Thorn-AEI Applications Laboratory

I N V E S T I G A T I O N   R E P O R T   NO. L.96

BRIMAR VA12 20 WATT HI-FI AMPLIFIER
USING 4 VALVES INCLUDING TWO EL506

S U M M A R Y

This report gives the design and performance of the Brimar VA12 high sensitivity, high fidelity, 20 watt, audio power amplifier circuit. The output stage uses two Brimar EL506 pentodes in the class AB_1 push-pull ultra linear mode.

The amplifier may be driven from a suitable pre-amplifier such as the Brimar VP10 (described in Investigation Report No. L.90).

The valve and rectifier complement is as follows:

2 - EL506 pentode output power valves,
1 - ECC83 double triode amplifier driver and phase splitter,
1 - ECC807 double triode high voltage gain input valve, and
4 - BY105 forming a silicon H.T. rectifier bridge.

P E R F O R M A N C E

Power Output and Distortion: 20 watts at 1 kc/s with total hormonic distortion of less than 0.1%.

Sensitivity: 130mV for 20 watts output.

Bandwidth: Flat to 0.1dB between 30 c/s and 20 kc/s at 20 watts.

Feedback: 36dB overall feedback.

Hum and Noise: 80dB below 20 watts with input short circuited.

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CIRCUIT DESCRIPTION

For the first two stages of the amplifier a high gain, low noise valve type ECC807 is used (Ref. V_{1a} and V_{1b} circuit diagram page 5). The total voltage gain of a double triode ECC807, connected in cascade, is approximately 4900 times. Used as the input stages of the VA12 Amplifier, however, a total gain of only 380 times was required. Consequently R_5 and R_6 form an attenuator for the first stage and R_{10} and R_{16} an attenuator for the second stage.

It can be seen from the circuit diagram that the first three stages of the amplifier are d.c. coupled. This improves the low frequency stability when negative feedback is applied by minimising low frequency phase shift in the amplifier.

A silicon voltage regulator diode LR91 is used in the cathode circuit of V_{1a} in order to give a stabilised d.c. reference to the amplifier. This is necessary for the amplifier which, apart from being d.c. coupled over the first three stages also employs d.c. feedback from the anode of V_{2a} to the grid of V_{1a}. Any drift or changes in H.T. voltage is, therefore, compensated for by the use of the voltage reference diode.

V_{1a}, V_{1b} and V_{2a} form part of a negative feedback loop with R_7, R_{12}, R_{13} and C_8. This only becomes operative at frequencies below 100c/s, which compensates for the lack of low frequency feedback, due to the limitations of the output transformer, which forms part of the overall feedback loop (Ref. C_{15} R_{27} circuit diagram, page 5). The negative feedback loop formed by R_7, R_{12} and R_{13} also controls the overall d.c. gain. C_8 causes the amount of negative feedback to be reduced as the signal frequency is raised.

To prevent high frequency instability within the amplifier a CR network (Ref. C_3, R_2 circuit diagram, page 5) is connected in parallel with R_3 the anode load of V_{1a}, giving an advance in phase.

Miller effect in V_{1b} and V_{2a} increases the attenuation and phase shift of the coupling circuits at high frequencies. These effects are reduced by the use of C_5 and C_7 which, thereby, further improves the high frequency stability of the amplifier.

The third stage, the driver and phase splitter of the amplifier uses the ECC83 double triode (Ref. V_{2a} and V_{2b} circuit diagram, page 5). To ensure sufficiently equal drive to the EL506 grids, the resistors R_{18}, R_{19} and R_{20}, R_{21} should be matched to within 5%.

At the junction of R_{11} and R_{14} the voltage is arranged to be the same as that of the grid of V_{2a}. This voltage is applied to the grid of V_{2b}, decoupled to audio by C_{12}. The arrangement so made, provides a measure of d.c. compensation for any change of components etc. occuring in the circuitry of V_{2b}.

The gain of the ECC83 in the cathode coupled form of phase splitter used is about 26 times. This is sufficient to provide a drive of 15V r.m.s. (distortion 0.3%) to each grid of the output stage, needed, for a total output power of 20 watts.

For the output stage two valves, type EL506, are connected in a push-pull, Class AB_1, ultra linear mode. The anode-to-anode loading of the output stage is 6.6kΩ with an H.T. voltage of 438V at the centre-tap of the primary winding of the output transformer (Gardners type AS7034). Primary taps at 43% feed the screen grids. Anode and screen grid dissipations are 17 and 2.2 watts respectively.

Direct current, out-of-balance in the primary winding of the output transformer, is limited by the use of separate cathode-biassing resistors R_{26} and R_{25} for the two EL506 valves.

Negative feedback is taken from the secondary winding of the output transformer to V_{1a} cathode circuit. With 36dB of feedback applied, as in circuit diagram page 5 , the amplifier is completely stable.

The H.T. supply is provided by a winding on a Gardners mains transformer type BS6040 and four BY105 silicon H.T. rectifiers connected in a bridge.

The bridge rectifier is connected across the mains transformer 0-320V secondary winding and is capable of supplying 150mA d.c. 108mA is drawn by the amplifier, leaving a further 42mA available for a pre-amplifier and f.m. tuner.

For such auxiliary equipment additional decoupling will be necessary since, in order not to alter the H.T. voltage for the amplifier input stage, the auxiliary supply must be connected to the reservoir condenser as shown on circuit diagram page 5. The mains transformer also contains two additional heater windings for use with auxiliary equipment.

NOTE: Due to the use of silicon rectifiers it is possible for 521 volts H.T. to appear immediately on switch-on, and remain until the valves draw current. This no load voltage can reach this value due to

(a) High mains voltage.

(b) High secondary voltage. The rated secondary voltage, having allowed for a voltage drop in the winding, being for the loaded condition.

(c) Two heater windings of the transformer not being used.

It is important, therefore, that capacitors across which the H.T. voltage appears should have suitable surge voltage ratings.

CONSTRUCTION

A suggested layout is shown on page 4.

The chassis is made from 16s.w.g. aluminium sheet. Important points to note when constructing the amplifier are as follows:-

1. The ECC807 input valve must be mounted as far as possible from the mains transformer in order to minimise hum pick-up.

2. The amplifier has only one earth point, this being in the input stage.

3. Valve heaters are connected in parallel, with the ECC807 input valve being connected directly to the transformer heater winding.

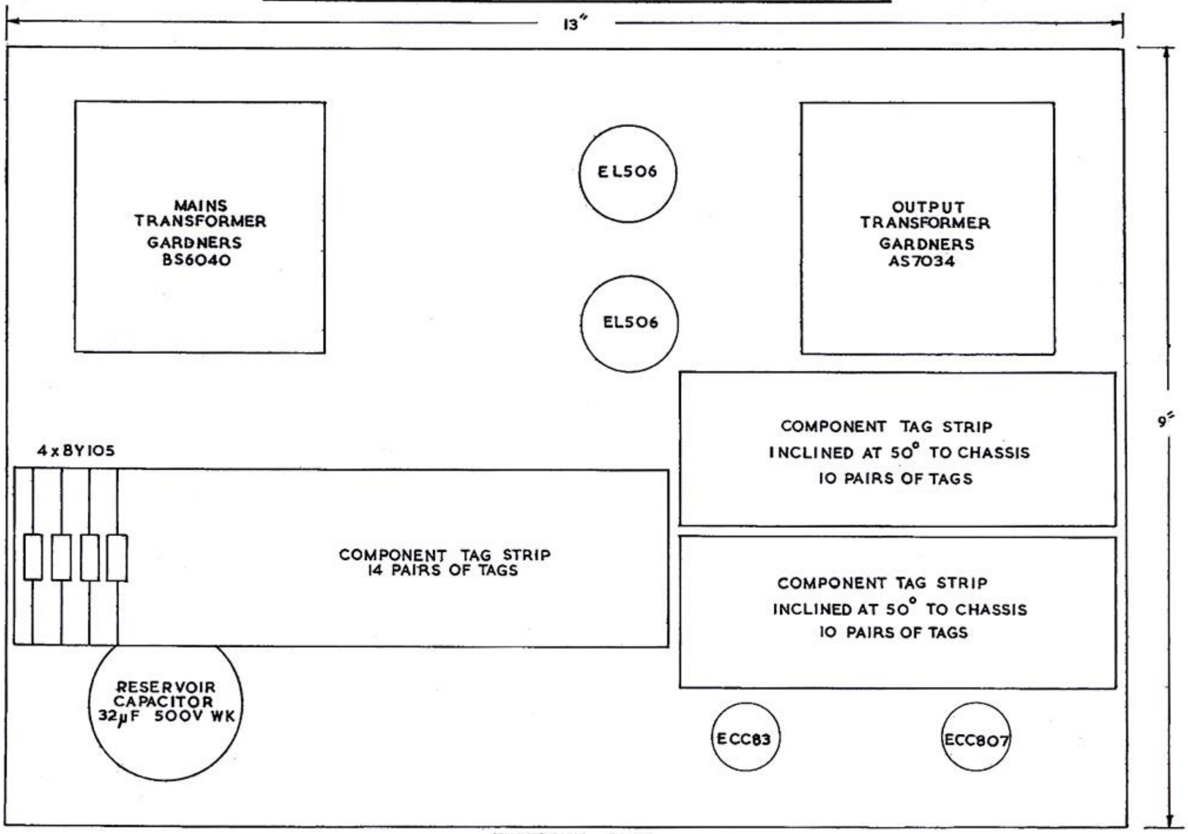
4. High-stability, cracked carbon resistors are used in the input stage as they give an improved level of noise compared with standard carbon resistors. They are also used as feedback components and at points throughout the amplifier where high stability is essential.

NOTE: All resistors and capacitors are either mounted on the tag strip shown in the suggested layout (Page 4) or between the tag strip and the valve holders.

GUITAR AMPLIFIER

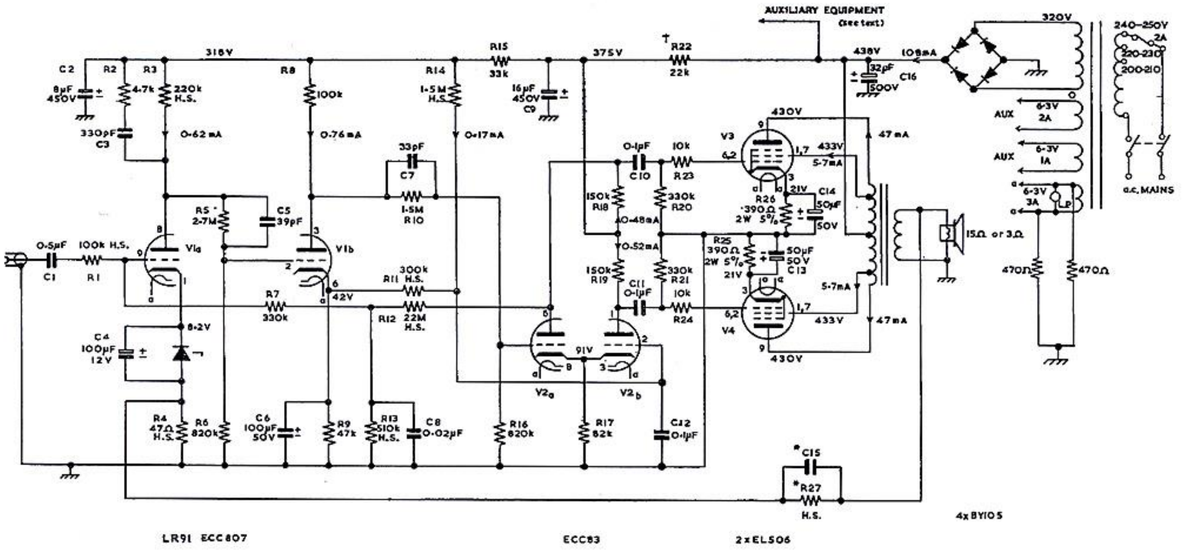
The circuit is suitable as a 30 watt guitar amplifier when the input signal is 220mV. For increase in sensitivity the feedback components (C_{15} and R_{27}) may be disconnected from the loudspeaker. The sensitivity will then be 7mV for 30 watts output.

SUGGESTED LAYOUT OF VA12 POWER AMPLIFIER



UNDERSIDE PLAN

VA12 POWER AMPLIFIER



MAINS TRANSFORMER: GARDNERS TYPE BS6040
SECONDARY RATING 20—0—20—260—320—380V; 210mA

OUTPUT TRANSFORMER: DETAILS OVERLEAF

ALL RESISTORS ±10%
UNLESS OTHERWISE STATED
H.S. HIGH STABILITY
CAPACITOR VOLTAGES ARE PEAK-WORKING VALUES
* C15=270pF; R27=8·2k ±5% FOR 15Ω SPEAKER.
C15=560pF; R27=3·9k ±5% FOR 3Ω SPEAKER
† IF AUXILIARY EQUIPMENT IS USED R22 SHOULD BE ADJUSTED TO MAINTAIN 375V ACROSS C9

OUTPUT TRANSFORMER
USED IN VA12 POWER AMPLIFIER CIRCUIT
(see Page 5)

TYPE	ULTRA LINEAR PUSH-PULL
MANUFACTURER & NUMBER	GARDNERS AS7034
RATING	30 W
PRIMARY LOAD	6.6kΩ ANODE TO ANODE
PRIMARY SCREEN GRID TAPS	43% OF 6.6kΩ
PRIMARY INDUCTANCE	200 H
PRIMARY/SECONDARY LEAKAGE INDUCTANCE	20 mH