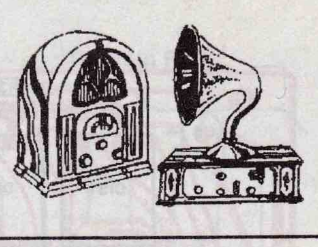
Vintage Radio

by PETER LANKSHEAR



The Loftin-White amplifier

In the 1929 edition of his standard reference book *Principles of Radio*, Keith Henney stated that spending time and effort on making an amplifier flat from 50Hz to 5kHz was not warranted — because a 10dB drop at the ends was not too easily noted! The reality was that increasing use of the moving coil speaker was encouraging research into improved fidelity, and at the beginning of 1930 the unique Loftin-White amplifier appeared. At the time it had an impact similar to that of the Williamson design which appeared 15 years later.

By 1930, wide range amplifiers were being developed for the movies and broadcasting, but for private users these were generally either unavailable or too expensive. The output pentode had been adopted to a limited extent in Europe, but America still relied on insensitive output triodes. A typical driver stage using the ubiquitous 27 triode produced a gain of about 25, but the gain in a resistance-coupled stage was only six. And things were not significantly better with the comparable Philips E415. Little wonder, then, that transformer coupling was practically universal.

Although transformer coupling had a lot of merit, there were also serious limitations. Inadequate inductance affected low frequency performance, and resonances, capacitance and leakage inductance restricted the high frequency response. Efforts to improve one end of the spectrum were traded off by a deterioration at the other. The performance of the Kolster-Brandes amplifier described in *EA* for September 1989 was typical.

To achieve high resistance-coupled gain, some work had been done with the first screen-grid valves, the UX222 and S625, but results were indifferent. The introduction early in 1929 of two improved valves, the mains powered UY224 screen-grid and UX245 output triode promised better amplifiers. One line of research was into resistance coupling the 224, using the outer grid as a control grid and the inner grid as a space charge electrode.

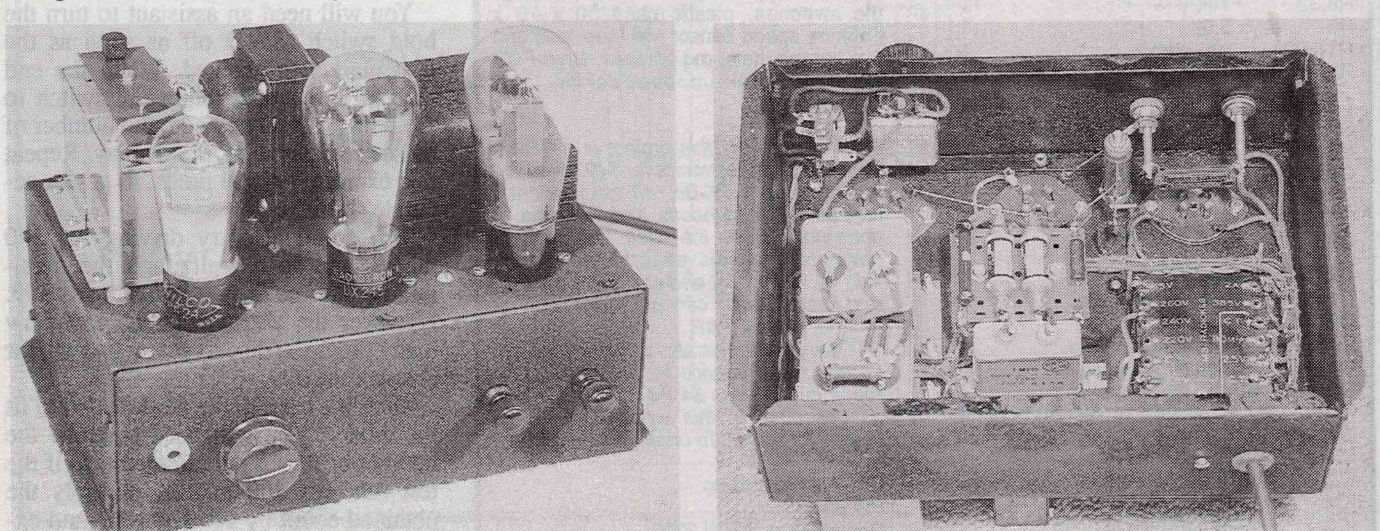
There was, at the time, a common misconception about the practicality of resistance coupling of output stages. It was held that when a Class A valve was driven to full output, grid current would cause grid blocking, from a build up of negative charges on the coupling capacitor. In reality, once valves of adequate power capability such as the 45 became available, distortion at maximum output was the limiting factor.

Direct coupling

One solution to the supposed 'problem' of grid blocking was to eliminate the coupling capacitor by direct coupling. It had been tried, but was impractical as the smallest drift anywhere in the chain upset the operation of the entire amplifier.

In today's solid state technology, direct coupling of audio power amplifiers is universal, but is very dependent on negative feedback for stabilisation. In 1929 the only type of feedback recognised was positive — good for oscillators, but to be avoided in amplifiers.

Edwin H. Loftin, with a background of naval electronics, and S. Young White, a General Electric research worker, had joined forces in 1924 to form the Loftin-



A surviving Loftin-White amplifier, very similar to the Electrad version of Fig.3. The wiring techniques are typical of 1930.

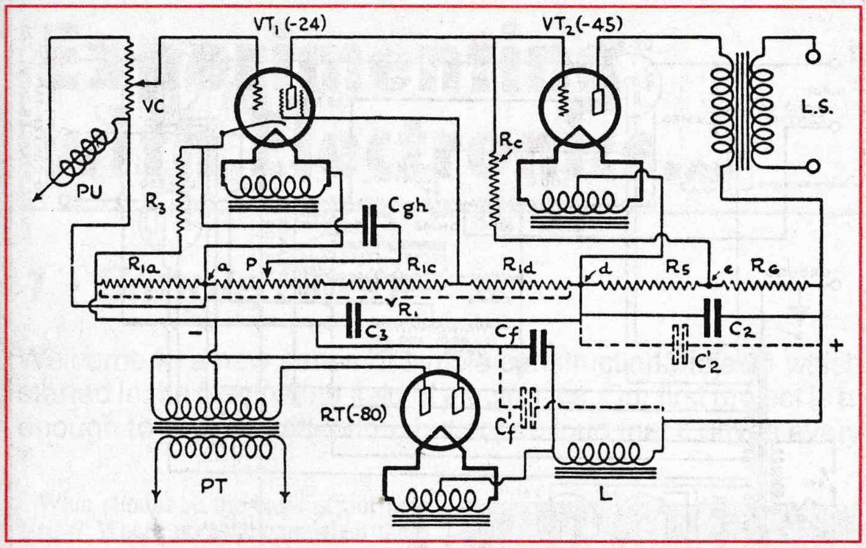


Fig.1: The original Loftin-White amplifier. All capacitors are 1.0uF.

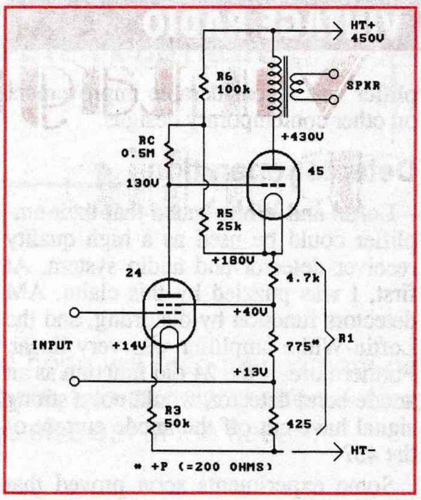


Fig.2: The DC configuration and voltage distribution in the original Loftin-White circuit. It was very stable.

White Laboratory. Some time later, they turned their attention to problems of audio amplification.

Loftin and White reasoned that a single direct-coupled 24 tetrode would have sufficient gain to drive a 45 triode, provided that there was some way of stabilising the combination. The outcome was a very successful but simple direct resistance-coupled two stage amplifier. With no interstage transformers, the Loftin-White amplifier had, for its time, a wide frequency response, and was both compact and inexpensive.

Very stable

The configuration was ingenious and is a very early example of the use of DC negative feedback. Fig.1 shows the original schematic, while Fig.2 analyses its DC operation.

HT is fed conventionally through the primary of the output transformer to the anode of the 45 output triode. A voltage divider connects its filament to HT negative. The grid of the 45 is connected directly to the anode of the 24 and a 0.5 megohm load resistor. Screen and control grid are fed from taps on the voltage divider and a cathode resistor provides automatic bias for the 24.

This arrangement produces very stable operation. A current increase through the 45 causes a rise in the screen and control grid voltage of the 24, increasing the current in R1. This in turn lowers the grid voltage of the 45, opposing the current rise. Alternatively, a reduction in the 45 anode current is countered by a lowering of the 24 control voltages.

The operational parameters are set by the screen and grid voltages of the 24, and are virtually independent of the characteristics of the 45. To check this aspect, I tried in turn, a standard and a low emission 45 and then a type 2A3, a much higher performance valve. Despite the wide differences in characteristics, there was a variation of only a few milliamperes in the anode currents of the three valves.

Massive HT voltage

Full output with low distortion was obtained with less than half a volt of input. There was a price to pay, though. Total power consumption was 35 watts to produce little more than one watt of audio power, and a power supply delivering 450 volts was necessary!

A novel method of hum reduction was used. Electrolytic capacitors were not commonly available before 1931, and high capacitance 500 volt paper capacitors were very expensive. By injecting into the cathode of the 24 a correctly proportioned bucking voltage from a variable resistor in the voltage divider chain, it was possible to cancel hum in the HT supply. As a result, filter capacitors of only 1.0uF were sufficient.

The frequency response was claimed to be practically flat from 35Hz to 6kHz, but this did not include the output transformer — which in most cases would have caused some degradation. Even so, the performance of the Loftin-White am-

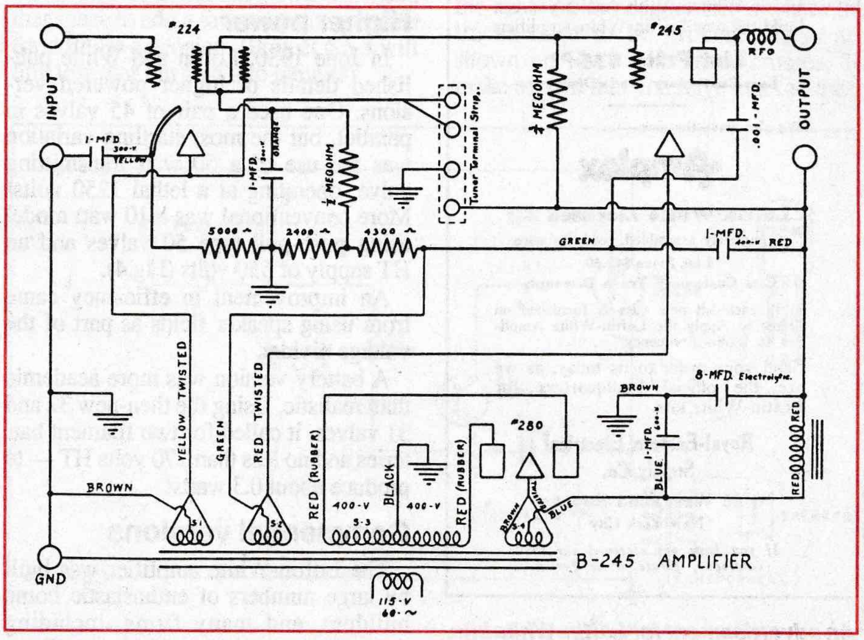


Fig.3: Electrad's later 1931 version of the Loftin-White circuit, with improved filtering and an earthed input terminal.

plifier was a considerable improvement on other contemporary designs.

Detector operation

Loftin and White stated that their amplifier could be used as a high quality receiver detector and audio system. At first, I was puzzled by this claim. AM detectors function by distorting, and the Loftin-White amplifier was very linear. Furthermore, if the 24 did function as an anode bend detector, would not a strong signal have cut off the anode current of the 45?

Some experiments soon proved that the amplifier does indeed constitute a

An advertisement for Loftin-White kits, from the May 1930 issue of US magazine 'Radio News'.

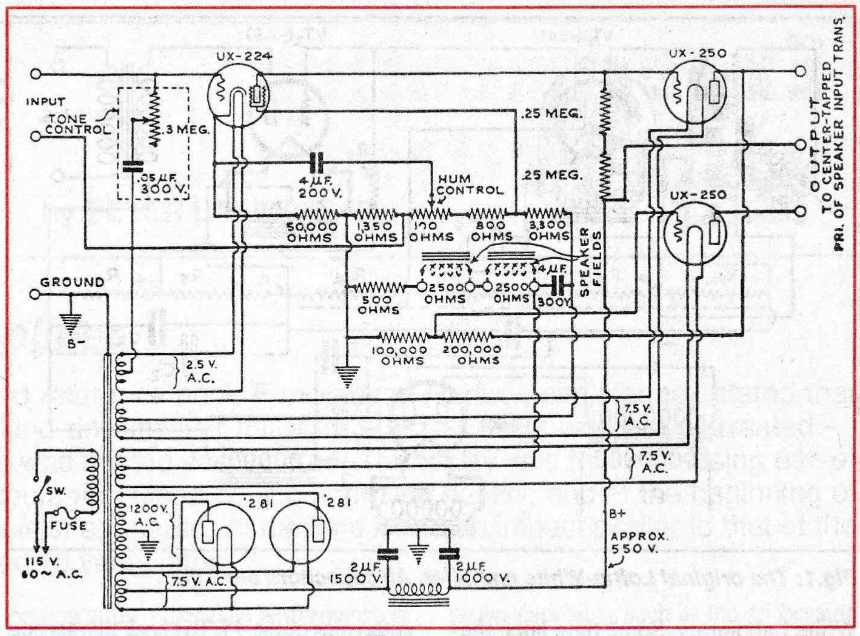


Fig.4: A 10 watt push-pull version. The lower type 250 output valve acts as a phase inverter, direct coupled to the upper valve's anode via a resistive divider.

good detector/amplifier combination. There is no demodulation below an input of about one third of a volt, the level at which audio overload commences, but RF signals above this level are demodulated with low distortion. The DC stabilisation holds the anode current of the 45 constant, the only variations occurring in the 24's screen current. With a reasonable amount of RF amplification, the Loftin-White amplifier could certainly be the basis of an effective radio receiver.

Higher power

In June 1930, Loftin and White published details of higher powered versions. One used a pair of 45 valves in parallel, but the most startling variation was the use of a 50 watt transmitting valve, operating at a lethal 1250 volts! More conventional was a 10 watt model using push-pull type 50 valves and an HT supply of 550 volts (Fig.4).

An improvement in efficiency came from using speaker fields as part of the voltage divider.

A battery version was more academic than realistic. Using the then-new 32 and 31 valves, it called for two filament batteries and no less than 270 volts HT — to produce about 0.3 watts!

Commercial versions

The Loftin-White amplifier was built by large numbers of enthusiastic home builders, and many firms, including some in Australasia, sold kitsets. There were, however, two weaknesses in the original design. The hum bucking control was critical in its setting, which changed with valve ageing, creating problems for non-technical users. Another problem was caused by there being no input terminal connected directly to earth — both sides were 'floating'.

Electrad, a resistor manufacturing firm, made suitable modifications to eliminate these problems and marketed a range of Loftin-White amplifiers, especially for PA work (Fig.3). But the major commercial application came as a result of a market trend in receivers.

Coincident with the development of the Loftin-White amplifier, market depression led to cost saving efforts to get away from the big console receivers of the period. The answer was the 'midget' receiver — later to be known as the 'mantle' radio — and some manufacturers used the Loftin-White circuit as the basis of their design. It was compact, did not need expensive interstage transformers and performed well.

The pentode arrives

During 1931, the Americans finally adopted the pentode output valve which could generate twice the power of the inefficient 45 with only one third the grid drive — easily delivered by conventional resistance capacity coupling. The Loftin-White amplifier with its requirement for an HT of 450 volts could not compete, and soon took its place in history as a significant but short-lived development in a rapidly changing technology. ■