# Vintage Radio

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## Understanding Automatic Gain Control — 2

**Last month we looked at the origins of automatic gain control or 'AGC' and the simple systems that evolved. Now we will cover more elaborate methods and some of the faults, often unsuspected, that AGC can provide.**

Advantage was soon taken of the availability of a second diode in dual valves. Balanced or full wave detection reduces the necessity for IF filtering and was used for a while, but as the signal and AGC voltages developed are halved, and a centre-tapped IF transformer winding is necessary, half wave operation became standard.

Although combined detection and AGC was used frequently right into the transistor era, it has limitations. Unless receiver audio gain is fairly high, simple AGC can limit the ability of weak to medium strength signals to drive the output valve fully, and reduces receiver gain with even the weakest signals. This is not much of a problem for radios intended only for local station listening, but it is obviously undesirable for higher performance receivers.

The usual solution is to use an independant AGC diode, with delay in the commencement of control action until the signal reaches a pre determined level. This is done by biasing the AGC diode by returning its load resistor to a point negative with respect to its own cathode.

Delayed AGC has another desirable characteristic. Once the signal generates sufficient voltage to overcome the delay, gain reduction action is more effective than that of simple AGC. Detector output increases linearly until the delay point is reached. At this stage the gain curve becomes flatter than with simple AGC, resulting in a more constant detector output over a wide range of signal strengths.

Fig.1 shows the circuit of a receiver incorporating a typical delayed AGC circuit, with the right-hand diode of the EBC3 connected by a .0001uF (100pF) capacitor to the anode of the EF5 IF amplifier. The voltage drop across the 6000-ohm cathode resistor of the EBC3 places the cathode about 3 volts positive with respect to earth. The AGC diode therefore will be inactive until its signal reaches a peak level of 3 volts.

Note that the left-hand diode of the EBC3 is used as the signal detector, and as its DC load is formed by the 0.5-megohm volume control, which is returned directly to the cathode, the detector receives no delaying bias and thus operates normally.

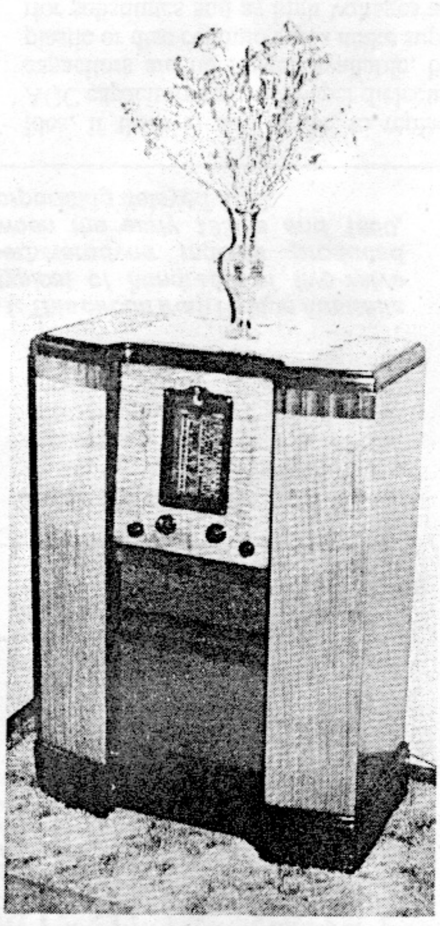
Just what is connected to a diode influences detector distortion and is least with a pure resistive load. However, AGC lines always have bypass capacitors, which make loading complex and their presence increases signal distortion. By connecting the AGC diode to the primary of the IF transformer, loading on the signal detector is reduced although not eliminated. There is still an increase in distortion at the point where the AGC diode does conduct, and as a compromise, delay voltages are usually kept sufficiently low that the transition point occurs with weak signals where good quality is not vital.

To reduce the possibility of leakage or breakdown of the coupling capacitor upsetting the AGC system, the AGC diode was often connected to the secondary of the IF transformer, but at the cost of greater distortion.

### Separate AGC amp

High performance receivers sometimes have a separate AGC IF amplifier stage operating in parallel with the signal channel, to take advantage of the benefits to be gained by separating detection and AGC functions. Greater delay voltages can be used, detector distortion is minimised, and as the AGC amplifier can operate at full gain at all times, there can be an effective amplification of the control voltage. Furthermore, the selectivity of the AGC channel can be tailored for the best results.

Stromberg-Carlson's model 837 is a typical example. Reference to Fig.2 shows that the IF signal is split to feed the grids of a pair of 6B7S valves. The upper 6B7S is a conventional IF amplifier and diode detector. Coupling between the two main coils can be adjusted with the IF transformer tapped winding operating as a variable selectivity control, and the diode load resistors R10, R11, and R12 are switched to compensate for changes in detector output as selectivity is changed. Although not used for AGC, the negative voltage developed



***The handsome Stromberg-Carlson 837 of 1937 had a specification to match its appearance, including delayed AGC.***

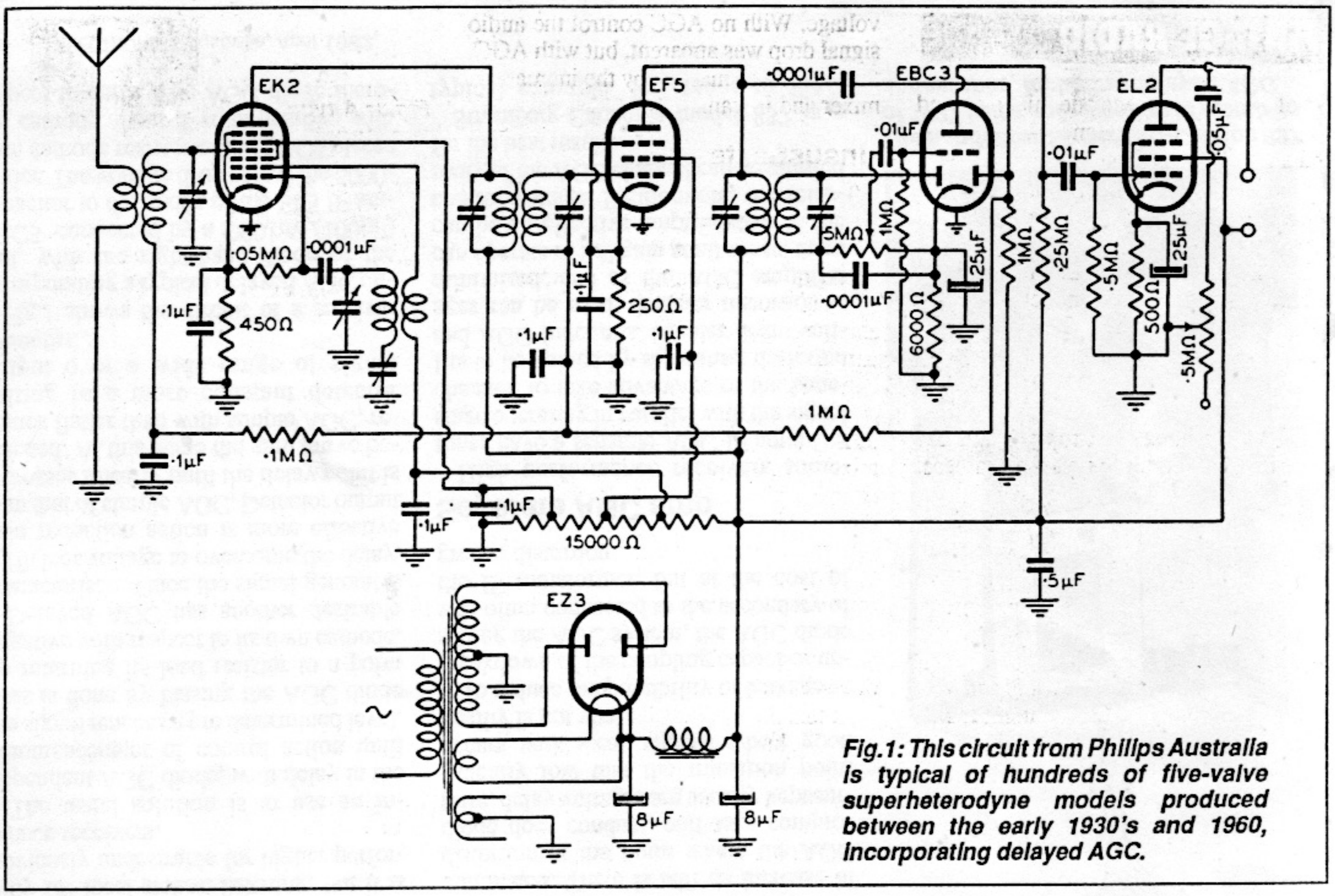



***Fig.1: This circuit from Philips Australia is typical of hundreds of five-valve superheterodyne models produced between the early 1930's and 1960, incorporating delayed AGC.***

across the diode load resistors does perform an additional function to drive the 6E5 tuning indicator.

The lower 6B7S AGC amplifier operates at full gain with fixed cathode bias and its output is coupled by an IF transformer to one of its own diodes, to be rectified to produce the AGC voltage in the usual manner. R16, the normal bias resistor, in series with R17 places the 6B7S cathode about 20 volts above earth, providing a much larger delay voltage than is practical with the usual combined detector and AGC valve. Resistors R14 and R15 divide the AGC voltage, so that only one sixth of the AGC voltage is applied to the mixer and IF valve.

Applying full AGC only to the RF stage and a fraction to the mixer and IF stages is good practice, but was not done as often as it might have been. AGC degrades shortwave frequency stability of pentagrid mixers of the 6A7 family, but even more important is the performance of the IF amplifier. When receiving strong signals, the IF amplifier may have to deliver 25 or more volts of signal to the diodes. This is well within the capabilities of a well designed IF amplifier, but if it is at the same time subject to an AGC bias of the same order, its own anode current will be severely reduced and the signal will be badly distorted. The effect of this distortion is the same as overmodulation.

Some designers took this into account in larger receivers and either left the IF amplifier without control, or applied only fractional AGC voltage. Other manufacturers simply relied on a 'Local-Distance' switch to bias back the RF and/or IF amplifier to cope with strong signals.

## Faults and repairs

Although they have only relatively few components, AGC circuits can produce some significant faults. Fortunately, most problems are readily cured, frequently by the replacement of 'tired' capacitors.

Most common is leakage in the bypass capacitors — traditionally 0.05uF (50nF) or 0.1uF paper types. These capacitors frequently have low resistance, often less than 10 megohms. For a capacitor bypassing a screen dropping or cathode resistor, this resistance would be of no significance, but with two or three capacitors bypassing a typical AGC line, losses can be quite significant.

Many moving-coil multimeters will not give much of an indication with resistances of this order. As suitable replacements are inexpensive, it is a good idea, if there is any doubt, to replace AGC capacitors anyway. Paper dielectric capacitors are no longer available, but plastic or disc ceramic types make superior substitutes and as high voltages are not involved, ratings as low as 50 volts are adequate. Modern components are very small, and the 'original' appearance can often be retained by heating the old capacitor to melt out the wax, removing the contents and concealing the replacement inside the case.

Lead dress can be important, especially for RF and mixer stages. Unfortunately replacing AGC bypass capacitors, which are often mounted beneath coil and bandswitch assemblies, may demand patience and dexterity. These capacitors often complete the circuit between tuning coils and their tuning capacitor rotors, and to preserve stability and shortwave tracking, they should be earthed at the same point as their associated tuning capacitor wiper.

One fault in AGC systems with the diode fed from the anode of the IF stage can cause a complete failure of the receiver. In many receivers the coupling capacitor was a silvered mica ('SM') type, which functioned well for years. These capacitors were made by depositing thin layers of silver on the faces of the mica dielectric plates, with the benefits of a saving in electrode thickness and of accuracy of capacitance — but they had a built-in time bomb!

If as is the case in this situation, the capacitor is exposed to a high potential between the electrodes, the silver coating tends to migrate into the mica, until eventually there is a conductive bridge between the two faces. The result is a short-circuited capacitor, which applies the receiver high tension to earth via the AGC diode.

The best replacement for one of these capacitors is a ceramic type, with at least a 350 volt rating.

One AGC-related fault gave me a lot of trouble the first time I encountered it. The receiver was a simple five valve standard superheterodyne, with a circuit much like that of the AWA in last months column. Occasionally there would be a small but irritating upward jump in volume — and typical of intermittent faults, any attempts at making a measurement caused a disturbance sufficient to make the fault disappear.

The obvious cause would be a shorting AGC bypass capacitor, but these had been replaced. Then I noticed that when the fault occurred with the AGC line disconnected, instead of increasing, the volume dropped! This provided the clue. The fault was an intermittently open .0001uF (100pF) detector load bypass capacitor. This capacitor acts as a similar manner to a power supply input filter capacitor, and when it was open circuited there was reduced audio signal and AGC voltage. With no AGC control the audio signal drop was apparent, but with AGC, this effect was masked by the increase in mixer and IF gain.

## Unsuspected fault

There is an often unsuspected problem that can seriously degrade performance in receivers with an RF amplifier stage ahead of the mixer. The symptoms are that the receiver performs indifferently and there is little AGC action. As an example, the Stromberg-Carlson 837 circuit of Fig.2 has a typical broadcast band coupling coil following the 6D6 RF amplifier, and connecting the anode to the mixer grid is a very small capacitor C9. In many cases, as can be seen in Fig.3, this capacitor actually consists of a single turn of wire wound on top of the grid winding, relying only on wire insulation for separation. With one winding having the full HT applied and the other with a negative potential, even a small amount of leakage can be serious.

At this point, the resistance to earth of an AGC line is typically 2 megohms. If, for example, the insulation leakage is only 10 megohms, potentially there could be something like 50 volts positive present on the AGC line. In practice the control grids of the AGC-controlled valves act as diodes, clamping this voltage to that of their cathodes, but the grid current flow seriously degrades performance.

The simplest way to check for this condition is to apply power to the receiver with all but the rectifier and output valves removed, and then with a high resistance meter such as a digital or vacuum-tube voltmeter, check for the presence of a positive potential on the AGC line. If there is, disconnect the wire capacitor and replace it with a 4.7pF high voltage ceramic type.

***Fig.3: A typical RF transformer with 'top coupling' capacitance provided by a turn of the primary wire closely coupled to the secondary (just visible on the centre winding). Breakdown of the insulation can seriously upset the receiver's performance.***

Another possible cause of this problem is leakage across dirty wavechange switch wafers. Aerosol cleaners can be used for cleaning these, but NEVER with the power applied to the receiver — as tracking can occur, with disastrous results.

This has not been an exhaustive coverage of all valve-receiver AGC systems, or even all the faults that can occur. But we have taken a look at the circuit arrangements most frequently encountered, and hopefully given the novice not only some insight into the way they work, but also the confidence to service them. AGC is an essential feature of vintage radio. ❖

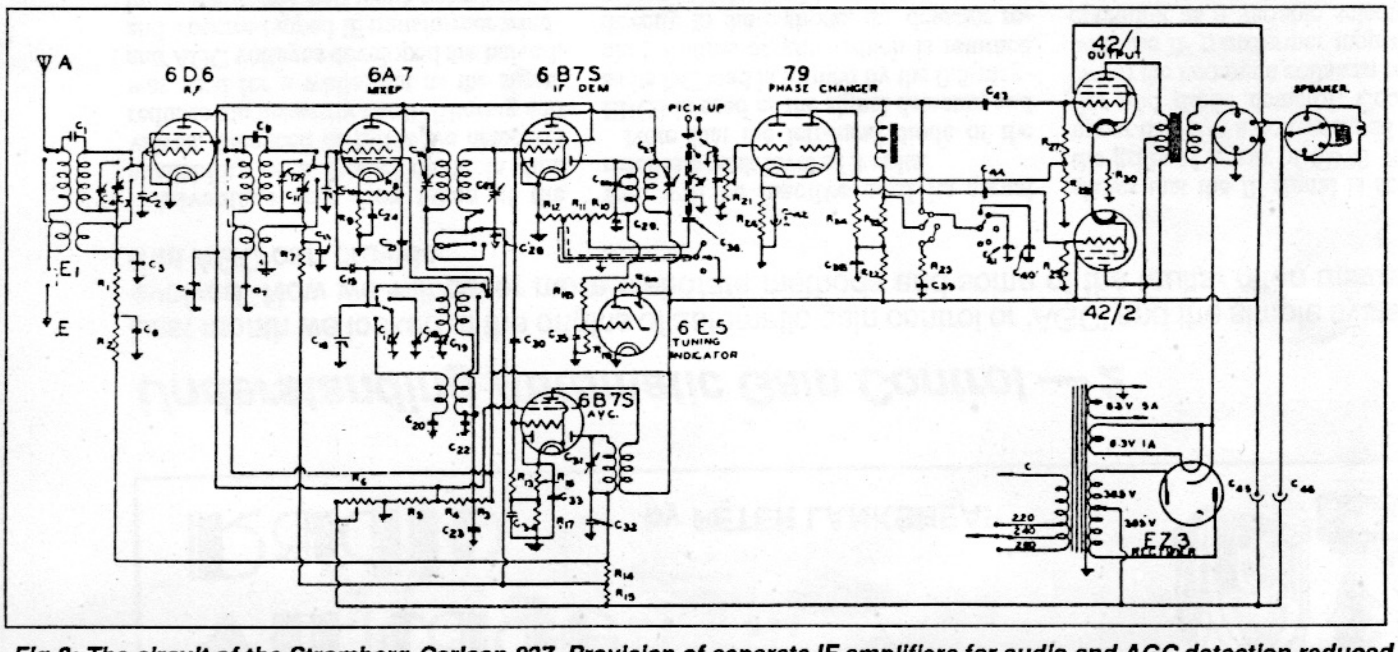



***Fig.2: The circuit of the Stromberg-Carlson 837. Provision of separate IF amplifiers for audio and AGC detection reduced the receiver's distortion and optimised amplification characteristics.***