VINTAGE RADIO

Phenix Ultradyne L-2 superhet radio (1925)

By Dennis Jackson

Various aspects of a vintage radio can impact its value and desirability including its rarity, condition, brand, nostalgia and appearance. I have witnessed the bidding on an AWA Empire State (model 48R from 1938) rising as high as $15,000 at our local auction house, mainly because it was the very rare green colour.

I prefer to collect sets that demonstrate the technical stages of development over time, especially those with a fascinating history. It is not so much what they look like to me, but how they work.

An interesting early radio caught my attention as I scrolled through vintage radio ads on eBay around ten years ago. It was described as a Lacault L-1 Ultradyne from November 1924. What interested me is that superheterodyne radios from the early 1920s are rare. But there was a problem: this pioneering radio was located in the Eastern USA, and at that time, I knew little about it.

Purchasing it would be expensive, especially considering that the delivery cost could be high, but it was probably my only chance to own such an early superhet. The auction ended the next day without me putting in a bid, and I had regrets, especially after realising that the going price was reasonable.

Surprisingly, an improved model featuring regeneration, the Lacault L-2 Ultradyne from June 1925, was offered by the same seller soon after. To cut a long story short, I threw caution to the wind, and it arrived at my door two and a half weeks later.

I was not disappointed. Appearance-wise, it was in near mint condition. It cost me around $500, including freight; very reasonable, I thought. I still cannot understand why it cost me so little; I presume that the vast majority of people take technology for granted these days.

The superhet radio receiver came out of the turmoil of WW1, when there was an urgent need to improve communications. Also, simple TRF receivers of the time lacked sensitivity and selectivity, making them inferior for

The Ultradyne L-2 designed by Robert Emile Lacault is extremely impressive for its time. It's a superhet that features regeneration, and uses eight UX201A triodes. It weighs approximately 15kg and comes in a timber cabinet stained to resemble mahogany.

A Graham Amplion horn speaker, made in 1925, was chosen to match the L-2's case. The two main knobs are Accratune vernier dials. Other versions of these knobs may have the letters REL (for Robert E. Lacault) engraved in their centre.

direction-finding and triangulation; that became increasingly important during wartime as technology progressed rapidly.

The contribution of Major Edwin Armstrong of the US signals Corps while based in Paris is well-documented, and he filed a patent on the superheterodyne principle in 1917. He went on to develop the first commercial superhet, the RCA AR-812 released in March 1924 (August 2019; siliconchip.com.au/Article/11782).

Less is known of the contribution of Lucien Levy of the French signal corps. Levy is now recognized as filing the first superhet patent, also in 1917, around seven months before Armstrong. He went on to make many improvements as both a radio engineer and manufacturer in France.

The Ultradyne L-1 & L-2

In November 1924, the Phenix Radio Corporation in New York released another superhet, the Ultradyne L-1, designed by R. E. Lacault.

Robert Emile Lacault was born in Paris around 1894. Formerly of the Radio Research Laboratories of the French Army Signal Corps, he migrated to the USA after WW1, settling in New York City. He became associate editor of the then popular magazine Radio News, where he published an article titled "A Superheterodyne Receiver with a new type of 'Modulator'".

The improved Ultradyne L-2 came onto the market during the middle of 1925. The physical layout of my Ultradyne L-2 is well thought out, with a view to show off the internal works as well as displaying the ebony-stained timber cabinet. All conductors are of square-sectioned tinned brass busbar, and all runs are symmetrical with 90° bends.

The internal layout is both practical and symmetrical. The components are all screwed down onto a substantial timber breadboard-style chassis or to the Bakelite front panel; typical of radio construction of the period.

The Ultradyne was sold in complete kit form, probably to work around the legal minefield of patent litigation. This is indicated by Lacault submitting his patent for the Ultradyne to the US Patent Office in February 1924, but it was not approved until December 24 1929, almost six years later.

The high level of construction expertise in my example suggests some factory involvement.

Operation

The two large tuning controls are spaced about equal thirds across the front Bakelite panel. The inner section of each knob serves as a reduction gear for fine-tuning, with a ratio of about 15:1.

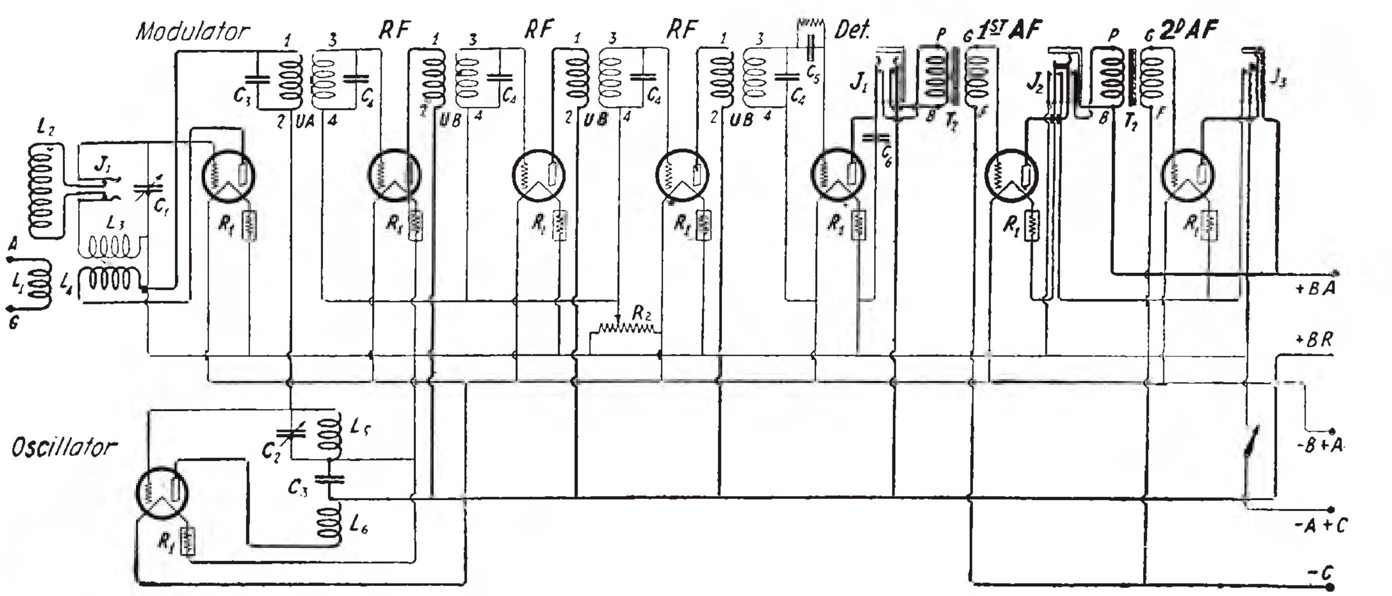
The knob on the left is marked "Tuner" and on the right, "Oscillator". Not being ganged, these controls must be tuned together by hand. This is not too difficult, as the set's bandwidth is quite broad. I find it easiest to watch the plates of the tuning condensers, keeping both about the same distance apart while slowly rotating the controls.

There is also an outer marked dial, but it is simpler to mark station positions with a removable mark once found.

Either side of the tuning controls are two smaller knobs. On the left is the "sensitizer", which controls feedback or regeneration between the plate of the first RF valve and its grid. This is via inductive coupling using a variometer style set of coils, one moving inside the other.

The small knob to the right of the oscillator tuning control is marked "stabilizer", and it controls the negative bias to the grids of the second, third and fourth RF valves. Together, these two controls have a limited effect on the operation of the set.

On the far left is a jack for plugging in a loop aerial. At far right are three vertical jacks in a row, marked "Detector", "1st stage" and "2nd stage".



The circuit diagram for the Phenix Ultradyne L-2 (sometimes labelled L2) shows that nearly all the circuitry is managed by the eight UX201A valves and matching IF transformers. The L-2 was originally manufactured around 1922 using UV201A valves, which had a thorium filament, and there were also later variants that used UX112, 171 & 171A valves. IFT1 ("UA") is the only type-A Ultraformer RF transformer in the circuit, the rest being type-B, and they all have an air-core with a peak frequency of 115kHz. The difference between the two types is that the Type-A has less coupling (0.25in [6.35mm] between the primary and secondary for Type-A; Type-B has no spacing). You can find an interesting write-up on the set published in the October 26, 1924 issue of the Daily Mail: https://trove.nla.gov.au/newspaper/article/219013077

The interior of the L-2 is nicely designed, with most components mounted on the timber "breadboard" and connected via point-to-point wiring. Considering this radio was originally designed in 1922, the layout is impressive.

Plugging a speaker into any of the three jacks operates a switch which cuts out the last audio stage or stages, reducing battery drain. High impedance headphones would generally be plugged into the Detector jack.

The on/off switch is below these, and it switches the A supply (filament cathode rail).

Tuning capacitors

The two brass tuning "condensers" or capacitors are of an unusual design. Both sets of plates are set into two separate parallel shafts, and they move into each other, controlled by a set of gears.

Lacault filed a patent on a then new type of tuning condenser while working with the Phenix Co. So this might be one of his designs.

Component selection

There wasn't much choice when deciding on a valve line up in 1924, so all eight valves are UX201A types with 5V thoriated directly heated filaments, each drawing 0.25A with a theoretical gain of eight times.

My Ultradyne L-2 operates best with around 70V on the RF and AF valve anodes or plates and 40V on the detector anode.

The aerial coils, oscillator coils and the sensitizer variometer coils are all of a compact self-supporting basketweave construction. This is designed to reduce inter-coil capacitance, to achieve a high Q factor, maintaining good efficiency.

Circuit details

The Ultradyne differs from other superhets mainly within the circuit around the mixer, or "modulator" stage as it was then known, and in the electrical arrangement of the oscillator.

In describing this circuit, Mr Lacault explained (and I quote in condensed form): The B+ supply is connected to the plate of the modulator valve. The plate-cathode (filament) space acts as a resistance in this circuit.

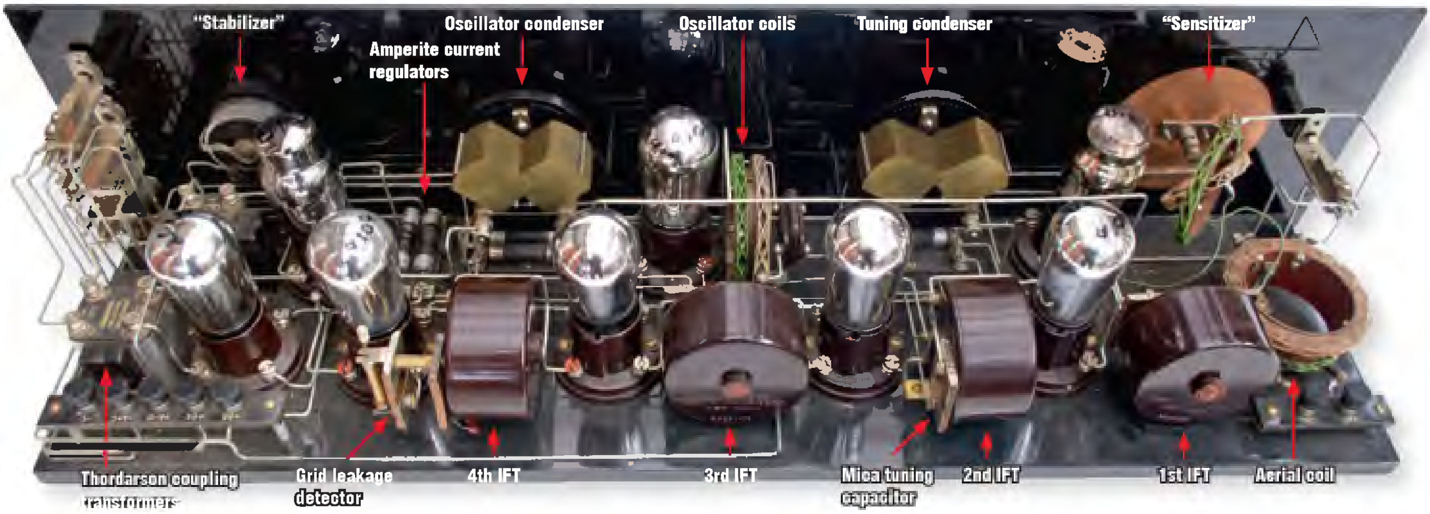
The plate of the modulator valve is supplied with high-frequency current from the oscillator, which conducts only on the positive half of each cycle. This produces a change in plate cathode resistance which varies from infinity to 20kΩ during each half-cycle of the oscillator current when no signal is being received.

When the grid potential of the modulator valve is varied by incoming signals from the aerial, the lower resistance value is varied above and below the amount mentioned with various degrees of amplitude, according to the phase relationship between the incoming signal and the local oscillations.

This produces a beat note which is amplified by the four intermediate frequency (IF) stages and then detected by a grid leak detector.

The next three RF stages are coupled via B-type Ultraformers in the usual way, but with only the secondaries being tuned to the intermediate frequency by fixed mica capacitors.

With the radio working and measured with a high-impedance digital voltmeter, there is only 0.34V DC on the plate of the modulator, and the impedance is such that the meter shunts away all noticeable signal. However, this circuit is very sensitive picking up local stations with just a 1m wire aerial.



The radio chassis is tinted with ebony. Note the unusual design of the two tuning condensors and their placements. Below these condensors are Amperites, which are cartridge-type automatic adjusting resistors (rheostats). At the bottom left is the connection board for the A (6V), B (90V) and negative bias C (-6V) supplies.

The grid leak detector and following two audio stages are as could be expected of a TRF receiver of the period. The detector recovers the audio information from the 115kHz IF signal. The grid leak detector is simple and very sensitive. It only requires two extra components: a grid leak resistor of about 2MΩ in parallel with a capacitor of around 255pF.

Manufacturers switched to plate or anode-bend detectors when indirectly-heated cathode and screen grid valves became available during the late 1920s, and later to diode detectors.

Both audio-frequency stages are coupled by two nicely presented Thordarson "amplifying transformers". They are called "amplifying" because they have a step-up voltage gain of 1:3 or even 1:5, which boosts the signal voltage between the plate of the preceding valve and the grid of the next.

Amperite automatic current regulators are inserted in series with the filaments of the UX201A triode valves, in place of the more common wirewound rheostat of about 8Ω used to limit the current flow which could otherwise damage the delicate thoriated valve filaments.

Amperites consist of a hermetically-sealed glass tube containing either hydrogen or helium gas, through which a resistance wire with a positive temperature coefficient passes.

The resistance of this element will automatically change according to the current flow, thus regulating it. Each valve is usually provided with a separate Amperite unit.

Metal RF or AF shielding is absent from the RL-2, as was the norm in these pioneering radio sets. However, the four Ultraformers and two Thordarson audio coupling transformers are alternately mounted at right-angles to limit radio-frequency coupling between adjacent units.

Initial checks

In common with other sets of the period, the breadboard and front panel slide out of the case after removing a few screws.

My first job was to check all eight UX201A valve filaments for continuity, as these were prone to burning out if more than the rated 5V was applied.

Having 5V filaments allowed a 6V 'accumulator' to be used for the valve heater A supply, the extra 1V usually being dropped across an adjustable wirewound rheostat. However, as I mentioned above, my radio uses Amperites instead.

Despite the current-limiting Amperites, the first three valves (including the modulator) did have open filaments and had to be replaced, but the remaining five were OK.

Next, I connected a period horn speaker, a long aerial and connected its Earth terminal to a copper water pipe. Then I wired up a battery eliminator and checked all the voltages before switching it on. The set should have been operational, but vintage radio is seldom that simple.

Power supply

The radio would typically have been powered using one 6V lead-acid battery or four large 1.5V telephone-type carbon-zinc dry cells in series for the A supply. The B supply would have come from a 90V carbon-zinc battery, possibly two 45V batteries in series or four of the less common 22.5V batteries.

Four small carbon-zinc cells in tapped series would have been used to provide the negative C bias voltage to the valve grids.

But I prefer to use a homemade mains-powered battery eliminator. It does give improved performance with a good Earth attached.

Troubleshooting

This problem proved to be a real stinker. All voltages appeared close to what was expected, so I brought out my signal tracer. The station signal seemed to disappear at the grid of the first RF valve. Was this a problem with the dreaded modulator? Was the oscillator operating?

I checked all of the UX201A valves for emission by swapping them into a known-good TRF set, with positive results. Was there a loose terminal connection or a socket making poor contact with a valve pin somewhere around the RF end?

After some more checking, I noticed four thin brass bolts protruding from the face of the first A Ultraformer (or IF transformer in later terminology). These bolts serve as busbar terminals going to the two coils within. Although both small nuts were firm, the grid busbar had slight movement; this should have been under some tension.

It was possibly a broken bolt; apparently, I hadn't been the first to check that all was firm. The Ultraformer unit would have to come out and be disassembled.

It was an interesting job, because I like looking inside things. After drawing a sketch and making some notes, I removed the unit and then opened it by melting away the sealing wax covering a larger central brass bolt.

Both fixed inductors inside are air-cored and neatly machine-wound on a removable Bakelite sleeve. The first (A-type) Ultraformer has a small gap to give lighter coupling between coils while the other three (B-type) Ultraformers are close-wound side-by-side.

The lead wires are soldered to the heads of the four aforementioned thin bolts protruding through the face of the unit. Some heavy-handed force would have been applied long ago, resulting in not only a broken bolt, but also a detached lead. That is likely why the radio was retired from active service.

A dab of solder, a bit of Araldite to stop the bolt turning again and a check with the ohmmeter, and the Ultraformer was ready for reassembly. This resulted in sound and satisfaction once more around my workbench.

A close-up of the left side of the radio chassis, from left-to-right are the Thordarson coupling transformers, grid leakage detector, 4th & 3rd IF transformers, plus the oscillator coils at the back (green/white wire).

A close-up of the right side of the radio chassis, again the 3rd IF transformer is in view, along with the 2nd and then 1st (A-type) followed by the aerial coil. Behind that is the "sensitizer" regeneration control.

Final comments

When listening through headphones at the detector jack, the sound is clear. But there is some deterioration after each of the final audio stages, probably due to the limitations of the Thordarson step-up transformers. Thordarson is still around making transformers under the name Thordarson Meissner (www.thordarsonmagnetics.com).

It would not have been difficult for a technically-minded person to assemble an Ultradyne set. The baseboard might have come with pre-drilled holes, or perhaps a paper template to position the parts precisely. The busbar conductors were most likely pre-shaped and soldered where needed, and just required fitting to screw terminals.

The Ultraformers were factory-tuned using selected mica capacitors. The oscillator and the tuning capacitors were hand-adjusted to achieve station alignment. Overall, this set's assembly would have been straightforward compared to a multi-band superhet of a later decade. Dealers and learned friends probably assembled some for clients also.

The price of the radio kit at the time of release appears to have been $90 including the cabinet plus $30 for the tuning coils, Ultraformers and four matched fixed condensers. That's a lot less than the $269 asked for the RCA AR-812 fully assembled superhet which came on the market in March 1924, just fifteen months before.

This kit was sold by Keystone Radio Service, but there is some doubt on how similar it is to the Phenix-branded Ultradyne L-2. An advert describes it as "carrying the last improvements of R. E. Lacault".

Upon reflection, I believe Robert Emile Lacault's modulator to be a stroke of true genius. Using a primitive triode valve as a mixer in conjunction with the local oscillator and without a high positive voltage supply to its plate was really thinking outside the box.

Lacault went on to produce other superhet sets, each an improvement on the previous. His last effort was the RE-29, released for sale in 1929, using three tetrode screen-grid valves.

Lacault died on March 12, 1929, at around 34 years of age, cutting short a brilliant career. SC

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