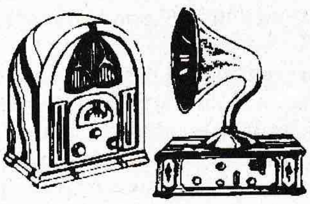
# Vintage Radio

by PETER LANKSHEAR



## Alternative detectors

**Last month we followed the history of the diode detector, its supersession by the triode, and its progressive re-adoption in the period accompanying the rapid technical developments of the 1930's. This month we look at the interim detectors which filled a very significant phase of receiver development, and some high fidelity versions which have had disappointingly few commercial applications.**

Although the American Lee De Forest is popularly credited with the invention of the triode valve, it also appeared, almost simultaneously, in Britain and Europe. These valves were 'soft' in that they contained some gas and were really only suitable as detectors, and it is clear that De Forest himself had little idea how his 'Audions' worked. He was convinced that some gas was essential to their operation.

These first valves were very different from their high vacuum successors. They were operated with only a few volts of high tension, the limiting factor being 'blue glow' — the point where ionisation occurred. Because of this they can be regarded as the parents of the thyratron, which is the 'hollow state' analog of the silicon controlled rectifier.

In operation, thyratrons remain non conductive until a triggering signal is applied to the control grid. They then conduct heavily, regardless of the grid voltage, until the HT supply is interrupted or becomes negative. Although very useful industrially, thyratrons were practically never used in receivers. Exceptions were early TV timebase oscillators, and there was one broadcast receiver application which we looked at away back in the November 1989 column.

This was in the control system of the remarkable Philco 'Mystery Control' receiver — with what, for its time, was a very sophisticated remote control system.

But back to the soft valve as a detector. It was capable of very sensitive operation, but was erratic. The quantity of gas was critical and it tended to be absorbed by the valve internals. Incredible as it may seem, a popular method of releasing some of the occluded gas was to heat the valve envelope with a lighted match. Some valves had an appendage containing a wad of asbestos specifically intended for application of a flame! In those far off days, radio could be more of an art than a science...

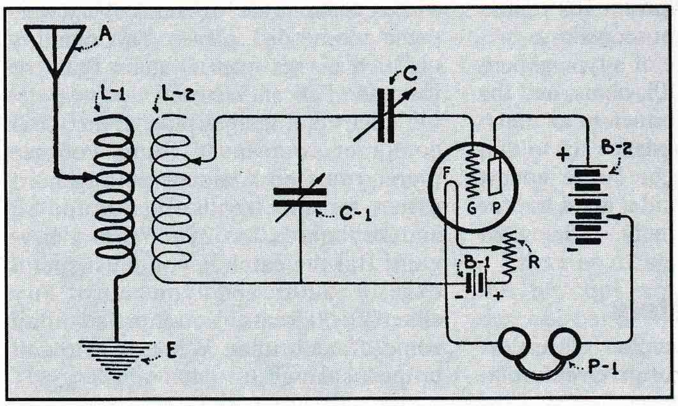
The basic circuit of these valve receivers was simple enough. A tuner was connected to the valve grid by way of a small capacitor. An HT battery and headphones were connected to the valve anode, to complete the simple setup as in Fig.1.

By the time broadcasting commenced in the early 1920's, with one exception the soft valve had given way to the high vacuum triode. The exception was the RCA UV200A, an optional plug-in replacement for the standard UV201A. The gas used was argon, and fortunately the valve did not require periodic warming!

### Grid leak necessary

When high vacuum valves were tried in the standard detector circuit, operators found that the signal would 'block' or choke up. This was caused by a charge of electrons building up on the grid, as a result of the rectifying action between the filament and the grid.

The remedy was simply to provide a high resistance path of several



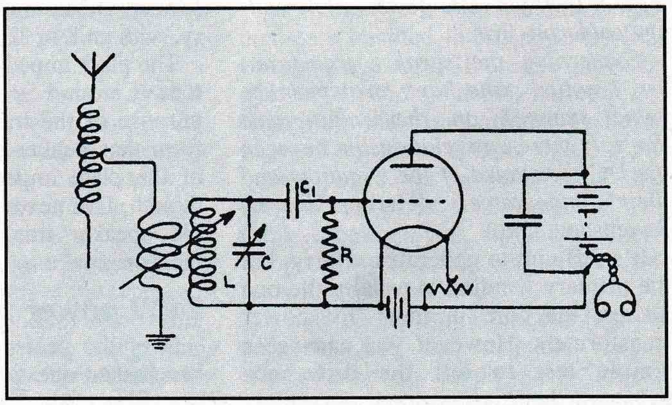




***Fig.1 (left): Taken from a 1919 textbook, a typical detector using a 'soft' vacuum valve. There was no grid leak and the grid capacitor was commonly variable to optimise performance. Fig.2 (right): The traditional grid leak detector, a hard vacuum valve version of Fig.1: This circuit was copied from the 1925 Admiralty Handbook.***


***Fig.3: The convenience of plug-in resistors and grid leaks appealed to experimenters as this advertisement copied from a 1929 magazine shows. The prices were astronomical compared with today's values.***

megohms, from the grid to the filament, so that the electrons could 'leak' away as in Fig.2. What better name for this resistor than the 'Grid Leak'? Often it was the only resistor in a battery powered receiver. A popular gag was to build a little trough to hang from the resistor, to catch any 'drips' from the leak!

Grid leaks were often just a pencil line drawn across the capacitor case itself, and could be adjusted with the aid of an eraser! Experimenters loved to try and optimise the value of the grid leak, and commercial versions were frequently made by enclosing a carbon-coated piece of paper in a glass tube with metal ends. These were often fitted to clips on the grid capacitor for ease of changing (Fig.3).

Practical values varied from about 0.5 megohms to 5.0 megohms or even more. With the higher values of grid leak the detector is most sensitive, but overloads readily; whereas with lower values, stronger signals can be handled.

As is sometimes the case with simple electronic devices, operation of the grid leak detector is much more complex than at first appearance, and was only fully worked out after it had come into general use. Fig.4 shows the fundamental circuit. It consists of a diode detector direct-coupled to a triode amplifier; but in practice there is no separate diode as the control grid itself doubles to perform this function.

The grid leak resistor can be connected to the cathode end of the tuned circuit, as shown, or more commonly, to the grid. But either way, the operation is the same. The diode rectifies the incoming RF signal, charging up the capacitor to the peak voltage of the carrier. In a practical circuit the reactance of this capacitor is for audio frequency variations, which are consequently not smoothed out, and the modulation component is transferred to the grid — to appear as an amplified signal at the anode.

Meanwhile, the rectified RF component of the signal varies with and is proportional to the strength of the incoming signal. This appears as a negative bias on the valve grid and is obviously greater for strong signals than for weak.

With a small signal, therefore, the grid has very little bias, and conversely with a powerful signal, the bias is very large, practically cutting off the anode current. The valve does not operate under optimum conditions, and by modern standards the grid leak detector has high distortion. Since about 1930 they have been used only in inexpensive receivers or for communications work.

The great advantage of the grid leak detector is that it is the most sensitive. But its shortcomings are serious distortion and also loading of the tuned circuit, which reduces selectivity.

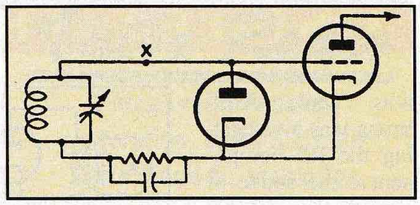



***Fig.4: A grid leak detector is in effect a triode shunted with a diode. In practice, the diode is created by the grid itself. The grid capacitor and leak are usually inserted at point X.***

## Something for nothing

The grid leak detector remained popular long after its time with generations of experimenters, because of its association with the regenerative detector. The great and eventually tragic American radio pioneer Edwin Armstrong is generally credited with discovering regeneration, but other researchers including Meissner in Germany and Round in England were concurrently researching positive feedback. Armstrong actually made his discovery in 1912, whilst still an undergraduate at Columbia University.

As well as rectifying, the grid leak detector operates as a reasonably linear amplifier, to both RF and AF signals, and consequently both are present in amplified form at the anode. It

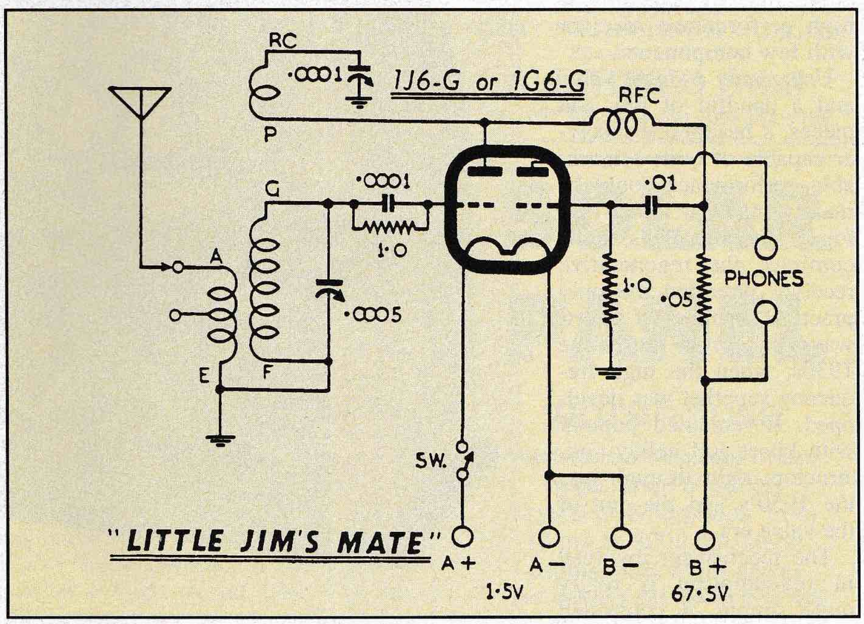



***Fig.5: Sensitive and simple to build, the regenerative grid leak detector insured its popularity with experimenters long after its abandonment in commercial receivers. This typical circuit appeared in our ancestral Radio & Hobbies for January 1947.***

was while Armstrong was investigating the RF component at the anode of a triode detector that he connected a tuning capacitor and inductance in series with the headphones, creating in effect a tuned grid-tuned plate oscillator.

The result was dramatic, to say the least. Suddenly his one valve receiver was displaying incredible sensitivity, receiving signals at previously unheard-of distances. Furthermore pure continuous wave (CW) signals from arc transmitters did not need a heterodyne signal to make them audible.

He had discovered a revolutionary new method of reception.

Regeneration has to be the best method of getting something for nothing that radio has ever known, and there can hardly be an 'old timer' who has not explored this application. With regeneration, the sensitivity and selectivity of a grid leak detector can be improved most remarkably, making possible a high performance receiver with few components.

Using only a single valve and a handful of bits and pieces, a headphone receiver capable of quite remarkable performance could be readily made at home (see Fig.5). In spite of its shortcomings, the regenerative receiver provided the only practical method of shortwave reception until the 1930s, when the high frequency superhet was developed. It remained popular with kitset and hobby constructors right through into the 1950's and the end of the valve era.

The mechanism involved in regeneration is really quite simple. A controlled amount of RF energy from the anode is fed back to the grid, in phase. This is positive feedback, resulting in a build up of energy and in the process, raising the effective 'Q' or efficiency of the tuned circuit to a remarkable degree. If the feedback is carefully controlled to the verge of oscillation, sensitivity and tuning sharpness are increased enormously.

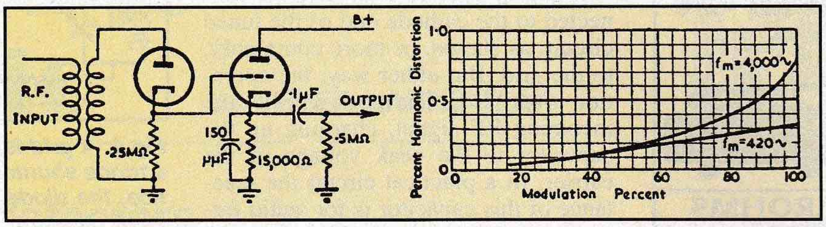



*Fig.6: This high performance detector arrived too late to find acceptance in commercial receivers. A limitation is its inability to provide automatic gain control voltage. A 12AU7/ECC82 double triode with one half connected as a diode works well.*

## Higher quality audio

With the arrival in the late 1920s of mains-powered receivers and moving coil loudspeakers, with their potential for better quality reproduction, the shortcomings of the grid leak detector for use in domestic receivers, especially its distortion, became increasingly apparent.

Mains operation exacerbated another problem — that of noise. The inability of a grid leak detector to provide more than a volt or two of audio meant that two stages of transformer-coupled amplification were necessary. This in turn resulted in a very high audio gain from the grid of the detector. In fact the total audio gain from the detector grid to the anode of the output stage could easily be in excess of 2000, making the elimination of hum and microphony difficult.

The answer was the biased or plate detector, sometimes also called the anode-bend detector, in which the valve is biased to the point where, with no signal, the anode current is virtually nil. This bias can be from a fixed source, but in the case of indirectly heated valves, was invariably derived from a cathode resistor.

When an alternating voltage, such as an RF signal is applied to the grid, the negative-going excursions have little effect on the already cut off anode current. Positive excursions however, oppose the bias and permit anode current to flow. The stronger the signal, the greater the reduction in grid bias and consequently, the larger the anode current flow. If the signal applied to the grid is modulated, the positive going components only will be amplified, and the anode current will vary with the modulation, producing an amplified signal at the anode.

It will be apparent that in the case of a weak RF signal, the anode current will be very small, and the valve will be unable to provide efficient amplification;

*Curved top 'Cathedral' receivers from the period 1931 - 33 are very popular with collectors. Many, like this 1931 'Zenette' LH, used a biased detector.*

efficient amplification; whereas an exceptionally strong signal will drive the anode current into saturation, creating serious distortion. In between these points however, the triode biased detector is efficient, with a degree of distortion that was acceptable by the standards of the day.

General practice was to control the gain prior to detection, so that the operating levels were taken care of, and an advantage was the high input resistance which minimised loading on the detector tuned circuit.

Soon after the adoption of the biased detector, the screen grid '24A and later, pentodes such as the 57 became available. A popular lineup for Australian made receivers was a 57 oscillator/mixer, a 58 IF stage and a 57 biased detector, driving a pentode output stage.

Unfortunately, there was no operating condition that produced low distortion and as a result, collectors today may spend fruitless time chasing non-existent faults in these receivers, in an effort to produce better sound.

By the mid 1930s the rediscovered diode detector had taken over in all but the cheapest receivers. The low distortion reflex or *infinite impedance* detector was used by some enthusiasts, the name indicating that the input impedance was very high. In some instances, it was a standard biased detector but the cathode resistor was not bypassed for audio.

One version was really a cathode adaptation of the same detector but with the audio signal taken from the cathode. The load resistor was also the unbypassed bias resistor, producing 100% negative feedback and therefore no audio gain, but with very little distortion. A major limitation was that the receiver needed a separate AGC detector, but nevertheless at least one commercial receiver, the New Zealand Radio Corporation's luxury model 99 used the infinite impedance detector.

Finally, as shown in Fig.6, an excellent detector appeared in 1953 as the result of work by W.T. Selsted and B.H. Smith. This is a combination of a diode with excellent AC to DC ratios, directly coupled to a cathode follower. Overall distortion is less than 1.0% at 100% modulation. Again, the major shortcoming for a commercial application is a lack of an AGC voltage.

I know of no commercial domestic application, but the New Zealand Broadcasting Corporation used it most successfully in their home grown fixed tuned TRF monitor receivers. ❖

## NOTES AND ERRATA

**PC-Driven Audio Sweep Analyser** (March 1996): On page 65, in the schematic for the analyser section of the circuit, the 47k resistor connecting from the rotor of trimpot RV4 to the non-inverting input of U2a is labelled incorrectly as R24. It should be shown as R28.

**Cancer & E-M Fields** (February 1996): On page 20, the author states that a handheld GSM cellular phone could be rated at 1W continuous, giving 100W peak if the duty cycle were 100:1. It has been pointed out that in Australia and various other countries, the maximum permitted peak power level for handheld cellular phones is 2W. The paragraph was therefore misleading in terms of the level of risk involved, and for this we apologise.

However please note that there may still be a risk in having a peak power of 2W radiating a few tens of millimetres from the user's brain.

**Microwave HV diode tester** (CDI, December 1995): The last sentence in the third paragraph should read 'Then reverse the probes across the diode'.

**PC-Driven DSO Adaptor Mk2** (May/June, 1994): To improve the stability and calibration of the instrument, especially when making measurements with 'DC' input coupling, the following modification is suggested so that R35 (1k) is included in the negative feedback loop around U8a. Cut the PCB link between pins 1 and 2 of U8a, and use a short length of insulated hookup wire to connect pin 2 to the 'other end' of R35 — i.e., the end connecting to C25, R6, R14 etc. ❖