High Fidelity Performance with Mullard's 520 Circuit

Over-all view of power amplifier. The three fuses are mounted on the left flange while the "on-off" switch appears on the right flange. The large housing (which is vented at top and bottom) directly behind the tubes covers the output and power transformers and filter choke. The other components are mounted below the chassis.

The original British-designed power amplifier was conservatively rated at 20 watts. Actual tests showed an output of 36 watts with .2% harmonic distortion. Maximum output is with .3 volt input.

By **E. J. PORTO***

CONSIDERABLE international attention has been focused on a new audio output pentode, the EL34, recently introduced in England by *Mullard Ltd.*, in view of the many American power amplifier designs based around this new tube. The circuit described in this article is basically an "Ultra-Linear" design that was originally worked up by *Mullard Ltd.* and published in *"Wireless World."* According to published data, it was rated at 20 watts with a total harmonic distortion of .05% at rated output. Actual tests by American standards resulted in a rather surprising performance in that, instead of 20 watts output, we were able to obtain up to 36 watts with a total harmonic distortion of .2%.

Before going into the actual details of this power amplifier, let us review the basic requirements of amplifier designs that are important considerations for high-fidelity reproduction. Briefly, they are as follows:

1. Low harmonic and intermodulation distortion
2. Linear frequency response throughout the audible range
3. Good response to transient signals
4. Low phase shift
5. Low hum and noise level
6. Enough power output to allow peaks to be reproduced without overloading
7. Low output resistance to provide electrical damping for the loudspeaker system
8. Stability under feedback conditions

TABLE 1.
THE MULLARD EL34 TUBE UNDER VARIOUS OPERATING CONDITIONS

MODE OF OPERATION	OPERATING CONDITIONS					IM DISTORTION (in per-cent at)		
	E_p (volts)	E_{g2} (volts)	R_k (ohms)	Impedance (P-P, ohms)	R_{g2} (ohms)	10 w.	14 w.	36 w.
Triode-connected	400		470 (each)	10K		.4	.6	....
Distributed-load ("Ultra-Linear")	400	400	470 (each)	6.6K	1000 (each)	.5	.6	.8
Pentode-connected (push-pull)	330	330	130 (common)	3.4K	470 (common)	1.5	2.0	4.0

Amplifier Designs

A low level of inherent distortion can be obtained in a push-pull triode output stage operating under virtually Class A conditions. It is found that with 25-watt pentodes or tetrodes, wired as triodes, a power output of from 12-15 watts can be easily obtained with harmonic distortion levels below 1%, using a supply voltage of from 430-450 volts.

The maximum power output and the corresponding distortion vary appreciably with the value of load impedance. Fig. 2 illustrates typical performance of the *Mullard* EL34 high slope output pentode, triode-connected, in a push-pull stage operating slightly below its rated plate dissipation of 25 watts.

Increasing interest is being shown in circuits employing distributed loading ("Ultra-Linear" operation) of the output stage (Fig. 1). These circuits apply negative feedback in the output stage itself. In the simplest form, the screen grids of the output tubes are fed from taps on the primary of the output transformer. The stage can be considered as one in which negative feedback is applied in a non-linear manner *via* the screen grids. The characteristics of the distributed load stage are intermediate between those for pentode and triode operation, approaching triode operation as the per-

*International Electronics Corporation, 81 Spring Street, New York, New York.