the common impedance, the more nearly are the anode currents in the two valves equal; if the conductance of this impedance is, say, one tenth of the mutual conductance of either valve, the discrepancy between the currents in the two valves will be 10% which is negligible.

Effect on Harmonics

If the two valves have similar characteristics it can be shown that the harmonics are increased in the ratio $\frac{2 - k^2}{2 - k}$ by this circuit compared with those created by one valve alone, where k is the ratio of out-of-balance signal current to signal current in one valve. Thus when k is 10% the harmonics are increased by 1.05/1, a negligible amount.

Optimum Load

The optimum load for maximum output from a single AC/SP3 with E_a = 250v. i_a = 12 ma. is about 20,000Ω. Hence for a push-pull output circuit the output transformer must convert the secondary load to 20,000 + 20,000Ω. The impedance of the loudspeaker is variable with frequency, and it was decided that the optimum load conditions should occur somewhere in the middle of the frequency range, though this optimum loading is not critical. A frequency where the impedance of the speaker, nominally 2Ω, had risen to 3Ω was arbitrarily chosen; hence the overall output transformer impedance ratio is approximately 3/40,000. The secondary of the output transformer is wound in two sections which when connected in parallel are suitable for a loudspeaker of 2Ω nominal impedance. With series connection a 10Ω speaker may be used.

Feedback

An output of 1.5 watts is obtained from two AC/SP3's arranged as above without feedback, but the harmonic content is of the order of

5%. The gain, however, is considerably higher than is required, since 22 db. is obtained from the input transformer, and 3 db. from grid to secondary of the output transformer. Negative feedback may be employed, therefore, to great advantage to reduce the gain, to reduce the harmonic content, and to lower the output impedance of the amplifier. This renders the variable impedance characteristic of the loudspeaker innocuous and provides damping for the coil.

The feedback voltage is taken from a monitor winding on the output transformer and it is fed in series with the input transformer to the grid of the 1st valve. The sensitivity of the amplifier is reduced by about 4/1 by this means, and the voltage gain from grid to output with the feedback is -9db. This plus the gain of the input transformer (22db) gives an overall gain of 13 db.

Input Circuit

The monitor circuit in the O.B. amplifier demands that the input impedance of the amplifier shall be 2,000Ω within close limits. The input transformer voltage gain is 22 db., the impedance ratio being 2,000/300,000. Volume control must precede the feedback circuit and is therefore placed directly across the secondary of the input transformer. The peak input level is -6 db. with the volume control at maximum.

Hum and Smoothing

Owing to the high anode impedance of the pentode large ripple volts may exist on the anode before any appreciable anode current will flow, and therefore before hum will appear in the loudspeaker. Further, in a push-pull circuit any anode current which does flow from this cause cancels out in the two halves of the transformer. Very little smoothing indeed is therefore required for the anode circuit. The feedback circuit further reduces the residual hum.

In order to avoid applying the H.T. ripple volts on the grid of the 2nd valve, the common impedance mentioned earlier in this report is connected in the negative H.T. return lead to the cathodes and consists of 1,000Ω resistance together with the cathode bias resistance of 70Ω. Each screen is decoupled by 20,000Ω and 8μF, which must be returned to cathode so that the screen signal current does not flow through the common cathode impedance.

The hum current flowing from H.T. + through these 20,000Ω screen resistances, the 8μFs to cathode and the 1,070Ω back to H.T.- develops a potential across this 1,070Ω which therefore appears between grid and cathode of valve 2. This is the most serious source of hum in the amplifier, but with the values of components mentioned adequate H.T. smoothing is obtained with 8μF reservoir condenser, 1,000Ω and 32 μF in the H.T. supply circuit, without the use of a choke.

Operating conditions for AC/SP3 Valve

The H.T. rectifier delivers 32 ma. at 300 volts, which is the total cathode current for the AC/SP3 valves. 66 volts are lost in the smoothing, paraphasing and bias resistances, leaving approximately 230 volts between anode and cathode allowing for the drop in the output transformer. The bias voltage is -2.25 volts, and screen voltage 150 volts approximately. For economy in components, bias is obtained from a resistance common to both valves. Therefore although the total current will be maintained approximately constant, variations in the anode currents of the two valves are to be expected. The separate feeds to the screens tend to reduce those variations which, however, do not affect the performance of the amplifier. They should not exceed ± 30% in each valve, which covers the makers' tolerances, in order that the valve taking the higher current shall not be over-run. Metering is therefore included for the total anode current, which should be 24 ma ± 15%. and for the individual anode currents which should lie between the limits of 9 and 15 ma.

Performance

The frequency characteristic is within ± 1.5 db. from 30 cycles/sec. to 10,000 cycles/sec. with a speaker whose impedance varies over a range of 20 db.

Maximum output = 1.5 watts

Maximum individual harmonic component = 2%

Maximum peak input level
(volume control maximum) = -6 db.

Overall gain (with feedback) = 13 db.

Input impedance = 2,000Ω ± 5%

Output impedance = 0.6Ω

Optimum load = 3.0Ω

Input from mains = 35 watts approx.

With secondary sections of output transformer connected in series

Overall gain = 19 db.

Optimum load = 12 ohms.

Output impedance = 2.5Ω

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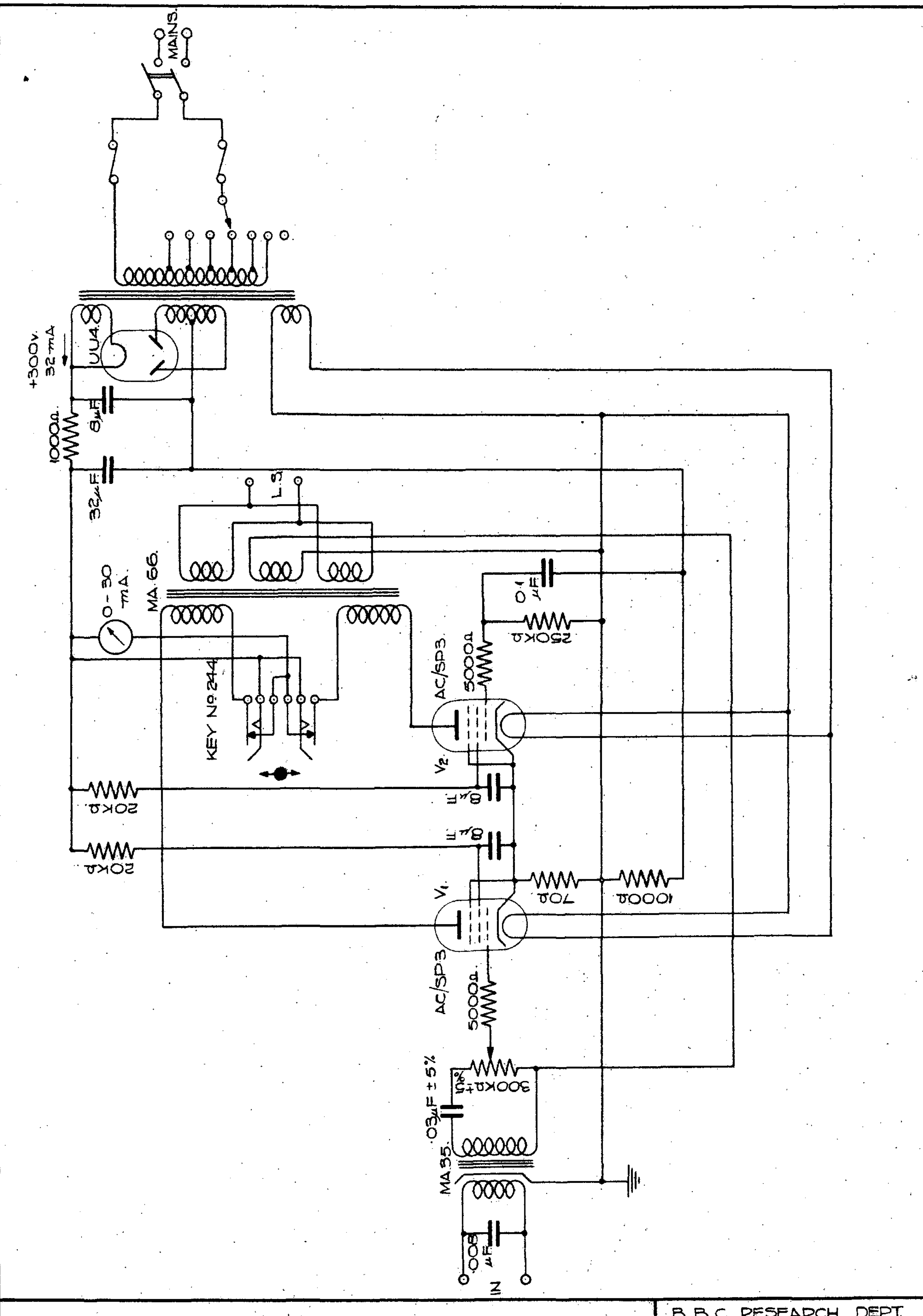

O. B. EQUIPMENT.
L. S. AMPLIFIER.

B. B. C. RESEARCH DEPT.	
DRN.	REPORT.
APPD.	L.011.1.