VINTAGE RADIO

By JOHN HILL

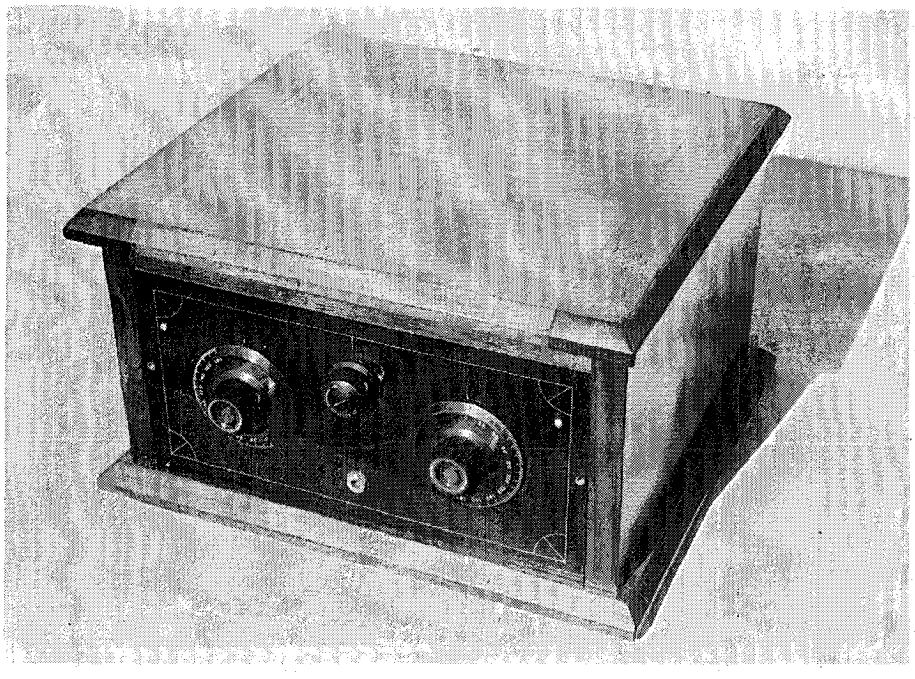
Automatic gain control: what it is & how it works

One of the most useful developments to come out of early radio was a special circuit arrangement known as Automatic Volume Control (AVC). The term was later modified to Automatic Gain Control (AGC) which, technically speaking, is more correct.

AGC is so widely used today that most people would be unaware of its existence. It is now just one of the countless things that we take for granted, without so much as a second thought.

While all modern radio (and TV) receivers have this useful control, some vintage models are less fortunate. Radios from the early to mid-1930s may or may not have been designed with AGC. Radios prior to 1930 would definitely not have AGC. The difference between having and not having AGC was very noticeable indeed.

A receiver with AGC reproduces most stations (with the exception of extremely weak or extremely strong signals) at very nearly the same volume. On the other hand, a set without AGC will vary greatly in volume from station to station, and a setting for a weak distant signal will just about split the speaker cone when the receiver is tuned to a strong local station. Tuning a set without AGC requires two hands; one for tuning and one for constant manipulation of the volume control. Indeed, listeners who like twiddling the dial will find a receiver without AGC fairly tedious to use.



Old regenerative receivers from the 1920s never had AGC as it was technically impossible. In any case, there was seldom enough gain to make it a problem.

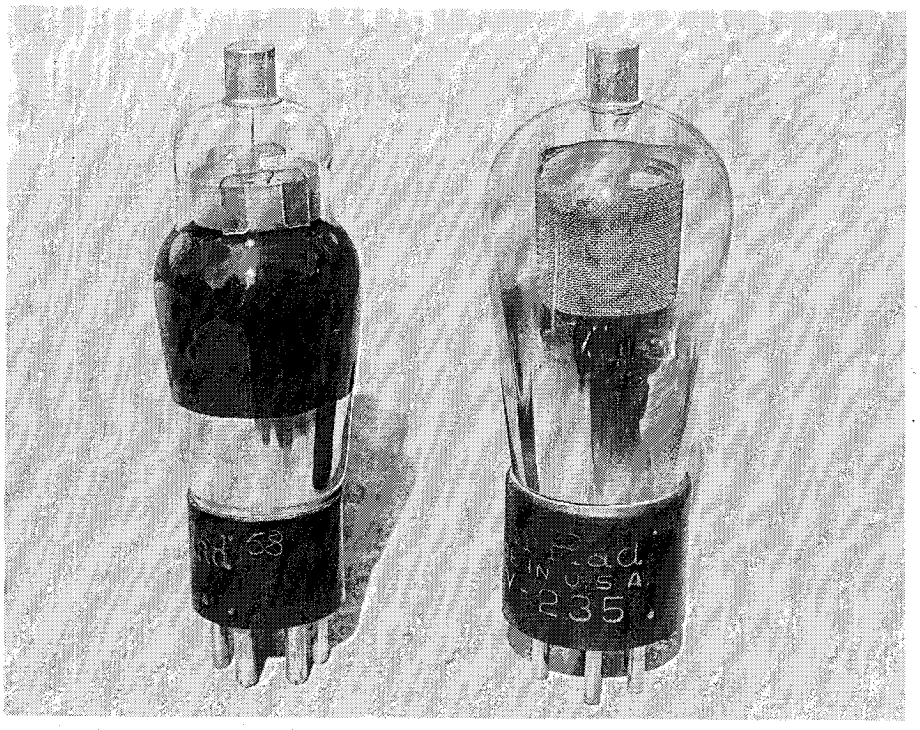
In my locality, there are four local stations with the nearest one being only a couple of kilometres away. Tuning a set without AGC under such conditions can be a real pain at times. One frequently stumbles onto one of these very strong stations, which is not only nerve shattering but could do serious damage to the loudspeaker as well.

As a matter of interest, I actually had a set stop dead when it encountered a local station. The reason was not difficult to find; the jolt had disconnected one of the speaker transformer connections. Admittedly, it was a poorly soldered joint but it was working OK until it was blown off. Such is the intensity of local station crashes with a receiver that lacks AGC.

Summing up the situation is easy. Receivers with AGC are far more pleasant and easier to operate than those without. AGC was one of the truly great developments of the 1930s.

How it works

What is the effect of AGC and how does it work?



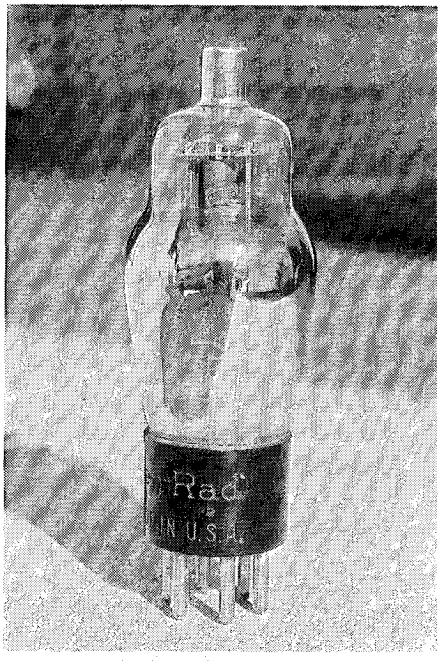
Valves such as the 58 (left) & the 235 were two of the early variable mu or remote cut-off types in service. These valves have specially constructed grids in which the turns are closer at the ends than in the centre. The application of progressively greater bias thus has the effect of concentrating the electron stream in the centre of the grid structure where there are relatively few turns, & this changes the amplification factor.

With the manual volume control set to a particular level, variations in input signal strength (within reasonable limits) have little or no effect on the level of the audio output. This convenient situation is accomplished by rectifying a sample of the received signal and applying this negative voltage as additional bias to the preceeding valves. Thus, when the set is tuned to a strong signal, the grid bias on the AGC-controlled valves increases and this reduces their gain.

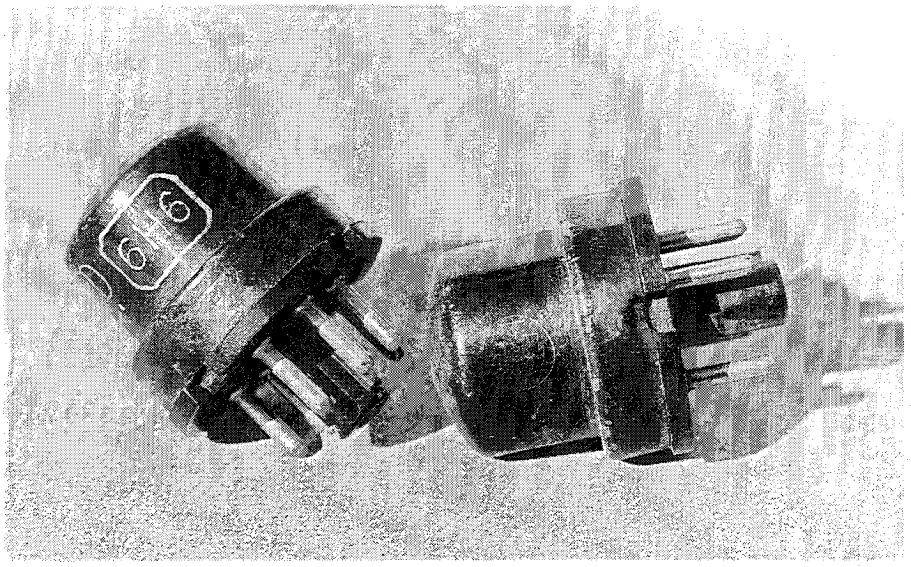
The opposite happens with a weak signal. In this case, there is less bias applied and the receiver becomes more sensitive. There are no moving parts involved and the constantly changing bias is produced electronically by the AGC circuit.

One of the advantages of AGC is that it helps to smooth out station fading, as when listening to interstate stations at night, or to overseas shortwave stations. Naturally, the AGC has its limitiations. If a station fades right out or drops into the noise level, then it is beyond the set's ability to receive a non-existent signal, or change a noisy signal into a noise-free one.

Circuits with AGC normally use diodes to produce the rectified signal. However, some very early forms used a separate valve to vary the



The old 55 was one of the first duo-diode triodes. The diodes are necessary for AGC & detection and share a common cathode with the triode section of the valve.



The 6H6 twin diode is sometimes used for AGC detection instead of a duo-diode triode valve. However, the basic principle is exactly the same.

screen grid voltage of the IF amplifier valve. Other methods of early AGC systems also used an additional valve. However, it was used as a diode in the conventional manner.

Although AGC techniques were used as early as 1930, only up-market receivers would have had such systems. Some of these arrangements were quite complex compared with later methods.

Valve types

From about 1932 onwards, diodes - usually twin diodes - were built into various valves. One of the earliest was the type 55, a 2.5V duo-diode triode. This valve was also made in 6.3V form, as the 85. A similar valve was the 2A6, another duo-diode triode, which became the 6.3V type 75, the 6B6 in octal based form, and finished its days as the 6SQ7-GT. The duo-diode arrangement, in both triode and pentode valves, was a popular one until the end of the valve era.

The diodes were usually fitted to valves designed for use as first stage audio amplifiers. Typical were triode valves such as those already mentioned, plus the 6AV6 and others.

However, the situation was not very favourable for the 4-valve receiver, which had no first audio stage. As a result, diodes were included in other types of valves, mainly "variable mu" types, used as IF amplifiers (more about these later). Typical types were the 6AR7, 6G8, EBF35 and 6N8. An alternative arrangement was to include the diodes in the power output valve, one example being the 6BV7.

It matters little in which valve the diodes are located; the diode section is separate from the rest of the valve, although it shares a common cathode.

One interesting valve is the 6H6. This is simply a 6.3V double diode. It was originally produced in metal form but there were a few glass versions made.

Similar developments took place in Europe, where valves with diodes were being used for detection and AGC as early as 1932.

Many superhets from the early 1930s, such as this 4-valve Airzone, also lacked automatic gain control. Next month, we will describe an AGC conversion for this particular receiver.

Variable mu valves

At a more practical level, while it is necessary to produce a negative AGC voltage to alter the grid bias of the earlier stages, this is of little use unless it is applied to the right valve types.

The AGC voltage can only be fully effective if is applied to the grids of "variable mu" or "remote cut-off" type valves. These valves have specially constructed control grids, designed to accept a wide range of bias. Varying the bias changes the amplification factor of the valve. "Variable mu" means variable amplification factor.

(Valves with conventional grid structures, known as "sharp cut-off" types, have only a limited range of grid bias gain control. If pushed beyond this range they can cause distortion and/or suffer interference from other strong signals).

To explain further, the variable mu control grid is unlike a normal grid which has evenly spaced turns. Instead, it is wound with a variable pitch, the turns being spaced progressively closer together towards the ends, and relatively open in the centre.

With this type of construction, the application of progressively greater bias has the effect of concentrating the electron stream in the centre of the grid structure, where there are relatively few turns. As a result, the amplification factor is low. In this way, the amplification factor can be varied by means of the bias.

With normal bias applied, the gain of these valves is similar to that of other pentode valves; it is only when the bias is increased that the gain is reduced. Variable mu type valves are used as radio frequency amplifiers, intermediate frequency amplifiers, and frequency converters.

One of the first variable mu type valves was the old 2.5V 58, which made its debut way back in 1931. It was later produced in 6.3V form as the 6D6, and then with an octal base as the 6U7G. The latter was used until the early 1950s and was a very popular valve.

In most four and 5-valve receivers, the AGC operates on the first two valves, the frequency converter and the IF amplifier. With these two valves

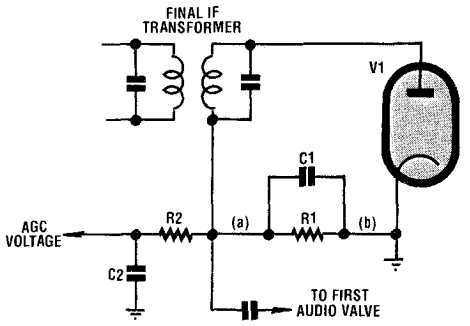


Fig.1: simplified AGC circuit. Resistor R1 is the diode load. When V1's anode is positive, current flows through R1 from (b) to (a). Thus, (a) becomes negative with respect to (b) & this negative potential varies in proportion to signal strength. This signal is then filtered by R2 & C2 to generate an AGC voltage which is then fed to the control grids of the pre-detector valves.

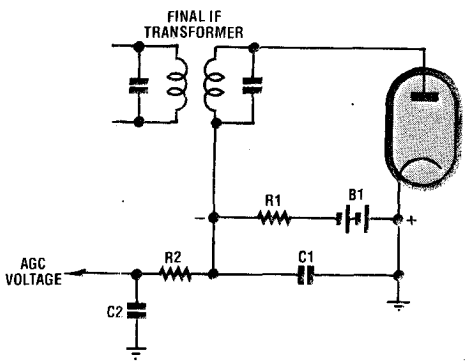


Fig.2: simplified delayed AGC circuit. By applying a small negative bias (from the battery) between the diode plate and cathode, the diode is prevented from conducting and generating AGC voltage, until the signal is greater than this bias. This gives maximum sensitivity on weak signals. Practical circuits do not use a battery; instead, the bias is derived from the cathode bias system of the audio valve.

controlled, AGC can be very effective.

If a receiver has a 6-valve complement, it could have either an RF stage or an extra IF amplifier stage. In either case, the extra valve should also be connected to the AGC line, otherwise the AGC system would not be fully effective.

Although AGC is easily accomplished, it can be a little mystifying, because there are many ways of incorporating it. One has only to look through a number of circuits to realise that there are quite a few variations in circuit technique. However, regardless of which circuit is used, they all give fairly similar results.

Checking out old circuits shows that some receivers use the two diodes for different purposes; one for detection and one for AGC. Other circuits tie the two diodes together as one and use them for both detection and AGC in the one circuit. Some circuits seem to use more components than others and, if you're not familiar with it all, it can be a little confusing.

There are two types of AGC circuits - simple AGC and delayed AGC. Where only a single diode is used the system must, of necessity, be simple AGC. If delayed AGC is required, then two separate diodes must be available.

With simple AGC, the negative AGC voltage begins to rise from the moment any weak signal (including noise) is received. In other words, very weak signals are subject to some reduction in volume because they generate small AGC voltages. This means that the maximum sensitivity of the receiver can never be fully realised although, in practice, this does not amount to a serious problem unless the signals are very weak.

Delayed AGC

Delayed AGC is a better system in that the AGC action is delayed until the incoming signal reaches a certain level. Below this level, no AGC voltage is produced, which means that the full receiver sensitivity is available to cope with weak signals. This means that very weak stations are not robbed of any volume as is the case with simple AGC.

The term "delayed" sometimes causes confusion. It does not mean a time delay; it means a level delay. This misconception can easily occur if one is unfamiliar with such systems.

I touched on AGC in a previous article, where I mentioned an intended project to add AGC to an old 5-valve Airzone, a rather stylish console model but without AGC. It was my intention to relate the details of that experiment in this story but, alas, we have run out of space again.

As I see it, there is little point in going into great detail about an important subject, without some preliminary discussion. In this case, the preliminaries took up a good deal more room than anticipated.

Next month's vintage radio column will give a full account of the AGC conversion on the old Airzone. **SC**