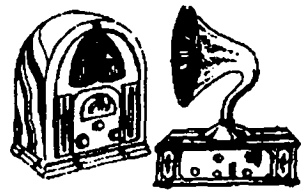
Vintage Radio

by PETER LANKSHEAR



The story of 'Reflexes'

This month's column is not about rubber hammers and kneecaps, but a technology that persisted throughout the history of valve radio, and one that was exploited to its greatest extent in Australia.

With semiconductors available today at only a few cents apiece, it is difficult to appreciate just how expensive amplification was in the early days of radio. Not only valves, but every milliampere-hour of precious battery power cost a lot of money. Any way to economise was well received.

During World War 1, much research went into triode valve applications. One US Navy worker, W.H. Priess, patented the concept of passing a signal twice through the one valve — once at RF and then, after detection, at audio frequencies. Provided that there was no overloading, with 'reflexing' (as it was called) one valve could, theoretically, do the work of two.

There seems to have been little immediate interest, but with the advent of broadcasting, reflexing became an attractive proposition to manufacturers and experimenters. Notable 1922 models were Marconi's two valve V2, and De Forest's D7 with three valves. Similarly many enthusiasts used their one precious valve as an RF amplifier feeding a crystal detector and then reflexed the audio back to the grid of the valve to again amplify the signal. Any problems like erratic operation and distortion were of little consequence.

Early superhet use

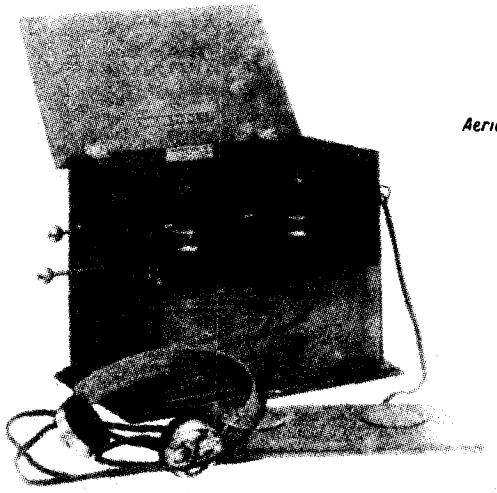
An early 'high tech' application of reflexing was in Edwin Armstrong's first generation of RCA superheterodynes, in 1924. To keep the number of valves to a minimum, the first valve was used as an RF amplifier, and then again as the first IF stage operating at about 50kHz.

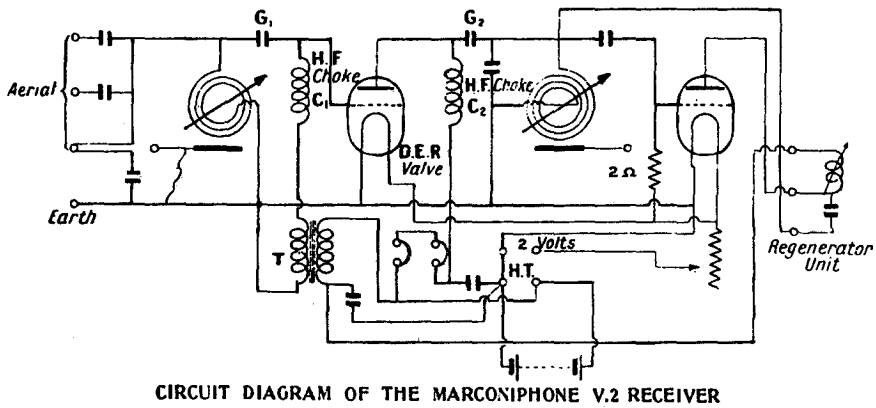
After 1925, as valves became cheaper, and users became more critical of its complications and limitations, reflexing was generally abandoned. But during 1932, the 6B7 and 2B7 double-diode-pentodes, and the 6F7 triode-pentode appeared. Each had a general purpose pentode suitable for both RF and AF amplification. The triode of the 6F7 was suitable as a detector or audio amplifier, and the diodes in the other valves were for detection and AGC.

The arrival of these multifunction valves coincided with a boom in 'midget' radios, and an increasing demand for car radios. Economies in space and battery consumption became important, providing an incentive to resurrect reflexing.

From late 1933 the Americans, especially RCA, made some use of the 6B7 in car radios as a reflexed IF and transformer-coupled audio amplifier, with the one valve providing IF and AF amplification, diode detection and AGC. This was an effective system, but a problem was that it was practically impossible to make an inexpensive wide range audio coupling transformer with sufficient inductance for pentodes such as the 6B7. The result was a restricted audio response — acceptable enough in a car, but inadequate for a domestic receiver.

With its pentode section used as an RF or IF amplifier and the triode as an audio amplifier or detector, the 6F7 soon became a popular alternative to reflexing for economical and compact receivers — typical Australian examples being the 1933 Healing 44F and Stromberg Carl-





CIRCUIT DIAGRAM OF THE MARCONIPHONE V.2 RECEIVER

Fig.1: One of the earliest British receivers made commercially was the 1922 Marconi 'V22', a reflex with the first valve combining the functions of RF and AF amplifier. Marconi used plug-in 'pancake' coils, tuned by adjustable copper 'spades'.

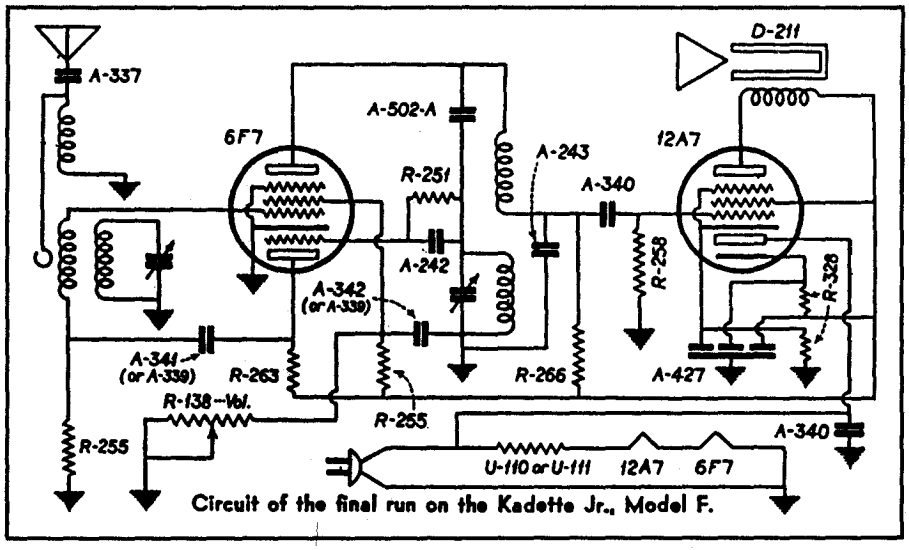


Fig.2: Using two double valves and a classic example of reflexing from 1933, the International Kadette Jr was a 'midget' which could be fitted into an overcoat pocket. The pentode section of the 6F7 was both RF and AF amp, with volume controlled by varying its screen voltage. The triode section of the same valve was used as a grid-leak detector. Note the absence of a power transformer.

son 564. Some writers confused this with reflexing, but the concept was quite different — multiple valves within the one envelope, rather than multiple use of a single valve.

However the American firm International *did* reflex the 6F7 in their unique 1933 'Kadette' TRF series. Claimed as 'The World's Smallest Radio' (for 'World' read 'America'), a Kadette could be fitted into an overcoat pocket. They had only two valves, combining the functions of RF amplifier, grid leak detector, two AF stages and mains rectifier!

Emerson and RCA made some small reflexed domestic superheterodynes in the mid 1930's, but they resorted to a resistive audio load for the 6B7. This compromise improved the audio performance, but created a serious limitation for IF/AF reflexing that was never fully overcome.

Limitations

There is insufficient space here to cover all aspects of reflex design. Readers interested in a full discussion are referred to the classic *Radiotron Designer's Handbook*, where an entire chapter was devoted to reflexing.

Briefly, to obtain a reasonable audio gain, the anode load resistor of the reflexed amplifier needed be of the order of 50k to 100k ohms. At the same time, for an acceptable IF performance, at least 100 volts were needed at the anode. With HT supplies normally around 250V, the maximum current through the anode resistor was therefore restricted to less than 2mA — inadequate for good IF amplifier performance.

If AGC was used, there was 'play through', or significant audio output even with the volume control at zero. As the control was advanced, there was a 'minimum volume' effect accompanied by distortion. As a compromise, some receivers did not use AGC, but had the manual volume control ahead of the IF amplifier.

Other problems included distortion at high modulation levels, and total receiver gain was significantly less than with the use an extra valve in a conventional receiver.

In Europe, where signal strengths were high, a less complex system became popular for economical receivers. Many European output pentodes, such as the PENA4, AL3, and EL3 had very high mutual conductances — typically 9mA/V, compared with the 2.5mA/V of the standard 2A5, 42 and 6F6 pentodes available in the US. With an efficient IF amplifier it was possible to eliminate the audio voltage amplifier, by driving these high gain valves directly from a diode detector.

The EL3 even had diodes incorporated, to become the EBL1 for this service. Unfortunately the EBL1 was a very tall valve, limiting its use in compact receivers.

Some early Australian sets such as the 1933 Astor OX, and a few New Zealand 'Ultimate' sets, did use this arrangement but their use of the insensitive American pentodes was a serious limitation. Later, the *Radio & Hobbies* 'Little General', using the higher gain beam tetrode 6V6G, was quite successful in good reception areas.

By 1937 reflexing had been pretty well abandoned in America, but not so in this part of the World. New Zealand's Ultimate produced a small four-valve reflex during the period 1937-39, but Australia became the real stronghold of reflexing.

The great Aussie reflex

The second generation of reflexing was to be taken up enthusiastically in Australia — particularly by AWA, who in 1934 introduced the first of their reflexed Radiolettes, the model 27.

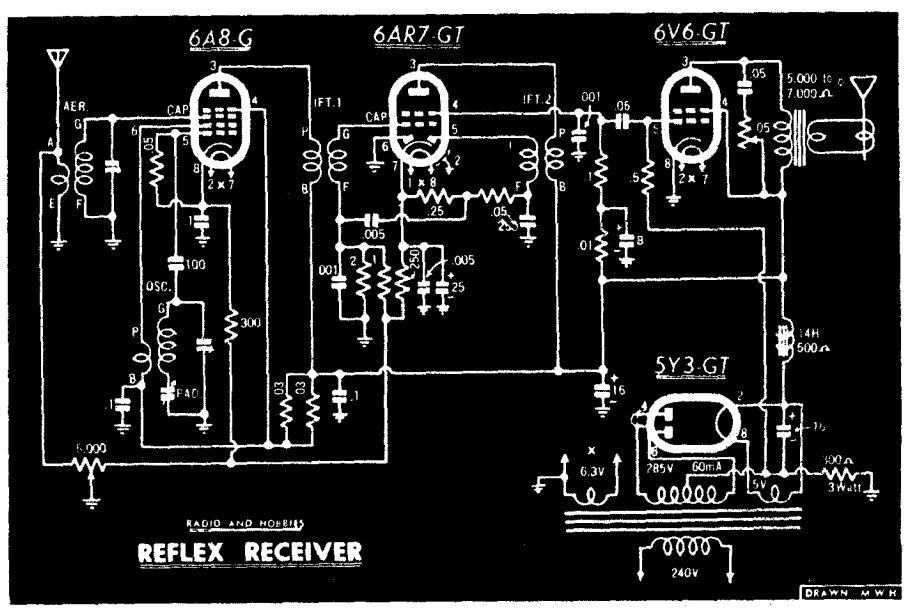


Fig.3: This 1952 'Radio & Hobbies' design represents the final development of the Australian reflex, with the screen grid of the 6AR7-GT IF valve acting as the audio stage anode. Breakthrough and low level distortion could be avoided only by using a manual gain control.

Despite the shortcomings of reflexing, the little five valve Radiolettes proved to be very popular with the public, although less so with servicemen!

With more gain than a straight five-valve receiver, their extra sensitivity could be useful. Shortwave models were added to the range in 1936. Other firms too found a demand for reflexes. The 1938 *Australian Official Radio Service Manual* lists eight different brands of reflex receiver, including battery powered versions.

For about 15 years Australia persisted with the reflex. AWV even developed valves more suited to reflexing than the semi variable-mu 6B7 and its octal equivalent, the 6B8G. There was an extended-cutoff and better shielded version, the 6B7S, and later in octal form, the 6G8G. Then in 1949 came the unique lead shielded 6AR7GT, with more than double the transconductance of the 6B7.

An interesting but late improvement came in November 1947, from a *Radio & Hobbies* reader, S.L. Marsh of Belmore in NSW. By using the screen grid of the reflexed valve as a triode anode at audio frequencies, the pentode anode could be run at full current and voltage.

This idea was taken up by *Radio & Hobbies*, who in October 1950 produced the circuit shown in Fig.3. But having no AGC, it was still a compromise.

Solid state reflexing

By now the valve reflex receiver had reached the limit of development. Miniature valves were becoming available, and the minimal cost savings of reflexing were not worthwhile.

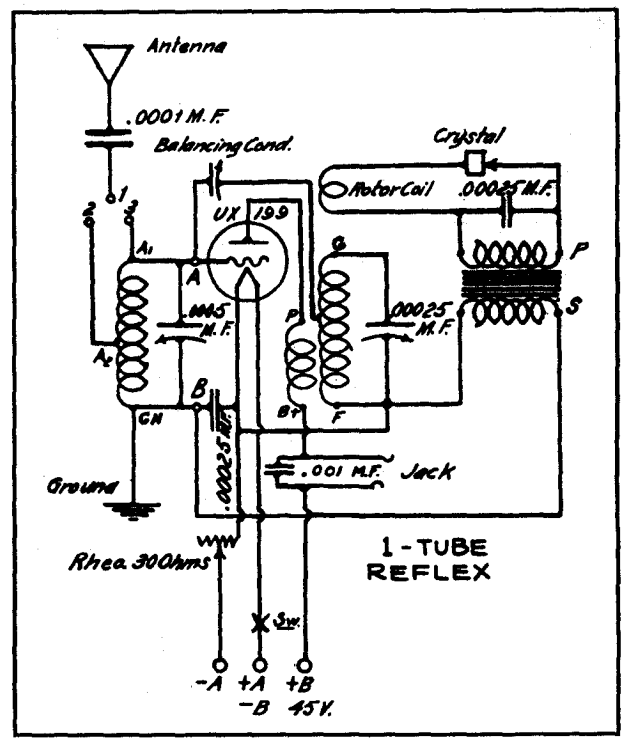
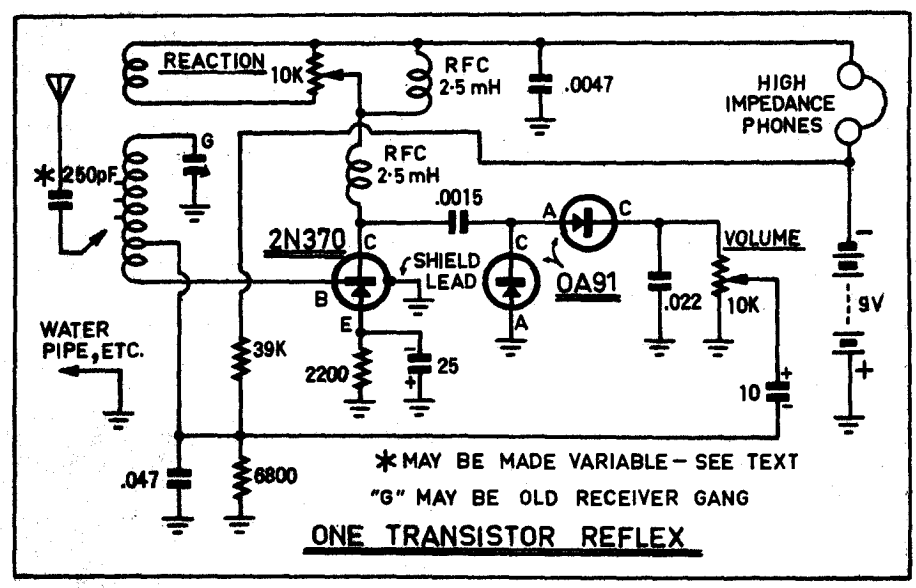


Fig.4: The wheel goes full circle! At right is the National one valve reflex for hobbyists, dating from 1925, while below is its solid state equivalent, described 37 years later by Jim Rowe in the then 'Radio, TV and Hobbies'.



But even in electronics, history has a habit of repeating itself. Experimenters were naturally excited by the arrival of the first RF transistors, but they were very expensive. In June 1963, *Radio & Hobbies* published a very full description (by Jim Rowe, now *EA*'s Managing Editor) of a single high frequency transistor reflexed receiver with RF regeneration and crystal diode detection — the solid state equivalent of the reflexed single valve circuits of 40 years before.

Finally, a successful and unusual example of reflexing came in the mid 1960's, from none other than Philips, in their F2 television chassis. The 5.5MHz sound IF signal was boosted by the transformerless 'Hi-Z' valve audio output stage, prior to conventional amplification and limiting by a single AF124 transistor IF stage.

This novel system worked quite well, as the IF signal was insignificant in an amplifier capable of several watts, and the frequency modulated IF signal was completely unaffected by the presence of audio frequencies.

Today, with amplification so cheap, reflexing is completely unwarranted and we are unlikely to ever again see this remarkable and sometimes frustrating technology, which has nevertheless left a legacy of receivers of considerable interest to the vintage radio enthusiast. ■