Vintage Radio

by PETER LANKSHEAR

Understanding automatic gain control — 1

For many vintage radio enthusiasts, much of the pleasure from their hobby comes from restoring their receivers to full working order. The functions of Automatic Gain or Volume Control, incorporated in the majority of receivers made after the mid-1930's, are important, and an understanding of what goes on can be of considerable help in fault finding.

First of all, we need to clarify a long-standing confusion — should we talk of automatic *gain* control, 'AGC', or of automatic *volume* control — 'AVC'? Over the years the two terms have often been used synonymously, but strictly speaking the latter term (AVC) is not accurate. 'Volume' refers to the sound level from the audio amplifier and speaker, which is normally controlled manually, whereas it is the receiver's *gain* that has automatic control.

By the late 1920's, the gain of large receivers was nearing the usable limit, and mains operation had made plenty of audio power available — with the result was that careless use of the volume control when tuning across strong signals could produce some very distressing noises. Another problem for listeners remote from transmitters was night-time fading. Some automatic control of receiver gain to compensate for varying signal strengths was needed.

Virtually all AGC systems encountered in valve radios vary control grid bias proportionally to the strength of the received signal. Several methods of generating a negative control voltage were developed, and some of the earliest were the most complex.

As there is no way that all the systems and variations that have evolved can be covered in two articles, we will concentrate on those most widely used, and therefore more likely to be encountered.

Fig.1: The 1932 model 71 was one of Philco's most popular series of 'Baby Grand' receivers. Advanced for its time, it used RF pentodes as well as a diode for both detection and AGC — a system Philco first used in its 1930 models. This simple and reliable arrangement remained a favourite for many years.

The first example of AGC seems to have been used in the RCA model 64, one of the '60-series' all-triode superheterodyne receivers which were very advanced at the time of their introduction in 1928. It used a separate AGC valve biased to cutoff, but with its anode connected to earth via a resistor and the cathode connected to a negative supply of 100 volts. Signals applied to the grid caused a current flow in the valve, producing a negative voltage at the anode proportional to the strength of the signal. This negative voltage was used to control the gain of the RF and IF amplifier valves.

RCA's AGC system was very effective, and various versions were used for several years. Meanwhile, a simpler system was devised by H.A. Wheeler of the Hazeltine Corporation, and released in 1929, to be taken up by some of their licensees — primarily Philco.

Wheeler's AGC system resurrected the valve diode, which had been largely neglected since the advent of the De Forest triode in 1906. After all, as valves were very costly, there had been little demand for a function that provided no amplification. However, diode detection has the great advantages of simplicity with low distortion — and as a bonus, can provide 'free' AGC from the negative voltage developed across the load resistor. Diode AGC became universal within a few years and, adapted for solid state electronics, is still in use.

A typical example

Philco's model 71 is a typical example of Wheeler's AGC system. Referring to Fig.2, the 'detector rectifier' is a type 37 triode, with its cathode earthed and its grid acting as a diode anode (anodes do

Philco Model 71 Series

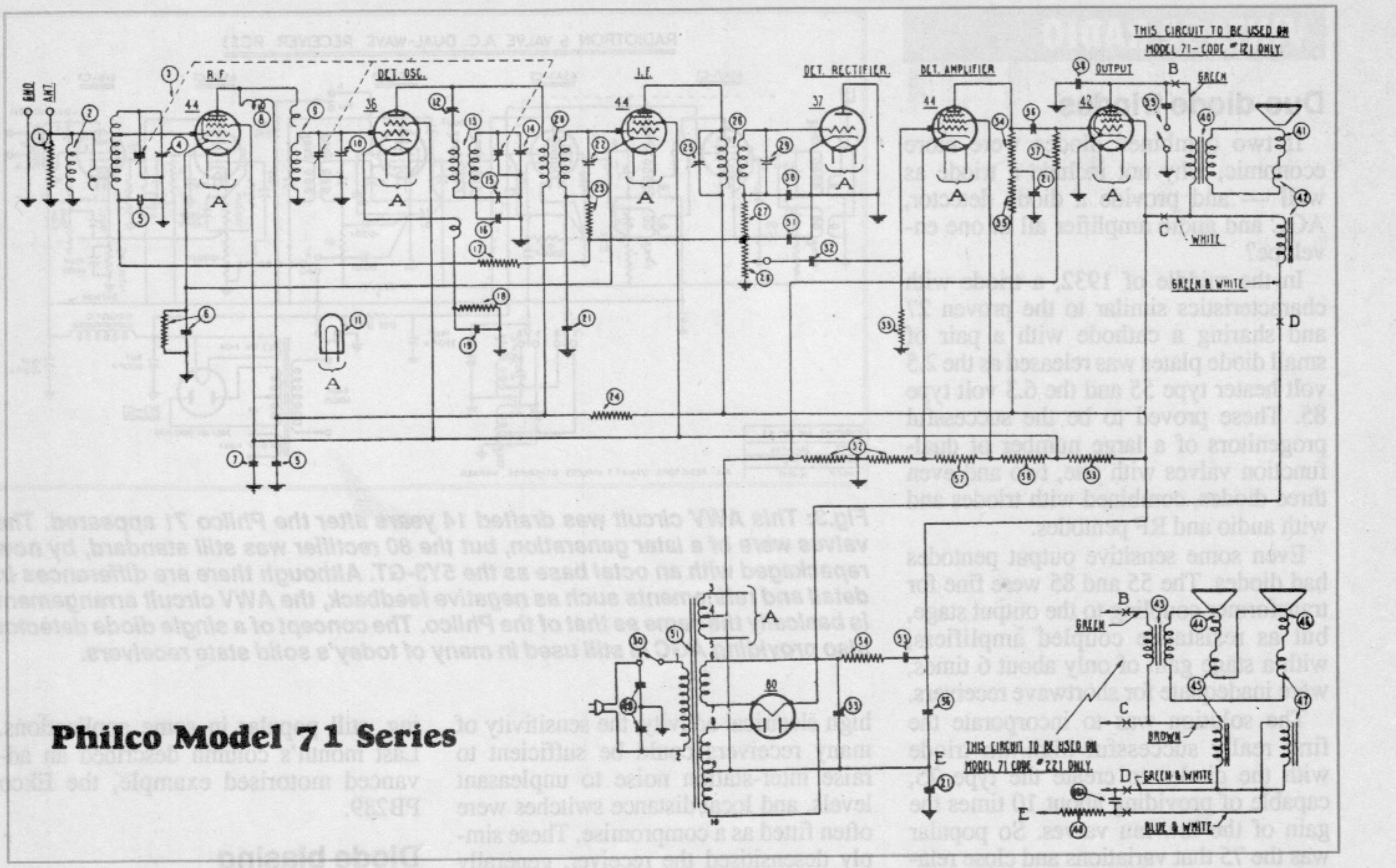

Fig.2: The Philco 71 used the type 39/44, the first variable-mu RF pentode, which had just been released. The autodyne mixer used a type 36 sharp cutoff tetrode, with a 37 triode connected as a diode for detection and AGC. The 42 output valve was also very new, and was to become a standard for many years.

not have to be solid metal). The normal anode is also earthed, and serves as a shield. Rectification of a received signal (in IF form) by the diode causes a direct current, with demodulated audio superimposed, to flow through resistor 27 and the volume control 28, producing a negative voltage proportional to the strength of the received signal.

Capacitor 30 is the 'reservoir' capacitor charged by the rectification of the IF signal, and capacitor 31 filters any IF from the audio. The audio signal is coupled out to the audio amplifier through capacitor 32.

The junction of the filter resistor and the volume control is the source of the AGC voltage, which is connected to the grid circuits of the RF and IF amplifiers. Resistors 17 and 23, together with bypass capacitors 5 and 21, have a long time constant and filter out any audio component — leaving a negative DC voltage to control the gain of the RF and IF amplifiers.

The first receivers using diode AGC were TRF's with sharp cutoff type 24 tetrodes as RF amplifiers, but gain control of these by bias variation was not very satisfactory as only a small increase would cut the anode currents right off. This was a problem even with manually controlled receivers, and it was finally solved by the 'variable mu' or 'super control' RF type 35 and 51 tetrodes, introduced in 1931.

These two valves had been developed independently and were so similar that they were combined in the 35/51, essentially a 24 with the control grid wound with a variable pitch. Whereas an increase in bias to 8.0 volts was sufficient to cut off the anode current of a 24 completely, the new valves took about 40 volts to achieve a smooth reduction to cutoff. This simple modification was very successful and thereafter became standard for RF amplifying valves.

The RF pentode

The next improvement was the addition of a suppressor grid to the tetrode to produce the first RF pentodes, the types 39 and 44. As with the 35/51 these had variable-mu characteristics, and again the two were very similar and were replaced by the 39/44.

Although these pentodes had 6.3 volt heaters and were originally intended for car radios, Philco anticipated the eventual changeover to 6.3 volt from 2.5 volt filament valves for domestic receivers and used them for their 1932 models, including their model 71. By now all of their sets were superheterodynes.

For manufacturers who still preferred the 2.5 volt filament series of valves, the type 58 variable-mu RF valve was in production by the end of 1932 and was one of the first group of valves made by Australia's AWV Co.

Using diodes

Other radio manufacturers were adopting the simple and very satisfactory diode AGC, but using triodes was uneconomic and inevitably diode valves were produced. The first American valves made for detector and AGC service were the G-2-S and G-4-S double diodes, made by Grigsby Grunow and first used in their Majestic radios in 1932.

These were used for full wave detection and AGC, as used by Stewart Warner in 1935 in their model 136 — as described in this column for June 1991. However, as will be described in the next of these articles, the extra diode also made *delayed* AGC practical.

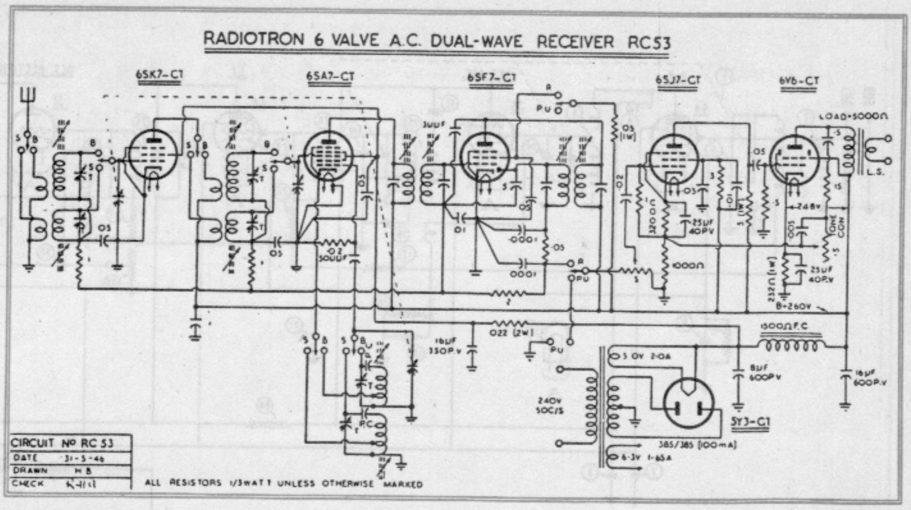

Fig.3: This AWV circuit was drafted 14 years after the Philco 71 appeared. The valves were of a later generation, but the 80 rectifier was still standard, by now repackaged with an octal base as the 5Y3-GT. Although there are differences in detail and refinements such as negative feedback, the AWV circuit arrangement is basically the same as that of the Philco. The concept of a single diode detector also providing AGC is still used in many of today's solid state receivers.

Duo-diode triodes

If two combined diodes were more economic, why not include a triode as well — and provide a diode detector, AGC and audio amplifier all in one envelope?

In the middle of 1932, a triode with characteristics similar to the proven 27 and sharing a cathode with a pair of small diode plates was released as the 2.5 volt heater type 55 and the 6.3 volt type 85. These proved to be the successful progenitors of a large number of dual-function valves with one, two and even three diodes, combined with triodes and with audio and RF pentodes.

Even some sensitive output pentodes had diodes. The 55 and 85 were fine for transformer coupling to the output stage, but as resistance coupled amplifiers, with a stage gain of only about 6 times, were inadequate for shortwave receivers.

The solution was to incorporate the first really successful high-mu triode with the diodes to create the type 75, capable of providing about 10 times the gain of the low-mu valves. So popular was the 75 that variations and close relatives were used as long as valve receivers were made. Some of the better known derivatives were the 2A6, 6B6G, 6SQ7 and 6AV6.

British and European valve makers compromised with triodes with a mu in the region of 30 to 50, popular examples being the EBC3 and EBC33.

With the availability of dual valves, diode generated AGC became increasingly popular and eventually only very inexpensive and some reflexed receivers did not have some form of AGC.

One application where AGC is essential is of course car radios. Not only must they have very good sensitivity, but also the wide variations in signal strength encountered, often at short intervals, demand an effective AGC system. Car radio development, especially in America where they could be afforded, increased rapidly with the introduction of 6.3 volt heater valves and AGC.

Problems for listeners

Although it make receivers more docile, AGC was not initially always an unqualified success. For one thing, it made accurate tuning more difficult for some users, by appearing to flatten the response curve. Consequently, several different types of tuning indicators were developed.

In some locations, such as cities with high electrical activity, the sensitivity of many receivers could be sufficient to raise inter-station noise to unpleasant levels, and local/distance switches were often fitted as a compromise. These simply desensitised the receiver, generally by adding extra bias to the RF or IF amplifiers, and were satisfactory in strong signal locations.

More sophisticated methods were muting, quiet automatic gain control, or squelch circuits which set receiver sensitivity to a predetermined level by applying a large biasing voltage to the detector diode, audio amplifier or IF stage. When the threshold was reached, the bias was overcome and the receiver operated normally. Most of these systems caused distortion, especially around the threshold level, and eventually were to be confined to communication systems and radio telephones.

Probably the most successful method of coping with difficult tuning and between station noise was pushbutton tuning, still popular in some applications. Last month's column described an advanced motorised example, the Ekco PB289.

Diode biasing

Diode biasing of the first audio stage made use of the negative voltage that is developed across the detector diode load resistor, and was used in some instances by direct coupling to the grid of a low-mu resistance coupled triode. Usually the diode load resistor was the volume control, so that the bias at the grid was dependent on both signal strength and control setting.

By simplifying loading on the diode, direct coupling is beneficial in minimising detector distortion and with low-mu resistance coupled triodes, especially the types 55 and 85, was a reasonably satisfactory system. However, volume control noise could be a problem, the low-mu triodes often did not have sufficient gain, and diode biasing was not suitable for the high- mu triodes that replaced them.

A variation of diode biasing was tried for a while, by using the resistance coupled semi-remote-cutoff pentodes 2B7 and 6B7. Plenty of audio gain was available and with the variable-mu characteristics of the valve there was an element of audio AGC, but noise caused by the action of moving the slider of the volume control was a problem.

In the next article we will look at delayed and amplified AGC, and the problems — some which can be unsuspected — that AGC faults can create. ❖