Amplified A.G.C. in Communications Receivers

by **J. B. Dance, M.Sc.**

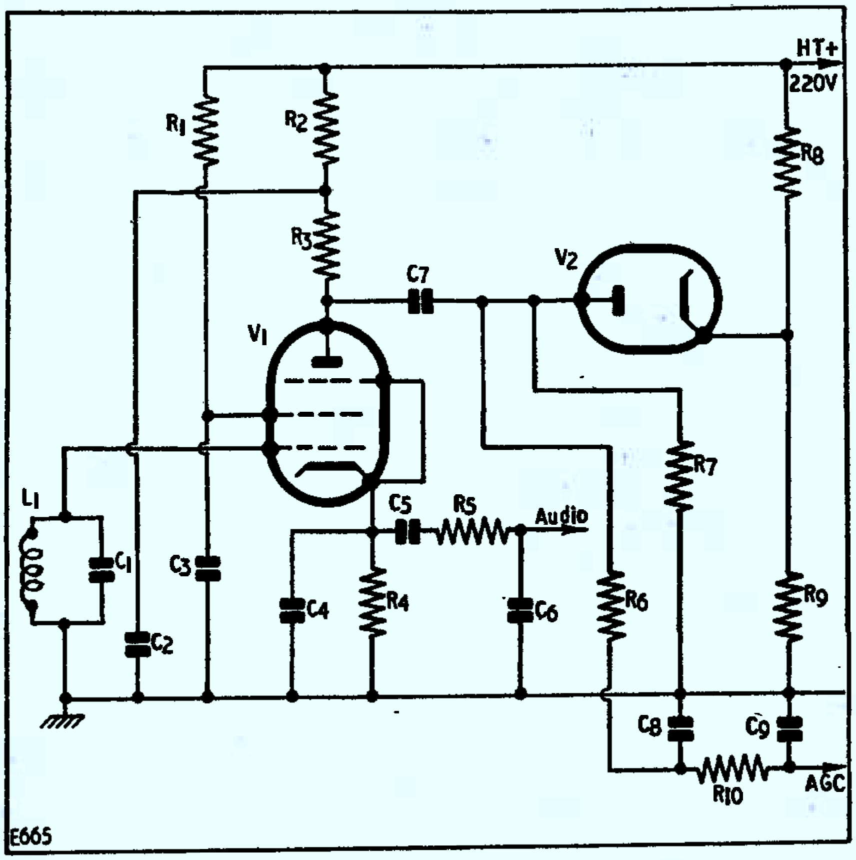
THE SIGNAL LEVELS IN THE VARIOUS STAGES of a large communication receiver must be closely controlled in order to obtain really optimum results. If the degree of control which is desirable is to be achieved automatically over a wide range of input voltages, it is essential to use some form of amplified a.g.c. Economic limitations prevent most manufacturers from incorporating a.g.c. amplifiers in their receivers, but there is no reason why amateur constructors should not use an a.g.c. amplifier in order to obtain the best possible performance. This article describes some practical methods of obtaining a.g.c. amplification which are especially suitable for the home constructor.

The need for amplification becomes obvious when one considers that the number of stages to which the full a.g.c. may be applied is strictly limited. The (first) r.f. stage should not be connected to the full a.g.c. voltage or the resulting reduced mutual conductance will give a lower signal-to-noise ratio at low signal input voltages. If, however, the first valve is left uncontrolled, the following valve will be overloaded if a strong signal is being received. It is not wise to connect the converter grid to the a.g.c. line, as the noise generated by this valve might then become greater than the amplified noise from the first r.f. stage; converters are always noisy valves and increasing this noise may lead to trouble. The application of a.g.c. to a converter may also cause frequency drift if the oscillator is not crystal controlled or if a buffer amplifier is not employed between the oscillator and mixer. There are a number of advantages to be gained from the use of the high selectivity i.f. unit in a double conversion superheterodyne at constant gain irrespective of signal input. The variable bandwidth second i.f. unit used by the author has already been described (*The Short Wave Magazine*, January 1958) and some reasons for operating this particular unit at constant gain were stated. Other advantages of using a second i.f. unit at constant gain are that the second converter always operates at a fairly low level and therefore the possibility of unwanted responses being generated by cross-modulation in this stage is reduced, the signal level is more suitable for the use of a crystal filter and enables the cut-off threshold of a 1st i.f. noise silencing circuit to be more easily controlled by a.g.c.

It therefore appears desirable to amplify weak signals as much as possible in the first i.f. stages and use the first i.f. unit to bring all the signal voltages up to a constant level for feeding into the second i.f. unit; this level should be high enough to avoid any possibility of increasing the receiver noise and low enough to completely avoid any possibility of cross-modulation in the second converter. The full undelayed a.g.c. has therefore been applied only to the first (1.6 Mc/s) i.f. valves. When a signal is being received these valves will operate with a fairly large negative a.g.c. voltage on their grids (up to minus 55 volts on very large inputs) and the effect of small changes in the a.g.c. voltage is therefore very much smaller than if the valves were operating at full gain. If the gain is to be kept fairly constant, an a.g.c. amplifier is almost essential in this type of receiver.

The desired gain may be obtained by further amplification at the i.f. frequency followed by a.g.c. detection, or by using an a.g.c. detector which itself gives gain, or by detection and subsequent d.c. amplification. The last method is more or less eliminated for practical reasons because stable d c. amplifiers giving much gain are always very complicated. Whilst reasonable results can be obtained by using one extra normal i.f. stage and subsequent a.g.c. detection, the extra i.f. transformer increases the bulk and the amplifier gain is not as great as could be desired. The possibility of the amplifier overloading is greater with this method than with most others. When a very low second i.f. is used an untuned i.f. amplifier could be employed to give considerable gain.

may be attenuated. If the i.f. is 50 kc/s suitable values for C_4 and C_6 are 3,300pF and 1,500pF respectively; if a higher i.f. is used, these values may be decreased in inverse proportion to a minimum of about 200pF. The value of R_8 should be adjusted



R_1 5.6kΩ
R_2 27kΩ
R_3 39kΩ
R_4 100kΩ
R_5 5kΩ
R_6 1MΩ
R_7 1MΩ
R_8 *See text*
R_9 4.7kΩ
R_{10} 220kΩ
L_1, C_1 *Final i.f. transformer*
C_2 0.5μF
C_3 0.1μF
C_4 *See text*
C_5 0.01μF
C_6 *See text*
C_7 100pF
C_8, C_9 *Adjust to produce desired a.g.c. time constant. (About* 0.1μF)
V_1 *Almost any small pentode (see text)*
V_2 VR92, ½ 6H6, ½ 6AL5, *etc.*

Fig. 1. A method of obtaining amplified a.g.c. from a cathode follower detector

Practical Methods

The circuit shown in Fig. 1 will provide amplified a.g.c., but the amplification given by this circuit alone is much too small to be satisfactory; it is, however, useful in combination with other circuits. An additional diode, V_2, is used in combination with the detector, V_1, which is virtually an infinite impedance detector. At the cathode of V_1 the i.f. (but not the a.f.) voltages are bypassed by C_4; the valve therefore gives appreciable gain at the i.f. frequency and the amplified i.f. output is taken from the anode of V_1 via C_7. V_2 detects this amplified i.f. voltage for a.g.c. purposes. V_1 may be an EF91 or almost any small pentode; if the i.f. frequency is not very high, V_1 may be a small triode such as a 6J5, 6C4, etc. The value of C_4 and C_6 required in Fig. 1 depends on the i.f. and on the amount by which the high frequencies to give the required delay voltage. Although the amplification given by this circuit is rather small, it has the advantage that the load imposed on L_1 C_1 is quite small and therefore the selectivity of the receiver will not be appreciably reduced by the addition of this a.g.c. circuit

An excellent degree of control may be obtained by using the circuit of Fig, 2. The valve operates in a similar way to an anode bend detector but is biased beyond cut-off under no-signal conditions. A separate detector is required for audio voltages. The a.g.c. amplifier-detector requires an h.t. supply negative with respect to earth; whilst it is possible to obtain this by putting a suitable high wattage resistor between earth and the negative h.t. line from the power supply, the only really satisfactory method is to employ a separate h.t. supply with the positive side earthed. This may sound expensive but is, in fact, not so (see appendix). When no signal is applied to the grid of the valve in Fig. 2, the anode current must be cut off by the bias developed by R_3 and R_4. It is necessary to use potential dividing resistors to maintain correct d.c. conditions at the rapidly once the anode current has started to flow and hence this circuit handles large signals very well. The previous i.f. transformer is loaded by C_2R_1; this may be avoided either by using two secondary windings in the last i.f. transformer, one to supply the audio detector and one to supply

R_1 1MΩ
R_2 560kΩ
R_3 20kΩ pot (*preset*)
R_4 220kΩ
R_5 75kΩ
R_6 100kΩ
R_7 500kΩ
R_8 5kΩ
L_1, C_1 *Final i.f. transformer*
C_2 100pF
C_3 0.1μF
C_4 0.1μF
C_5, C_6 *Adjust to desired time constant*
C_7 0.1μF
V_1 EF91, *etc.*

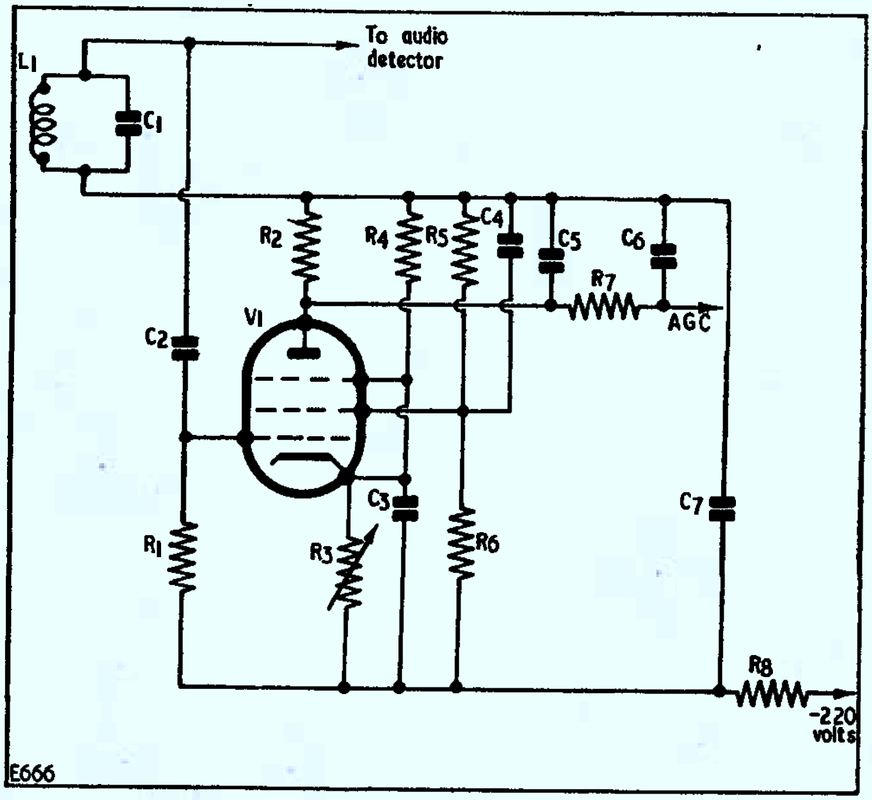


Fig. 2. Amplified a.g.c. circuit employing a negative h.t. supply.

valve electrodes, as single dropping resistors are useless when the valve is cut off. The a.g.c. delay is controlled by the setting of R_3; the adjustment of this potentiometer must be carried out carefully if the best results are to be obtained. The choice of component values is not at all critical, but a valve having a very sharp cut-off should be chosen so that the a.g.c. voltage quickly mounts up on an increase of signal strength; a 6SH7 is excellent in this respect, although most valves which are not variable-mu would give good results. The author has used 6SH7s and EF91s; the circuit of Fig. 2 was designed for an EF91. The screen grid of an EF91 may be used at a higher positive potential than that of many pentodes and if desired the screen grid of an EF91 used in the Fig. 2 circuit may therefore be earthed. A triode could be used in a similar circuit. The gain of the circuit is very large, especially if a high g_m tube is used; if a small alternating voltage is applied to the grid, the anode may become as much as 200 volts negative with respect to earth. The slope of the I_a/V_g curve increases

the a.g.c. valve, or by feeding the audio detector and the a.g.c. valve from the same i.f. transformer winding and using the grids of both these valves at a negative potential with respect to earth.

A better method of avoiding the loading of the last transformer by C_2R_1 of Fig. 2 and obtaining a little more amplification at the same time is to use the audio cathode follower detector to amplify the i.f., which is then detected for a.g.c. purposes using the anode bend detector as before. A suitable circuit is shown in Fig. 3; this circuit is really a combination of the circuits shown in Figs. 1 and 2 and gives excellent a.g.c. control.

The circuit shown in Fig. 4 (neglecting, for the moment, the components shown dotted) overcomes some minor objections associated with the circuits of Figs. 2 and 3. In the Fig. 4 circuit, V_1 is not biased quite beyond cut-off at no-signal level; this is better for valve life than the two previous circuits. Whilst using the circuits of Figs. 2 and 3 it was found necessary to considerably increase the bias to completely cut off the last few