

## **Who really DID invent the Superheterodyne?**

The invention of the superheterodyne is one of the most important developments in the history of radio, and is basic to the operation of virtually every receiver and many transmitters in operation today. Without the 'superhet', modern electronic communications would not be possible. Yet for all its significance, its exact origins have been controversial.

The basic principle of the superheterodyne is simply that any two signals can, when mixed together, create other signals that have a mathematical relationship to the original pair. For centuries musicians have known of this effect, called beating, in which two notes will appear to the ear to produce a third. In the superhet, the equivalent beat note is, of course, the intermediate frequency.

Although radio matured during the 1920s, with the TRF the dominant type, the superhet is the older technology, having been around for the best part of 80 years. But who invented it? Many Americans give the credit to Edwin Armstrong, but others recognise the work of Lucien Levy.

A few years ago, there was some

correspondence in *EA* on the subject, and the 'When I Look Back' column for July 1990, which described the accomplishments and tragedy of Edwin Armstrong, put into perspective the part played by the Frenchman Lucien Levy in the invention of the superhet.

At about that time, Winston Muscio (a retired STC engineer) provided me with some interesting data, including a copy of the Levy patents, which made the events a little clearer to me. However, as we shall see, recently significant information about the French involvement has become available and clearly throws some doubt on Levy's integrity.

Early radio was often marred with patent claims and sometimes bitter lit-

igation (more than once involving Lee de Forest). Depending on the source of writing, significant developments are attributed to different inventors and piecing together the true story can be a time consuming but fascinating task.

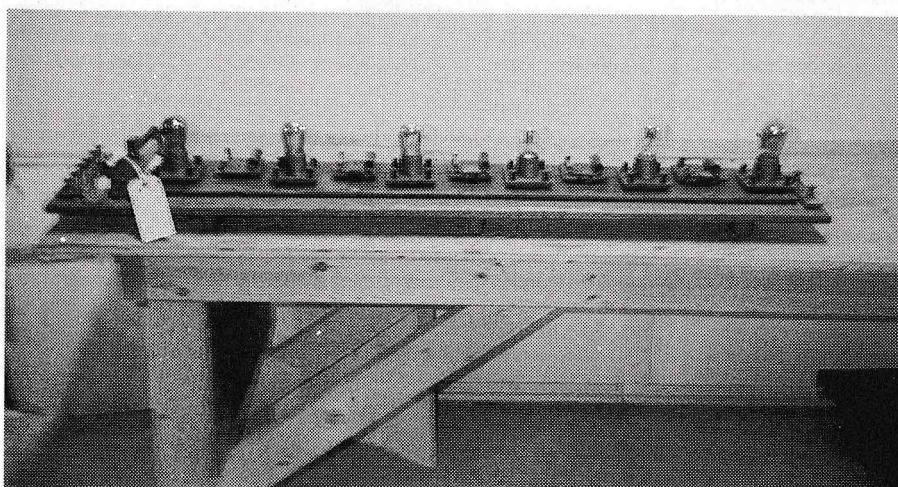
Radio is of course not the only field where this has occurred. Morse and the electric telegraph, Edison and the electric lamp and the phonograph, Bell and the telephone have all achieved immortality for their inventiveness, but in each case their work was closely paralleled by that of other researchers.

### **Fessenden's heterodyne**

Marconi's transmitters, based on the experiments of Hertz, used high voltage discharges across spark gaps to excite tuned circuits and aerials into oscillation and thereby generate RF signals — which were, in effect, modulated by the individual sparks. Progressive engineers, among them the Canadian Professor Reginald Fessenden, realised that spark transmissions were inefficient and crude and that real progress lay in using continuous waves; but he realised that existing detectors would produce very little audio output from an unmodulated signal.

A further problem was lack of sensitivity, in the coherers and magnetic detectors of the period. Fessenden had observed that by far the most sensitive instrument available was the standard telephone earpiece — but of course this could not be used to receive radio signals directly.

His solution, patented in 1902, was the simultaneous transmission of two signals with a small difference in fre-



*One of the world's finest, largest and longest established collection of vintage radio equipment is at the Antique Wireless Association's Museum in the charming little New England style village of East Bloomfield, in New York State. Among their many priceless and historically significant acquisitions are several pieces of equipment constructed by Edwin Armstrong. This is a resistance coupled IF amplifier strip, built to demonstrate his superheterodyne receiver. The device with the label attached is the filament rheostat!*

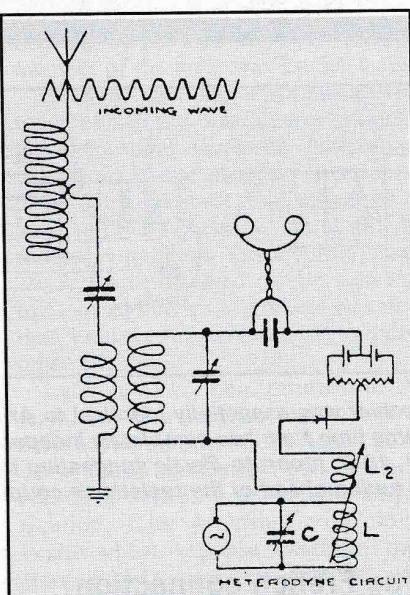
quency. These supersonic signals were each fed to individual windings of a special headphone and an audible difference beat was registered by the operator's ear. Thus, if the two signals were separated by a difference of 1kHz, a note of that frequency would be heard in the earpiece.

Fessenden also realised that only one transmitter would be necessary if the second signal was generated by a local oscillator. This was the origin of the *beat frequency oscillator* or 'BFO', and for the note produced, Fessenden gave us the term 'heterodyne' from the Greek meaning 'other force'. Heterodyne reception had the advantage too of improving detector efficiency, by in effect adding energy to the audible signal.

### Ahead of its time

Valves did not exist in 1902, and it was not until after the invention of the valve oscillator a decade later that the heterodyne detector came into its own. Until then the local signal had to be generated by a miniature arc transmitter, or even a high frequency alternator! Obviously these were unwieldy methods, and a classic example of a system being in advance of technology.

The invention of the valve oscillator was a landmark in radio history, and a classic example of simultaneous effort in different countries. In September 1912, whilst still a student at New York's Columbia University, Edwin Armstrong demonstrated the regenerative detector and the closely related valve oscillator. Meanwhile, in Germany the Telefunken engineer Alexander Meissner and in England, Marconi engineers Franklin and Round had been successful in producing valve oscillators.



*This diagram of a receiver using Fessenden's heterodyne principle is taken from the 1925 Admiralty Handbook. Before the advent of the valve, the source of heterodyne oscillations was an arc generator or a high frequency alternator.*

As an indication of the closeness of the race, in 1913 Meissner took out his patent on April, Franklin's patent dealing primarily with regeneration was registered in June and Armstrong's patents were filed in October.

Armstrong was an impecunious student who, with more resources, could have applied for his patent earlier. History has credited Armstrong as being first to make a valve oscillate in his discovery of the regenerative detector, although De Forest eventually won the legal battle on the dubious strength of getting audio feedback between a microphone and telephone earpiece.

Regardless of the true inventor, the oscillator enabled the heterodyne receiver to become a practical device, and was widely used by various navies during the first World War.

### WW1 spurred development

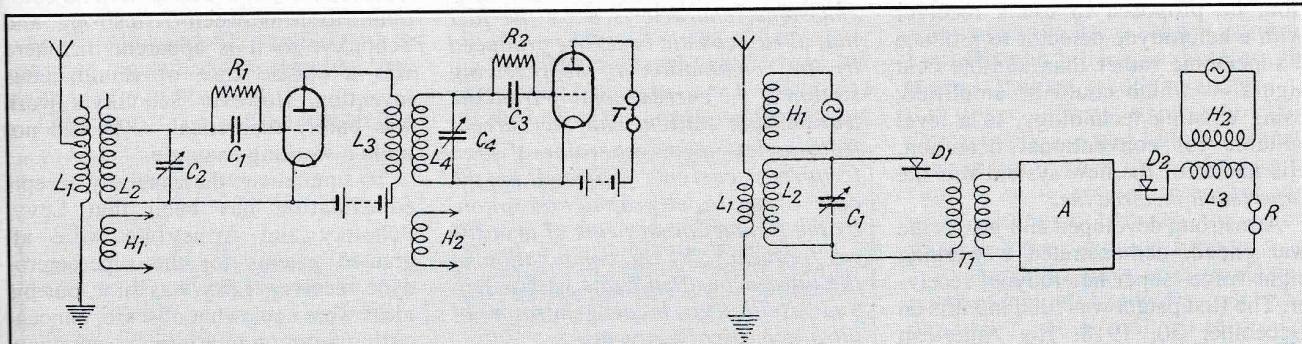
The period 1914-18 saw considerable radio development on both sides. From an erratic curiosity which Lee de Forest, the nominal inventor, did not fully understand, the triode valve was made into a stable and practical device.

By 1917, when America entered the War, radio was an integral part of warfare, and Armstrong, by now an acknowledged authority on reception, was soon given a commission and sent to France to research military radio applications.

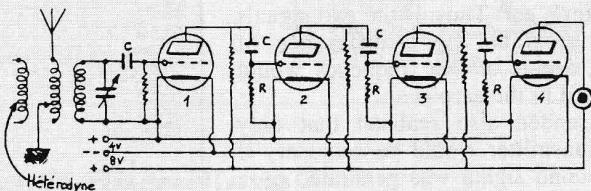
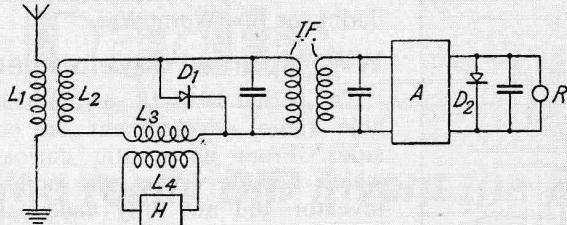
On his way to France, in October 1917, Armstrong had been able to visit London, and called on Captain Henry Round of the Marconi Company. The two 'hit it off' immediately, and Round was able to demonstrate his 14-stage RF amplifier, which had been used for direction finding by eavesdropping on the German Fleet's low powered interfleet communications while they were stationed in Heligoland. The Royal Navy was alerted to movements of the German ships in harbour, and the outcome was the Battle of Jutland.

Round's amplifier illustrates the difficulties of the time in obtaining useful RF amplification. Although he developed a special low capacitance valve, the baseless V24, he could only achieve a stage gain of two. However, given a sufficient number of stages, sufficient amplification to reach to the noise level of the aerial was possible.

By all accounts, the Round receiver was extremely difficult and time consuming to set up and tune. For practical



*Diagram 2 (left): Levy's patent application included this configuration in which an IF amplifier was optional. His prime claim was for interference cancellation, with the superheterodyne principle almost as an afterthought. Diagram 3 (right): Armstrong's ideas were much clearer than Levy's, and this diagram from his superheterodyne patent application shows a practical and recognisable configuration using an IF amplifier labelled A.*



**Diagram 4 (left):** Schottky's proposed receiver was essentially identical to Armstrong's, a remarkable example of how the same invention can originate at the same time from two completely independent sources. **Diagram 5 (right):** The diagram that accompanied Laut's February 1, 1917, report to Ferrie suggesting the use of supersonic heterodyne signals. This is a practical circuit, although some tuning ahead of the resistance coupled IF amplifier would be of considerable benefit.

work, simpler methods of amplification were needed.

The next part of the story has become part of the folk lore of early radio. At this time, most radio communication was carried out at frequencies below 1MHz, but there was a belief that the Germans were using much higher frequencies where valves could not be made to amplify.

Sensitive as it is, the regenerative detector has a lower limit to signal strengths to which it will respond, and the only remedy is pre-detection amplification, which was not possible with valves of the type then used by the military. Armstrong gave thought to this impasse, and is said to have thought of the solution while watching a night time air raid on Paris.

It occurred to him that it might be possible to locate aircraft by tracking the high frequency radiation from their ignition systems, but considerable amplification would be necessary.

To obtain the necessary amplification, he proposed to use a receiver with a heterodyne detector to produce a supersonic rather than audible beat signal — which could be amplified, using existing technology, to a level suitable for conventional detection. His name for the new system was the *super(sonic)heterodyne*.

Armstrong developed and just as the war ended, demonstrated a working eight-valve 'super heterodyne' receiver. The first patent was filed in Paris on December 30, 1918. His American patent, which even allowed for multiple frequency conversion, was filed on February 8th 1919, and was issued on June 8, 1920.

### The French connection

During World War One, the French set up a radio research organisation under Colonel Ferrie, one member of the team being engineer Lucien Levy. Levy's chief interest seems to have been in noise cancellation, a common enough research subject in the days of low frequency transmissions with their heavy static background. In August 1917, he made a long and somewhat rambling patent application dealing with problems in radio transmissions: 'atmospheric disturbances, confusions between the different emissions, and the lack of secrecy'.

Finally, after several obscure pages describing what seems to be interference reduction, and almost as an afterthought, he mentions what has been identified as the superheterodyne principle stating:

*A method as claimed in Claim 1 permitting of the selective reception of the ordinary radio-telegraphic or radio-telephonic sustained-wave emissions, characterised by the fact that ultra-acoustic beats are produced by the combination at the receiving station of the current coming from the transmitting station with the current from a first local generator of high frequency current, followed in the case of radio-telegraphic reception, by the production of beats of acoustical frequency, by the combination of the ultra-acoustical beats with a second oscillating local generator of ultra-acoustical frequency.*

When compared with Armstrong's precise wording and his working receiver, it is understandable that Levy's claim to have invented the

superheterodyne has been questioned. It is significant that the French Government recognised Armstrong's patent, and according to his biographer, presented him with a medal. However, in another of Armstrong's disappointments, Levy later claimed that Armstrong had stolen the superhet concept from him. Several years later, in an implied recognition, American Telephone and Telegraph bought Levy's US patent application for \$20,000. Of the nine claims in Armstrong's 1919 patent, all were lost in later interference proceedings in the US Patent office.

We will never know whether or not Armstrong was influenced by ideas from Levy, or developed his invention completely independently. But it is certain that there was no contact with W. Schottky of the Siemens laboratory in Germany, who applied on the 18th June 1918 for a patent that was almost identical to the application that Armstrong made six months later. Clearly, there could have been no communication between Armstrong and Schottky; so it is apparent that here was a classic case of simultaneous invention. However Schottky's work was purely theoretical — he did not build a working example.

To summarise, the generally accepted situation has been that Levy, Schottky and Armstrong were all granted patents for the superheterodyne receiver. Levy was first, but his ideas were somewhat obscure, concentrating more on interference reduction, with the supersonic heterodyne principle almost an afterthought. Schottky's patent application was next, with a clear description of a workable system,

but his work was theoretical only. Finally, Armstrong delayed his patent application until he had a working receiver with advanced and detailed concepts of its potential.

Levy may have been first to the patent office, but Armstrong was considered by his peers to be the father of the superheterodyne. Given the nature of the man, and his ability, proven by his later achievements in developing super-regeneration and pioneering FM transmissions, it is highly unlikely that he needed to or would have stooped to stealing Levy's ideas, as the latter at one time suggested.

### Twist in the tale

Until recently, that was where the story ended. But all good tales have an unexpected turn at the end, and this one is no exception.

The 1991 *Review of the American Antique Wireless Association (AWA!)* has a translation of a French article, originally published in 1979 in *Liason des Transmissions* by Robert Champeix. In the article Champeix wrote that in 1968, he was involved in setting up the French Radio and TV's museum, when an elderly but dapper and alert man introduced himself as Paul Laut. Laut had a very interesting story to tell.

As an electrical engineer, Laut had been a member of the radio research team set up in August 1914 under Colonel Ferrie at the Eiffel Tower, for development of equipment using the

new TM valves. Laut's specialist research subject was heterodyne reception. As we have already seen, another member of the team was Lucien Levy.

In 1916, Laut was hospitalised with tuberculosis, but was able to continue his theoretical work on heterodyne reception. In the process, it occurred to him that the beat note, although at an inaudible frequency, could still be readily amplified. On February 1st, 1917, Laut presented a report on this to Colonel Ferrie — who, as was normal practice, distributed it to other team members.

Later in 1917, Laut returned to the team, but was surprised and upset to find that on August 4th Levy had taken out a patent application, part of which was Laut's idea for heterodyne amplification. Laut protested to Colonel Ferrie, whose response was that as they were at war, disagreements between team members would be out of place.

Now it would be easy to assume that the accuracy of Paul Laut's recollections had suffered from the passage of 50 years; but there is unexpected confirmation.

At the end of 1925, and into the following year, Lucien Levy carried on a heated debate with several radio personalities via the correspondence columns of the magazine *L'Antenne*. (Compared with some of these exchanges, the arguments that Jim Rowe 'buys' in his Forum column are models of politeness and affability). The debate descended to personalities,

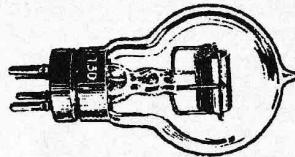
and one protagonist was unsporting enough to introduce the subject of Paul Laut's report on the heterodyne receiver to Colonel Ferrie.

Following some more acrimony in which Levy tried to play down the event, the Editor of *L'Antenne* waded in with a transcript of the Laut report which had been kept and made available by one of the Eiffel Tower team. *Touché Monsieur Levy!*

As Winston Muscio commented after reading the Champeix article, "When everyone gets their just deserts in the hereafter, it will be Laut who gets the superhet medal". ♦

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READER INFO NO. 19

## Flexible Dual Power Supply Module

*Continued from page 83*  
lators in the standard TO-220 package, laying down on the board and fitted with small finned 'U' heatsinks if and when these are needed. The module shown in the photos is the one for the PC-Driven Audio Sweeper, and in this case it only needed a heatsink for the positive regulator as the negative regulator is very lightly loaded.

Capacitors C5 and C6 are mainly to

ensure regulator stability, and should be either MKT or metallised polyester types. By the way you could use the very small TO-92 package regulators instead of TO-220 types, if you are using the module in a situation where it will always be loaded very lightly — e.g., a few tens of milliamps.

The final regulated outputs from the supply are brought to three terminal pins at the end of the board. As the module

will generally be built into equipment, rather than used as a 'stand alone' unit, this should be quite acceptable.

Insulated standoff pillars can be used to mount the module in a larger piece of equipment, as shown in the photos. The PCB is provided with 3mm mounting holes for this purpose. I used 10mm pillars, as these are the shortest that are readily available.

If space is very tight, you could alternatively use two nuts underneath each screw to pack the module up by 4mm or so — enough to ensure adequate clearance between the solder joints and the mounting surface.

So there you have it: a small dual polarity regulated power supply module which can be built up to provide various voltage levels, and to suit a variety of applications. Hopefully it will meet your needs as well as mine, at least some of the time! ♦

### PARTS LIST

#### Capacitors

C1,2 2200uF 25VW RB electro  
C3,4 470uF 16VW RB electro  
C5,6 0.1uF 100V MKT or met.  
polyester

#### Semiconductors

U1 7812 or other positive regulator\*  
U2 7912 or other negative regulator\*  
D1-4 1N4001 (or WO-4 bridge)

#### Miscellaneous

T1 7VA PCB mount transformer\*  
PCB, 110 x 51mm, code 95dps12; three-way PCB mount mains terminal block,  
10mm or 5mm spacing; three PCB terminal pins; two finned 'U' shaped heatsinks  
for TO-220 packages; two 3mm x 10mm  
machine screws and nuts; insulated  
standoff pillars for module mounting;  
long nylon cable tie for securing transformer.