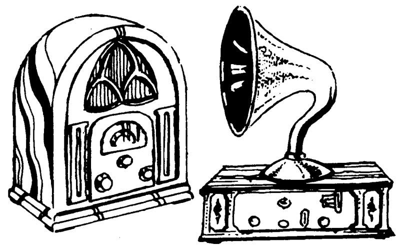
Vintage Radio

by PETER LANKSHEAR



Early receiver developments

There can be little argument that the two most significant developments in the history of radio were made in 1906, when several crystal detectors were patented and Lee de Forest invented the triode valve by putting a grid into Fleming's diode. The valve was to dominate radio development for the best part of half a century, while 40 years on, the crystal became the parent of the transistor.

Initially, neither development revolutionised radio. The crystal diode was too delicate for marine and military use, whilst the prime functions of the "Audion" as de Forest called his triode, were as a detector and later as an oscillator. The presence of a small amount of gas made these early valves more sensitive as detectors, but erratic as amplifiers.

De Forest did not for many years fully understand the operation of his invention and was convinced that some gas was essential. In 1913, Western Electric took the Audion, gave it a hard vacuum and improved mechanical construction, turning it into a reliable amplifier for repeater work on long distance telephone circuits. These same WE valves made possible the first transcontinental telephone circuit from New York to San Francisco, in 1915. As was often the case, parallel development was taking place in Europe.

It should not be assumed that early radio receiving systems were insensitive. By the use of large and efficient tuned circuits fed from massive aerial systems, quite remarkable performances were possible, even with primitive diodes as detectors. The Audion valve was slow to receive commercial acceptance until 1913, when a student at Columbia University, Edwin Armstrong invented regeneration, or positive feedback around a triode detector. This gave a dramatic increase in sensitivity.

At this time, radio transmissions used what is now the bottom end of the spectrum. The region above a few hundred kilohertz was virtually unused, because the presence of the ionosphere was unsuspected and conventional engineering wisdom was that frequencies above about 1.5MHz were useless. As well, there were considerable difficulties in making transmitters and receivers which would work well in this region.

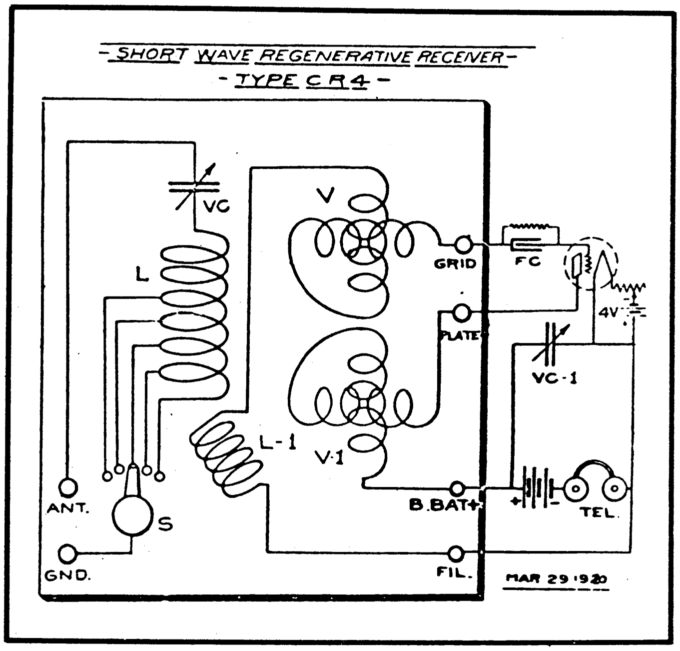
WW1 developments

World War 1 gave considerable impetus to radio development. With the entry into war in 1917 by the USA Armstrong, who had by now graduated, was given an Army commission and sent to France to carry out research. The Americans were convinced (erroneously, as it turned out) that somehow the Germans were communicating with frequencies around 3000kHz and Armstrong was asked to devise a very sensitive receiver to monitor them.

Existing valves were inefficient at such high frequencies and even his regenerative detector was ineffective. Armstrong's brilliant answer, the superheterodyne, was announced just as the war ended in 1918 and was eventually to have a profound influence on receiver design for all time. The subsequent history of the superheterodyne is an absorbing story which we will cover in the future. It is sufficient to say for the moment that it did not come into its own for another decade.

It was left to another type of receiver, the tuned radio frequency or "TRF" set to be the workhorse of the 1920's and, along with the horn speaker, to become

The 1925 Freed Eisemann was a typical 5-valve TRF, with 3 tuning controls and 2 filament rheostats for controlling gain. The hinged lid was almost universal at this time.



The circuit for the Grebe CR4 of 1920, typical of pre broadcasting era receivers. The valve was separate from the receiver cabinet. With 2 variable capacitors, two "variometer" variable inductors, a tapped inductor and a filament control it demanded a lot of skill, but results could be impressive.

the symbol of early broadcasting.

Whilst the US Army was concerned with non-existent German HF transmissions, the Navy was having a real problem. When receiving weak low frequency signals, their receivers were suffering from interference from strong local 500kHz transmissions. The Navy requested L.A. Hazeltine, then Professor of Electrical Engineering at the Stevens Institute of Technology, to design a new receiver. To avoid the interference problem, one of its features was to have minimum capacitive coupling between the aerial and secondary tuned circuits. His remedy was to cancel or *neutralise* the effect of the capacitance by the use of a separate coil.

A typical amateur receiver of 1920 was the Grebe CR4, the circuit of which is shown in Fig. 1. "Short Wave" indicates that it covered what is now the broadcast band. The variable capacitor VC and coil L tuned the aerial circuit, the main tuning and regeneration being by variable inductors V and V1 called *variometers*. Note that the detector valve was separate from the receiver. More gain could be provided by adding a two stage audio amplifier.

The controls of a receiver like this all interact, demanding a fair amount of skill to use. A few radio telephone stations were to be heard, but most transmissions were Morse, many still from spark transmitters. By now improved valves, including the UV 201 (shortly to be modified to the famous 201A) had appeared.

In America, radio broadcasting as such began during 1920. Naturally, the "ham" fraternity were involved, often using home built regenerative receivers. Marconi engineers in Britain were also experimenting with radio broadcasts. There, economics were such that only crystal sets or very simple one or two valve receivers were affordable by the average user. Oscillating regenerative detectors create interference, so their use was discouraged.

By the end of 1923, England was covered by a network of BBC transmitters of reasonable strength, and modest receiver sensitivity was sufficient. Consequently, during the 1920's English receivers were generally simple.

American conditions were different – as they were in Australia and New Zealand when radio came to this part of the world. Away from the cities, long distances from transmitters meant that receivers had to be sensitive and stable. The regenerative detector is remarkably efficient, but its sensitivity falls off rapidly with weak signals, and as mentioned previously, it radiates interference badly if used carelessly. A receiver was required that was stable, sensitive and easily tuned by unskilled users.

Armstrong's superheterodyne was not sufficiently developed. Meanwhile he had discovered super regeneration which initially showed great promise. Capable of phenomenal performance from just two valves, super regeneration was later to be successful at VHF in radar and communications, but for broadcast work, it proved to have inadequate selectivity.

Different solution

What was needed was amplification prior to detection. Valves that would amplify at RF were now available, but to achieve a worthwhile amount of gain and to provide a reasonable degree of selectivity, tuned amplifiers would be necessary. However, a valve with tuned circuits at both its grid and anode becomes a healthy oscillator. This occurs because the unavoidable small capacitance between the grid and anode inside the valve feeds sufficient energy back to the grid to cause the valve to oscillate.

One way of preventing this problem would be to cancel the effect of this capacitance. Professor Hazeltine worked on the problem and in 1923 demonstrated a solution based on his Naval work of 1918. In this he "neutralised" the grid plate capacitance by feeding a *phase reversed* signal from the anode circuit back to the gird via a very small adjustable capacitor. Correctly adjusted, this permitted stable RF amplification and by 1924 the "neutrodyne" tuned radio frequency (TRF) receiver was being sold in increasing numbers.

The TRF was very successful and soon took on a standardised form using 5 valves. There were two tuned RF stages, a grid leak detector generally without regeneration, and two transformer-coupled audio stages feeding a horn loudspeaker. Each RF amplifier and the detector had tuning capacitors with separate knobs which, along with a couple of filament control rheostats, presented a pretty fearsome array to the non technical user.

As a very small boy, I remember my grandfather tuning in Melbourne on a 1925 Federal Neutrodyne. No one else had the confidence to attempt the task. In these receivers, the dials do not track and unless all three are tuned "on the nose" nothing will be heard. Careful tuning in small increments is essential. Naturally, an important part of the operation was to write down or "log" all the settings for future reference!

Radio takes off

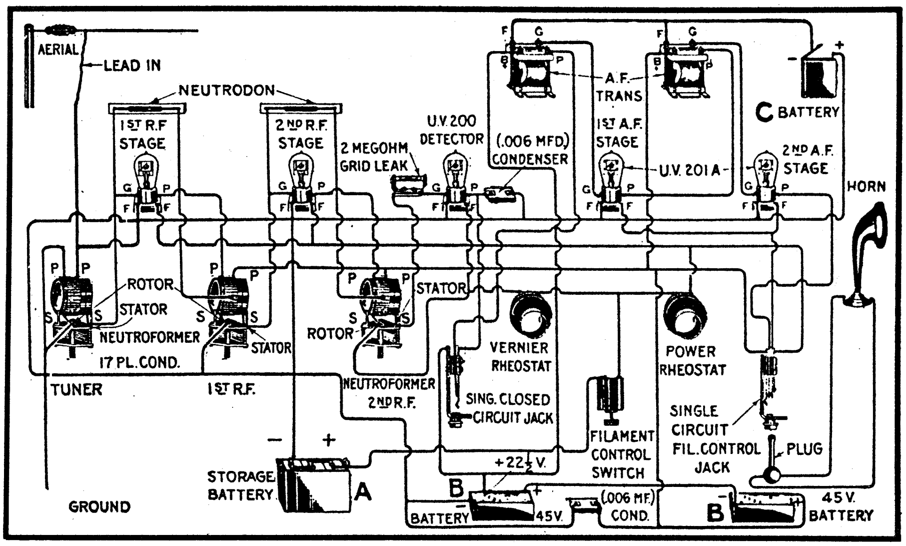
By 1925, America had gone radio mad. Literally dozens of manufacturers were making millions of receivers, the vast majority being the standard "three-knob" TRF.

Many companies resented paying Neutrodyne royalties to Hazeltine, and extensively used alternative ways to stabilise RF amplifiers. One method was to connect resistors of a few hundred ohms in series with the RF amplifier grids. The idea was to introduce sufficient losses to balance the tendency towards positive feedback. Another less elegant method was to return the grids of the RF valves to the positive end of the filament. This biased the grid positively, causing the valves to load the tuned circuits and again damp down any tendency to oscillate. This was a poor method, leading to short battery and valve life. Amplifiers stabilised by these methods were in no way as effective as well designed neutralised amplifiers.

Here was now a receiver of adequate performance, but with the serious problem of being difficult for the non technical user to operate. Attempts were soon made to couple the tuning controls together, one of the most ingenious coming from Grebe with their "Synchrophase" receivers whereby the three controls were connected by chain drives and clutches.

A later Grebe used an incredible linkage of "Meccano" parts to couple five capacitors together, whilst Atwater Kent used phosphor-bronze belts.

Two problems arose with "ganging" as it was called. One was was wide tolerances between tuning capacitors. The other was that, although RF stages could be made to track well enough, aerial tuning circuits created problems through being affected by the characteristics of individual aerials connected to them.



Dozens of 1925 receiver models differed only in small details from this Standard 5-valve Neutrodyne, with 2 neutralised RF stages.

One solution was to couple the amplifier and detector stages, but to have separate aerial tuning. This reduced the tuning to a two-handed exercise instead of three! A less satisfactory method was to directly couple the aerial without the benefit of tuning, to the grid of the first valve – leading to problems of cross modulation and harmonics. However, by 1928, tracking problems had been largely overcome and the TRF had reached the stage of being a reasonably useful and useable receiver.

There were to be two further major developments before the end of the decade. Both were to have a profound influence on radio design and will be described next month. I hope you can join me!