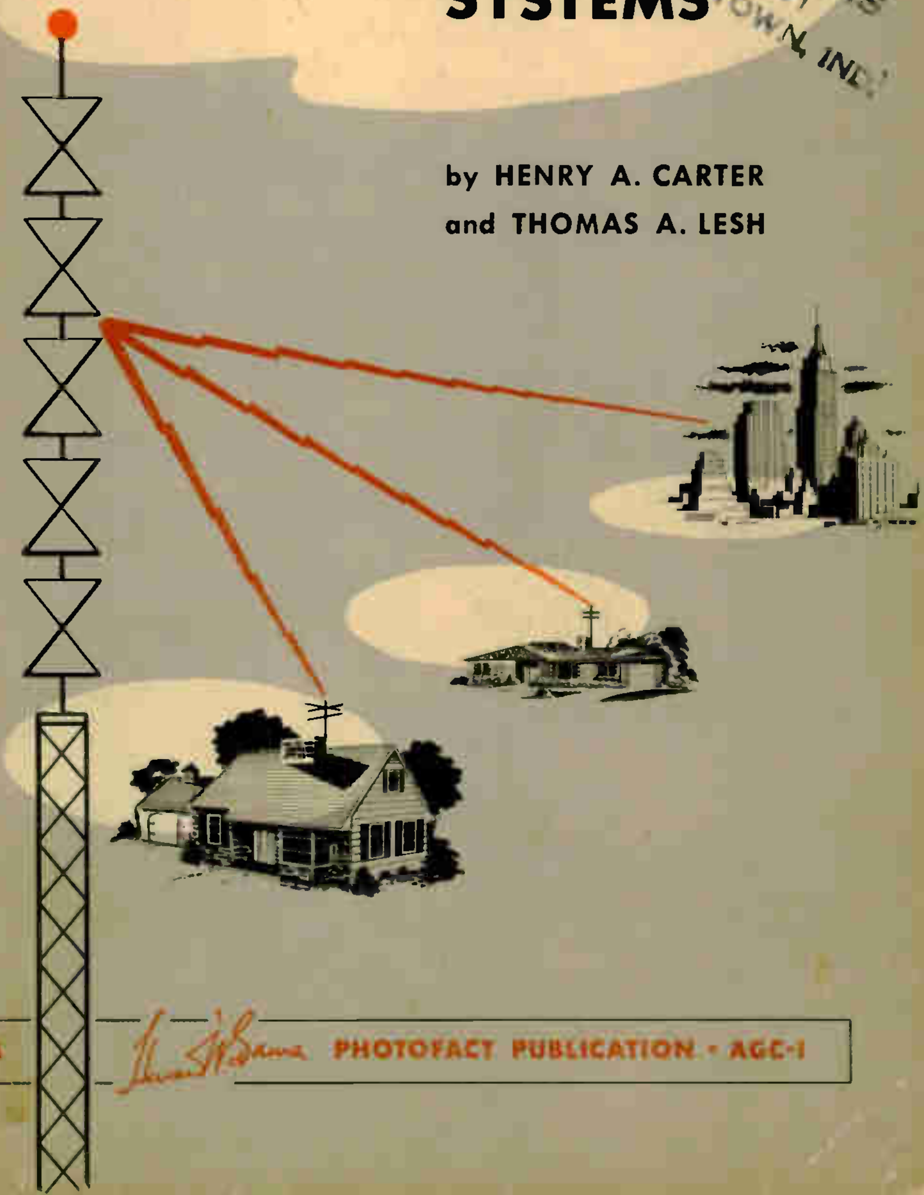
SERVICING
AGC
SYSTEMS

by HENRY A. CARTER
and THOMAS A. LESH



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PREFACE

The AGC systems in television receivers are by no means as simple as they seem to be at first glance. An AGC circuit is only one segment of a feedback loop which includes most of the stages in the video channel of a receiver, and trouble anywhere within this group of circuits affects the operation of the entire feedback loop. In this book, we have presented information which will help the technician to gain a good understanding of the problems involved in AGC servicing.

The subject of automatic gain control is discussed in considerable detail. The basic theory of AGC operation is presented, and the various types of AGC systems which are used in actual television receivers are thoroughly described. Typical symptoms of AGC troubles are shown in photographs. Servicing techniques which are applicable to AGC systems are explained, and the uses of these techniques are illustrated by a number of case histories.

We feel that the AGC circuit is important enough to be a worthwhile subject for an entire book, and we hope that our readers will profit from the information that we have gathered.

Henry A. Carter
Thomas A. Lesh

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INTRODUCTION

Some of the most difficult service problems faced by television technicians involve the automatic-gain control system of the TV receiver. The AGC circuit affects the operation of many sections at the same time. Trouble which seems to be in the AGC circuit is sometimes difficult to localize because confusion may arise as to whether the actual defect is in the AGC system itself or in one of the stages that are acted upon by the AGC.

When servicing a receiver which has AGC trouble, the technician is handicapped if he does not have a thorough understanding of the way in which the AGC system should perform. The aim of this book is to cover the subject of AGC in detail in order that the reader may undertake the servicing of automatic-gain-control circuits with increased confidence.

Why Receivers Need AGC

The purpose of automatic gain control is to minimize the effect of changes in signal strength at the receiver antenna. The gain of the RF and IF stages is regulated in such a manner that a strong signal is amplified less than a weak signal, with the result that the quality of the TV picture is relatively constant.

Variations of signal strength are of two types – the variations between the signals which are received on different channels and the variations which occur from time to time on the same channel.

Both strong and weak channels are available in many locations. If AGC is provided in the receiver, the contrast control does not need to be reset each time a new channel is tuned in. AGC also compensates for the extremely strong signals which are received from powerful stations in metropolitan areas.

The AGC system levels out most of the periodic amplitude variations which would cause fading on a particular channel; therefore, a steady picture is obtainable even in moderate fringe areas. The rapid flutter that is caused by airplanes flying near the path of the transmitted signal is also corrected as much as possible through AGC action.

Requirements of an AGC System

The first requirement of a workable AGC circuit is that of supplying a DC control voltage which is proportional to the amplitude of the incoming signal. One good way to obtain this voltage is to filter the rectified signal which appears at the output of the video detector. A filter capacitor is kept charged nearly to the peak amplitude of the sync pulses in the signal. Since the amplitude of the pulses is a good index of signal strength, the voltage across the filter capacitor can be used to control the gain of the receiver automatically. Additional filtering is necessary because practically all traces of AC ripple must be removed from the AGC voltage. The time constant of the RC filter must be long enough to remove ripple but short enough to follow the variations caused by fading of the signal.

The second requirement of the AGC system is a network to supply the correction voltage to the RF and IF sections of the receiver. The control grids of the RF amplifier and of several IF amplifiers are returned to the AGC line instead of to ground, and the AGC voltage appears on the grids as a negative bias which increases when a stronger signal is received. An increased negative bias causes these amplifiers to yield lower amplification in order to prevent distortion or signal clipping. Since the application of an AGC voltage always reduces the gain of the stage which is controlled, the feedback that is provided by an AGC circuit is degenerative in nature.

The AGC system is not able to maintain at a perfectly constant amplitude the signal which appears at the output of the last controlled stage. Such perfect control of output level is impossible in any simple system employing degenerative feedback because some variation in the output signal is needed in order to produce the required variations in the feedback voltage. The most efficient system of automatic gain control is the one which most closely approaches the ideal condition of perfectly regulated output voltage.

The AGC system may include some method of biasing the IF amplifiers more heavily than the RF stages, or vice versa. In fringe areas, it is necessary to have a low bias on the RF stages in order to get maximum gain in the tuner; however, some AGC action is desirable in the IF stages for the reduction of fading. In the strongest signal areas, it is desirable to reduce the RF amplification sharply in order to prevent overloading of all stages.

Development of AGC Designs

The first gain controls were adjusted manually to vary the bias on the RF and IF amplifiers. Automatic gain control was developed to eliminate the necessity for constant readjustment.

The simplest AGC system has already been outlined. It is a filter system that is basically similar to the automatic volume control which has long been used in radio circuits.

One refinement of the simple circuit uses an additional tube which amplifies the AGC voltage before it is applied to the RF and IF stages. This amplified AGC is not commonly used in the newest receivers; either a simpler or more complex system is currently favored.

The most highly developed commercial AGC system is called "keyed AGC." In this circuit, the AGC circuit includes a keyer tube which conducts only during the time of the horizontal sync pulses; therefore, a sample of the video signal is taken only during the pulses. The AGC voltage which is developed in this system is not affected by noise which occurs between sync pulses, nor is it affected by variations in the amplitude of the video signal.

The following chapters will describe in detail the circuitry of the various AGC systems, the relative advantages of different systems, and the methods of servicing AGC circuits.

PART I

Theory of AGC Circuits

CHAPTER 1

Simple AGC Filter

Part I of this book will be concerned with the general nature of AGC systems and the principles upon which they operate. Later parts will be given over to thorough descriptions of actual AGC circuits and of trouble-shooting procedures.

AVC the Forerunner of AGC

This discussion of AGC will begin with a review of the operation of the automatic-volume-control (AVC) circuit which is used in most radios. This will be done because AVC is the basis from which television AGC systems were derived.

Although AVC operation is highly effective, it is very simple. In most cases, only two extra components are required to incorporate AVC in a receiver. These two components are represented as R2 and C3 in the schematic diagram of Fig. 1-1A. This simple RC combination is called an AVC filter. Its job is that of converting the output of the second detector into a DC voltage which is proportional to the amplitude of the received signal. The voltage developed across the AVC capacitor C3 is fed to the control grids of several RF and IF amplifiers.

The values of R2 and C3 are both important from the standpoint of the time constant of the RC combination. It should be recalled that the time constant of an RC circuit is defined in terms of the time that it takes for the capacitor to charge or to discharge a certain amount. A charging time constant is the time in seconds which is required for the voltage across the capacitor to rise to 63.2 per cent of the value of the charging voltage, and a discharging time constant is the time in which the capacitor voltage will drop to 36.8 per cent of its peak value. During a length of time equal to five time constants, the capacitor voltage will reach 99.5 per cent of the peak charging voltage or will discharge from peak value to nearly zero.

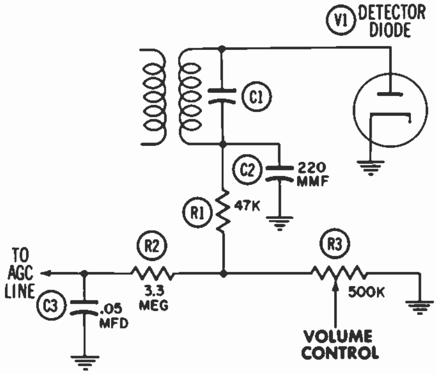


Fig. 1-1A. Schematic Diagram of a Simple AVC System Employed in Radios.

The charging or discharging time of the capacitor in an RC circuit is lengthened in direct proportion to the ohmic value of the resistor in the circuit. The time constant (expressed in seconds) of any RC filter combination can be obtained by multiplying the resistance in megohms times the capacitance in microfarads.

A filter which has a long time constant is unable to follow any variations which occur at a fast rate in the charging voltage. The time constant of an AVC filter should not be too long; if it were, the AVC system would fail to compensate for fading which occurs as often as once or twice each second. On the other hand, the time constant should not be too short. If it were, the lowest audio tones in the signal would be able to produce a noticeable change in the AVC voltage.

It is common practice in radio application to use a time constant of approximately one-tenth to one-fifth second in duration. The AVC filter in Fig. 1-1A charges through the diode-load resistor R1 as well as through R2. The resistance in the charging circuit is 3.347 megohms, and the charging time constant is approximately .17 second. The discharge path of C3 includes not only R2 but also a return path to ground through the manual volume control R3. The filter resistor in the discharging circuit therefore has a total resistance of 3.8 megohms, and the time constant in this case is .19 second.

AVC Circuit Modified for AGC Use

A circuit which is very similar to the AVC circuit of a radio can be used to provide AGC in a television receiver. In fact, such a circuit will be found in many TV receivers that are now in use. A typical AGC circuit composed of a simple filter network may be seen in the schematic diagram of Fig. 1-1B. The filter is composed of R1 and C1. The time constant of this filter circuit is approximately .15 second, a value which is very nearly the same as that of the AVC circuit in Fig. 1-1A.

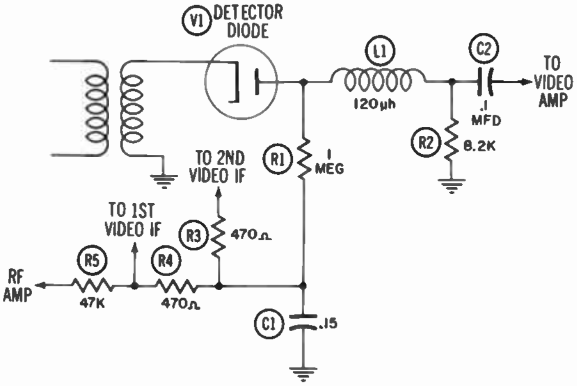
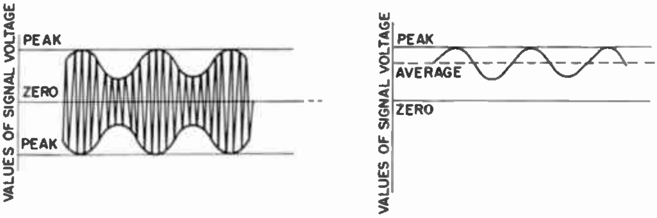


Fig. 1-1B. Schematic Diagram of a Simple Filter Used as an AGC System in a Television Receiver.

This system provides a satisfactory amount of AGC action with a minimum of extra circuitry. The video detector is a single diode which performs the dual function of furnishing an input signal to both the video amplifier section and the AGC system of the receiver.

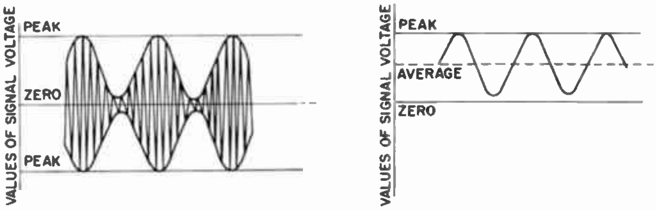
The performance of this system can be refined by the use of a special AGC diode and also by the use of a charging time constant that is shorter than the discharging time constant. A circuit which has these modifications will not be affected by the variations in scene brightness. Such variations cause shifts in the amplitude of the carrier in the television signal.

The waveform drawings in Figs. 1-2 and 1-3 are presented in an effort to clarify this peculiarity of the TV signal. The waveform drawings of Figs. 1-2A and 1-2C show a modulated IF signal which is the output of the IF amplifier of a broadcast-band receiver, and the waveform drawings of Figs. 1-3A and 1-3C represent a modulated IF signal which is the output of the last video IF amplifier of a television receiver. Each figure is bracketed by lines which represent the positive and negative peaks of signal amplitude and is bisected by another line which indicates zero voltage.



(A) Modulated IF Signal at Low Level of Modulation.

(B) Demodulated Audio Signal at Low Level of Modulation.



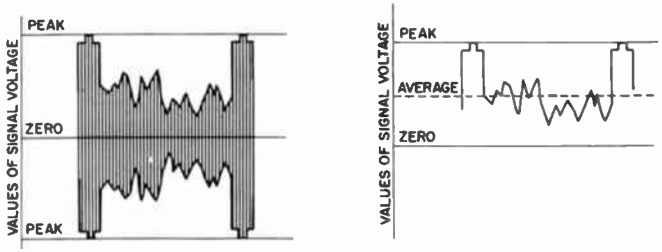
(C) Modulated IF Signal at High Level of Modulation.

(D) Demodulated Audio Signal at High Level of Modulation.

Fig. 1-2. Waveform Drawings of AM Radio Signals at Different Levels of Modulation.

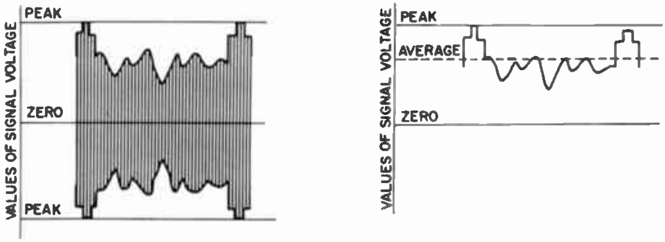
In Fig. 1-2A, the carrier is only about 50 per cent modulated; but Fig. 1-2C shows almost 100-per-cent modulation of the carrier. Since the modulating signal is a sine wave, the modulating signal is made up entirely of AC. The average amplitude of the carrier itself is the same in both figures because modulation by an AC voltage does not change the average carrier level.

The waveform in Fig. 1-3A is of a typical video IF signal which is received when a brightly illuminated scene is being transmitted. A video signal which resembles that in Fig. 1-3C will produce a comparatively dark picture. The apparent percentage of modulation is greater in Fig. 1-3C, but the difference between the two figures must be explained in a somewhat different manner. Unlike an audio signal, the video signal contains a DC component which determines the level of brightness of the picture. The picture details are carried by an AC component which varies around the DC level. The darker the over-all illumination of the picture, the higher this DC level will be. The carrier level itself changes when the DC brightness level is altered, and the power output of the television transmitter is actually greater for a dark scene than for a light one.



(A) Modulated IF Signal at Low Level of Modulation.

(B) Demodulated Video Signal at Low Level of Modulation.



(C) Modulated IF Signal at High Level of Modulation.

(D) Demodulated Video Signal at High Level of Modulation.

Fig. 1-3. Waveform Drawings of TV Receiver Signals at Different Levels of Modulation.

The B and D sections of Figs. 1-2 and 1-3 are presented for further clarification of the difference between audio signals and composite video signals. These figures illustrate the rectified and demodulated signals which are obtained from the waveforms in the A and C sections respectively.

An extra line which represents the average value of the signal voltage is drawn through each of the B and D waveforms. When the rectified signal is correctly filtered, a DC voltage with an amplitude that is represented by the distance between the extra line and the zero-reference line in the figures is developed. The level of this DC voltage may be considered to be proportional to the level of the carrier of the transmitted signal. Since the carrier level of a video signal rises when a dark scene is being transmitted, the level of the demodulated and filtered voltage will also rise when the scene is dark.

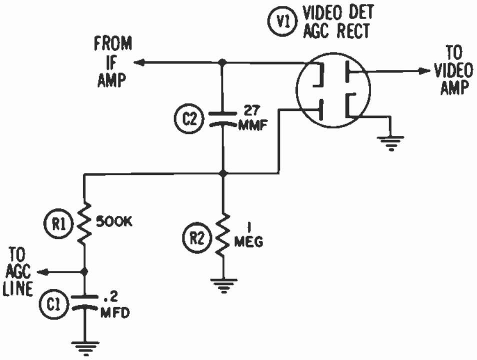


Fig. 1-4. AGC Filter Circuit Having a Long Discharging Time Constant for Use in a Television Receiver.

It is apparent that the average value of voltage of a video signal is not an absolutely true indication of signal strength. If the AGC voltage were developed from this average voltage, the output of the AGC filter would tend to increase during the transmission of scenes containing many large dark objects or a dim background.

The only portion of the composite video signal which has a constant amplitude regardless of picture content is the sync pulse signal. If the strength of the received signal does not change, a consistent peak value of voltage is reached by the tips of these pulses. This peak is comparable to the maximum voltage that is attained during 100-per-cent modulation of a carrier by an audio signal. Improved AGC action will be obtained if the AGC filter capacitor can be charged to this peak voltage and if most of this charge can be maintained between pulses.

If the charging and discharging time constants of the AGC filter are of nearly equal length, the system is never able to build up a charge that approaches the peak amplitude of the signal voltage. The discharging time constant can be lengthened in order that a greater charge may be retained on the filter capacitor. This feature has been included in the circuit that is shown schematically in Fig. 1-4.

Resistor R2 in Fig. 1-4 corresponds to R2 in Fig. 1-1B, but the value of the resistor in Fig. 1-4 has been increased to one megohm. As a result, the charging time constant is .1 second; but the discharging time constant is increased to .3 second.

A separate diode must be used for the rectification of the AGC voltage if a resistor of high value is used in the discharge circuit of the AGC capacitor. The reason for this requirement will be clear if it is noted in Fig. 1-1B that the voltage which is applied to the video amplifier is developed across R2. Most of the high-frequency portions of the video signal would be lost, if that resistor were large in value, because the shunting effect of stray capacitance in the video amplifier would be exaggerated. R2 of Fig. 1-4 may be as large as necessary because the video detector is separate from the AGC rectifier.

It should be repeated that AGC action can be obtained without special concern for the changes of brightness of the picture, but correction for that condition is important enough that many of the relatively simple AGC systems and all of the more complex systems develop the AGC voltage from the peak voltage of the sync pulses.

CHAPTER 2

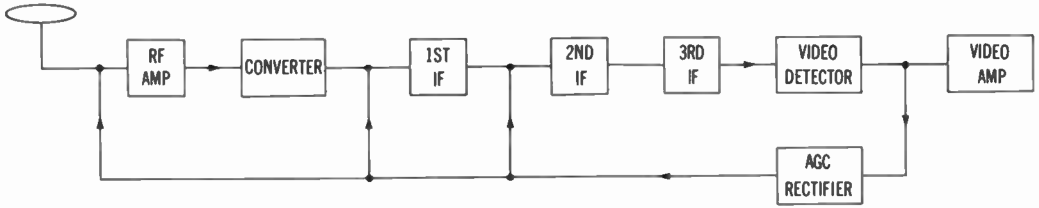
Amplified AGC Systems

An early improvement on the basic AGC system was the addition of an amplifier tube which was used to boost the amplitude of the rectified AGC voltage. Amplified AGC was used in numerous models of receivers built by RCA and several other manufacturers before 1951 or 1952. By that time, keyed AGC had replaced amplified AGC in general usage.

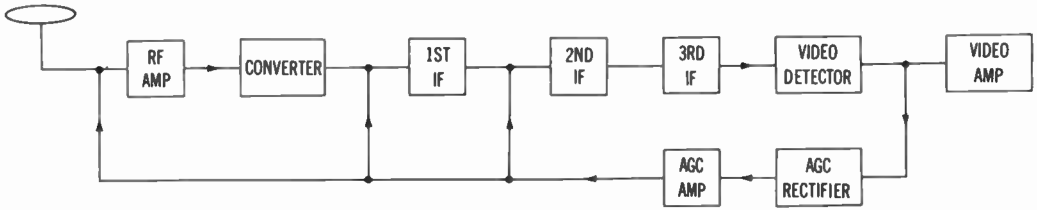
The amplified AGC system is compared with the basic filter circuit in the block diagrams of Fig. 2-1. The output of the AGC rectifier in both systems is an almost pure DC voltage which varies according to the amplitude of the sync pulses in the video signal. The output in the case of the circuit in Fig. 2-1A is negative and is applied directly to the controlled stages, but the output of the rectifier in Fig. 2-1B is positive in polarity to suit the input requirements of the AGC amplifier.

The second AGC stage in Fig. 2-1B is called a DC amplifier because the signal which it amplifies is a relatively slow variation in the DC bias voltage on its grid. Large changes in plate voltage are produced in response to small changes in grid voltage. The voltage which is present in the plate circuit of the amplifier is used directly as AGC control voltage. This voltage is applied to the grids of several amplifiers by means of a network which is commonly called the AGC line.

The two-stage, amplified AGC circuit is able to develop an adequate control voltage when the changes in the amplitude of the video signal are so slight that a simple AGC system would not respond to them. Amplified AGC is therefore more efficient than ordinary filtered AGC.



(A) Basic Type.



(B) Amplified Type.

Fig. 2-1. Black Diagrams of AGC Circuits.

Basic Circuit Operation

An amplified AGC circuit is shown in simplified form in Fig. 2-2. An almost pure DC voltage which is positive in polarity is produced across C1 and R1 when a video signal is applied to the plate of V1. This signal is directly coupled to the grid of the AGC amplifier V2.

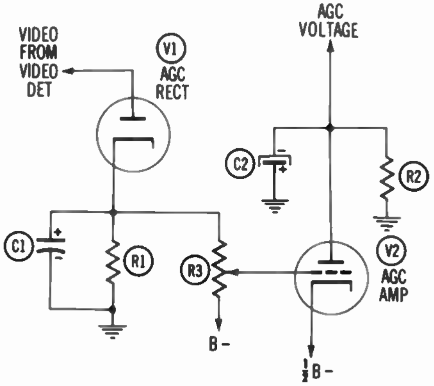


Fig. 2-2. Simplified Schematic Diagram of Amplified AGC System.

Since the AGC voltage is taken directly from the plate of the AGC amplifier, a negative voltage of low amplitude must be present in the plate circuit of V2. Unusual operating voltages are therefore applied to the tube. The plate is kept near ground potential, and high negative voltages are applied to the cathode and grid.

It is assumed that the circuit of Fig. 2-2 can be supplied with a B- voltage of approximately -100 volts. A voltage which is equal to one half the B- potential is applied to the cathode of the amplifier. The average grid voltage is determined by the setting of potentiometer R3. This control is a voltage divider between the full B- voltage and the slightly positive voltage which is present at the cathode of V1. The grid voltage of the amplifier should be slightly negative with respect to the cathode voltage.

The bias on V2 automatically varies in step with the voltage that is developed across R1 and C1 by the video signal. An increase in the amplitude of the incoming sync pulses causes the cathode voltage of V1 to go in a positive direction;

therefore, the voltage at the arm of R3 is less negative than before, and the bias on V2 is reduced. Conduction increases in the amplifier. The plate voltage of V2 swings in a negative direction, and C2 in the plate circuit is heavily charged in the polarity which is shown in Fig. 2-2. The time constant of R2 and C2 is so long that C2 discharges very slowly. The AGC control voltage is therefore nearly equal to the voltage which charges C2.

If the sync pulses decrease in amplitude, the amplifier becomes more heavily biased; and its plate voltage becomes less negative. The charge on C2 is reduced, and the AGC voltage decreases.

Detailed Circuit Description

Fig. 2-3 is a schematic diagram of an amplified AGC system which is typical of the most widely used commercial designs. The rectifier tube in this circuit is a triode, but the principle of its operation is similar to that of the diode rectifier. The incoming video signal is obtained from the plate circuit of the first video amplifier and is passed through isolating resistor R1 to the grid of the rectifier tube V1. The sync pulses in the signal are positive in polarity, and conduction through V1 is proportional to the peak amplitude of the pulses. The RC combination of C1, R2, R3, and R4 develops on the cathode a DC voltage which is proportional to the amount of conduction.

The output of the rectifier is not a perfect DC voltage because the time constant of the RC circuit is relatively short. Capacitor C2 discharges slightly between horizontal pulses, and a sawtooth waveform of voltage consequently appears at the cathode of V1. This sawtooth is of low amplitude in comparison with the DC voltage, and it is filtered out by the circuit of the AGC amplifier. Capacitor C2 is included in the circuit for filtering purposes.

The cathode of the amplifier tube V2 is returned to -50 volts. The level of the grid voltage is determined by the setting of the AGC threshold control R3. The average voltage at the arm of R3 is several volts more negative than the V2 cathode voltage. Since the average bias on V2 determines the average amount of conduction through the tube, R3 can be used to adjust the range of AGC voltage that is applied to the controlled RF and IF stages.

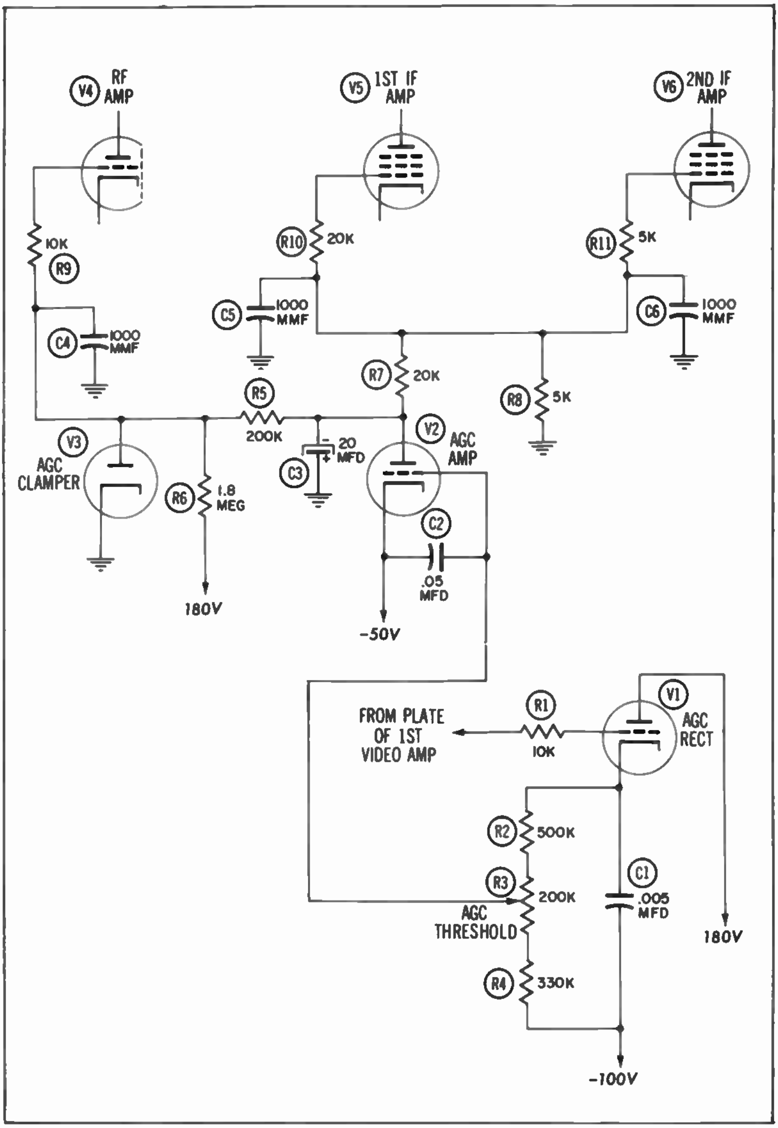


Fig. 2-3. Schematic Diagram of Typical Amplified AGC System.

The output voltage of V2 is developed across the RC combination of C3, R7, and R8. The negative charge on C3 is proportional to the amount of conduction through the tube. The time constant of the RC network is considerably longer than the interval between vertical pulses. This RC time is long enough that the output is maintained at a level which is very close to the peak voltage across C3. All signal fluctuations which are due to the sync pulses are leveled out, but the system is able to adjust its output to the slower variations which are caused by fading of the input signal.

The voltage which is present at the plate of V2 is much higher in amplitude than the required AGC bias voltage, and therefore both the IF bias and the RF bias are taken from intermediate points on voltage dividers. The bias for two IF amplifiers V5 and V6 is obtained at the junction of R7 and R8, and the bias for the first stage V4 of a cascode type of RF amplifier is tapped off at the junction of R5 and R6.

Delayed AGC for RF Stage

Even the weakest usable input signal develops some AGC voltage which reduces the gain of all stages controlled by the AGC system. Unfortunately, the amplitude of a weak signal at the grid of the RF amplifier is barely more than the amplitude of the noise which is present in that stage. When reception is poor, full gain in the RF stage is essential so that the signal-to-noise ratio can be kept high. Once the signal has been amplified above the level of the noise, it canbe acted upon by AGC in the IF amplifiers without bad effects.

Provisions are therefore made for delaying the action of the AGC bias on the RF amplifier in many receivers. The delay circuit includes a connection through a high resistance to B+. When a weak signal is being received, the tuner bias is sharply reduced because of the presence of this B+ connection. Frequently included in a delay circuit is a clamper diode which conducts and shorts the AGC line to ground whenever the bias voltage tends to become positive. The circuit of Fig. 2-3 utilizes both a B+ connection and a clamper.

A difference between RF and IF bias voltages results from the operation of the delay circuit of Fig. 2-3. This difference is shown in the graph of Fig. 2-4. It can be seen that no bias is applied to the RF amplifier until the incoming signal is strong enough to develop -4 volts of bias in the IF section of the AGC line. The RF bias appears at this signal level, increases more rapidly than the IF bias, and eventually becomes greater than the IF bias. When the incoming signal is strongest, the RF amplifier is biased most heavily; and the signal is promptly reduced before it has a chance to overload any of the IF amplifiers.

Recall that the RF bias is taken from the junction of R5 and R6 in Fig. 2-3. This take-off point is a tap on a voltage divider between a fixed B+ potential of 180 volts and the negative voltage which is present at the plate of V2. One tenth of the total voltage difference is dropped across R5 because the resistance of R5 is one tenth of the total resistance of the voltage divider.

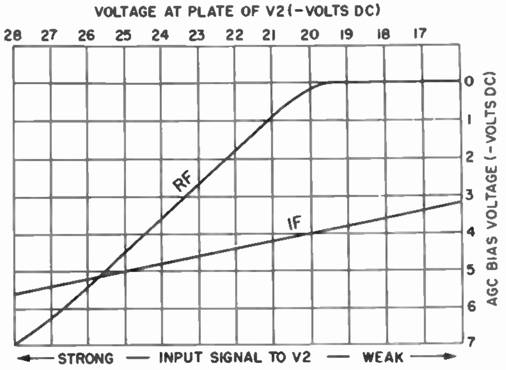


Fig. 2-4. Comparison of RF and IF Bias Voltages Developed in Circuit of Fig. 2-3.

If the plate voltage of V2 is -20 volts, the difference of potential across the entire divider network is 200 volts. The drop across R5 is:

$$\frac{1}{10} \times 200 = 20 \text{ volts}$$

The voltage at the junction of R5 and R6 is 20 volts positive with respect to the plate voltage of V2, and therefore it is zero with respect to ground.

At this same plate voltage of -20 volts, an AGC bias of -4 volts is delivered to the IF amplifiers because of the 4 to 1 resistance ratio of 20K to 5K ohms between R7 and R8.

A decrease in the strength of the input signal would cause the plate voltage of V2 to become less negative. The IF bias would be slightly reduced. The RF bias would attempt to become slightly positive, but V3 would conduct and would maintain the bias voltage at practically zero.

If the input signal became strong enough to drive the plate voltage of V2 to a value more negative than -20 volts, the IF bias would increase in the proportion of 1 volt for every 5-volt change of plate voltage. The RF bias would build up rapidly to the values shown in Fig. 2-4.

The manner in which the RF bias is developed is best explained mathematically by computation of the value of a representative point on the RF curve in Fig. 2-4. For this computation, it will be assumed that the plate voltage of V2 is -25 volts. The total voltage across R5 and R6 in series will then equal -25 plus 180, or 205 volts. Since the resistance of R5 is one tenth of the combined resistance of R5 and R6, the voltage across R5 will be one tenth of 205 volts, or 20.5 volts. The RF bias voltage is taken from the less negative end of R5; consequently, this voltage will be 20.5 volts less negative than the plate voltage of V2. The bias voltage will be the algebraic sum of 25 and +20.5 volts, or -4.5 volts.

The AGC threshold control can be varied in order that the strength of the video signal which will produce -20 volts at the plate of V2 can be determined. In other words, the setting of the control establishes the amount of delay for the RF bias.

The clamper diode is not a distinctive feature of the amplified AGC system. It is often included in AGC circuits of all types, but it may be omitted if a delay of AGC voltage is not thought necessary in the design of a particular receiver. The clamper is frequently a diode section of a combined diode-triode such as the 6AV6, and therefore a failure of the clamper tube may affect the operation of a seemingly unrelated section of the receiver.

Problems Unsolved By Amplified AGC

The amplified system gives somewhat more efficient control of amplitude variations than can be achieved with the simplest AGC circuits, but there are still deficiencies in the amplified type of AGC.

One problem which was not solved by the use of amplified AGC is that noise pulses of high amplitude in the video signal add to the charge on the filter capacitor of the AGC rectifier. The AGC voltage consequently is increased by the presence of noise, and the signal is too greatly attenuated. The signal-to-noise ratio becomes worse than it would be without the action of the AGC circuit.

Another deficiency of amplified AGC is that the time constant of the filter must still be long enough so that the vertical pulses which occur at a rate of 60 cycles per second will be eliminated. If the pulses were allowed to reach the AGC bias line, they would produce a buzz in the sound and they would also decrease the amplitude of the incoming vertical pulses and lower the efficiency of the vertical sync circuits. The operation of a filter which has the required time constant is too sluggish to compensate for the more rapid types of airplane flutter. Disturbances which occur in the signal at a frequency as great as 20 cycles per second can still produce a noticeable flicker in the picture.

Since keyed AGC largely overcomes these drawbacks, it is preferred over amplified AGC in the design of new receivers. In spite of this fact, there are still many sets in use which contain amplified AGC and which will require servicing.

CHAPTER 3

Keyed AGC Systems

The most efficient AGC system which will be discussed in this book is called keyed AGC. A block diagram of such a system is presented in Fig. 3-1.

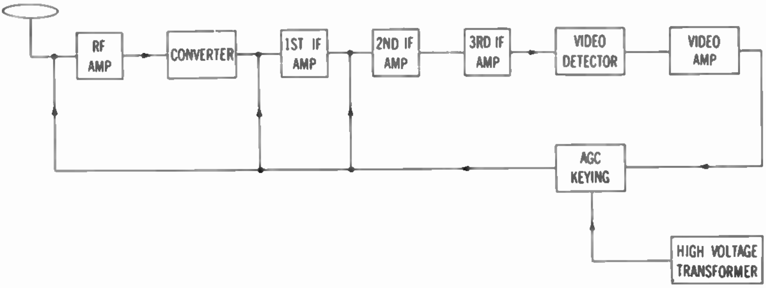
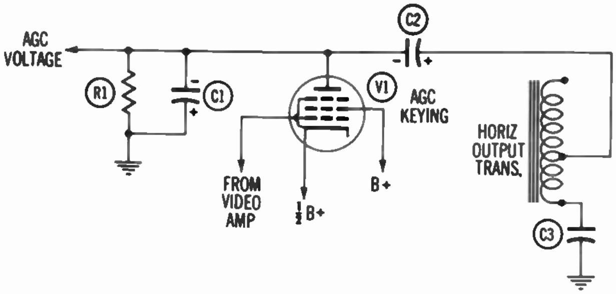


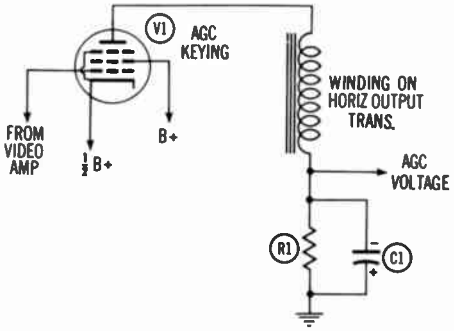
Fig. 3-1. Block Diagram of Keyed AGC System.

The system uses a keying tube which is typically a pentode but may be a triode. The tube serves as a combined rectifier and DC amplifier, and it requires two inputs. A video signal which contains positive-going horizontal sync pulses is applied to the control grid, and positive pulses of high amplitude are coupled to the plate from a winding on the horizontal output transformer. A keyed AGC system is of the shunt or series type according to whether the high-voltage winding and the AGC filter are connected in shunt or in series from plate to ground. Simplified schematic diagrams of these two basic varieties are shown in Fig. 3-2.

The conduction of the keying tube depends upon the arrival of a high-voltage pulse at the plate at the same time that a horizontal sync pulse arrives at the grid. Since the plate pulses are timed by the horizontal oscillator, they have the same frequency and phase as the sync pulses if the receiver is correctly synchronized. A short burst of conduction occurs 15,750 times each second in response to the arrival of each pulse. Since the level of the sync tips determines the bias of the keying tube during the burst of conduction, the amount of conduction that occurs during the pulses depends upon the



(A) Shunt System.



(B) Series System.

Fig. 3-2. Simplified Schematic Diagrams of Keyed AGC Systems.

DC level that is reached by the tips of the horizontal sync pulses at the grid. The level of the sync tips in turn depends upon the strength of the incoming signal. The keying tube is cut off between pulses, and the plate voltage assumes a negative value which is proportional to the amount of conduction that takes place during the pulses. The greater the conduction, the more negative the average plate voltage.

The plate voltage is filtered in both circuits of Fig. 3-2 by the combination of R1 and C1, and the resultant DC voltage is applied to the RF amplifier and to one or more IF amplifiers as grid bias.

Since the keying tube is cut off in the interval between horizontal sync pulses, noise and video cannot affect the production of AGC voltage. In addition, the keyed AGC circuit does not respond to the vertical sync pulses. The keying tube conducts only during alternate equalizing and serration pulses. This amount of conduction is not sufficient to cause a periodic rise in AGC voltage at the vertical rate of 60 cps; therefore, the AGC filter no longer has to be designed to remove the vertical pulses from the output voltage. The time constant of the filter in the keyed AGC circuit can be shortened enough to make the receiver largely immune to airplane flutter.

Refer again to the diagrams in Fig. 3-2. In the shunt type of keyed AGC circuit shown in Fig. 3-2A, the high-voltage pulses are coupled to the plate of the keying tube through a capacitor. In this case, the pulses may be taken from a tap on the horizontal output transformer. The capacitor isolates the AGC circuit from the transformer, and a special AGC winding on the transformer is not required. In spite of this fact, an isolated winding is often used.

The conduction of the keying tube causes C2 to charge in the polarity shown in Fig. 3-2A. Between pulses, C2 discharges and maintains a charge on the filter capacitor C1. The voltage across C1 is supplied to the various controlled stages as AGC bias.

The series type of keyed AGC, which is shown schematically in Fig. 3-2B, uses direct coupling of the keying pulses to the plate of the tube. Since the AGC winding of the horizontal output transformer is tied directly to the AGC bias line, this winding must be isolated from other transformer windings which might carry high AC or DC voltages.

Capacitor C1 is charged to a degree which is determined by the amount of conduction through the keying tube, and the time constant of C1 and R1 is long enough to maintain the charge on C1 at a value which is very close to the peak value of the conduction.

In both of the circuits which are shown in Fig. 3-2, the keying tube is kept cut off between pulses. This condition of cutoff is maintained because the negative AGC voltage is the only voltage that is applied to the plate of the tube between keying pulses.

The grid and cathode voltages of the keying tube have high positive values in most actual circuits. The reason behind the use of a highly positive grid voltage is that the grid of the keying tube must be directly coupled to the stage which supplies an input signal to the AGC system. Frequently, the signal source is the plate circuit of a video amplifier; and the high voltage which is present at the amplifier plate also appears at the grid of the keying tube. A detailed explanation of the need for direct coupling will be given in Chapter 7.

The DC cathode voltage is made several volts more positive than the average DC grid voltage in order that the keying tube will be correctly biased during the period of conduction.

The actual value of the grid bias during the period of conduction of the tube depends upon the peak amplitude of the horizontal sync pulses in the video signal, and therefore the amount of conduction through the tube is determined by the peak amplitude of the sync pulses. If the video signal is weak, the positive voltage on the grid of the keying tube is relatively low. The difference between the grid voltage and the cathode voltage is great, and the heavily biased tube passes less than average current. Little AGC voltage is produced under these conditions because the charge on the capacitors in the circuit is comparatively small. On the other hand, a strong video signal develops a high grid voltage which is closer to the value of the cathode voltage. The bias on the tube is low in this case, conduction through the tube is heavy, and considerable AGC voltage is produced in the plate circuit.

Description of Circuit Details

Fig. 3-3 is a more detailed schematic diagram of a shunt type of keyed AGC circuit which contains features that are most typical of commercial circuits. The plate receives high-voltage pulses through the coupling capacitor C1. In this circuit, the AGC winding of the horizontal output transformer is separate from all other windings. The cathode of the keying tube is returned to a source of 125 volts. The video signal which is developed in the plate circuit of the video amplifier is used as an AGC input signal. It is passed through the isolating resistor R1 to the grid of V1. The DC voltage on the grid varies according to the strength of the incoming signal, but it is about 100 volts.

The waveform of the signal which is present at the grid of V1 is shown in Fig. 3-4A, and the waveform at the plate of V1 is pictured in Fig. 3-4B.

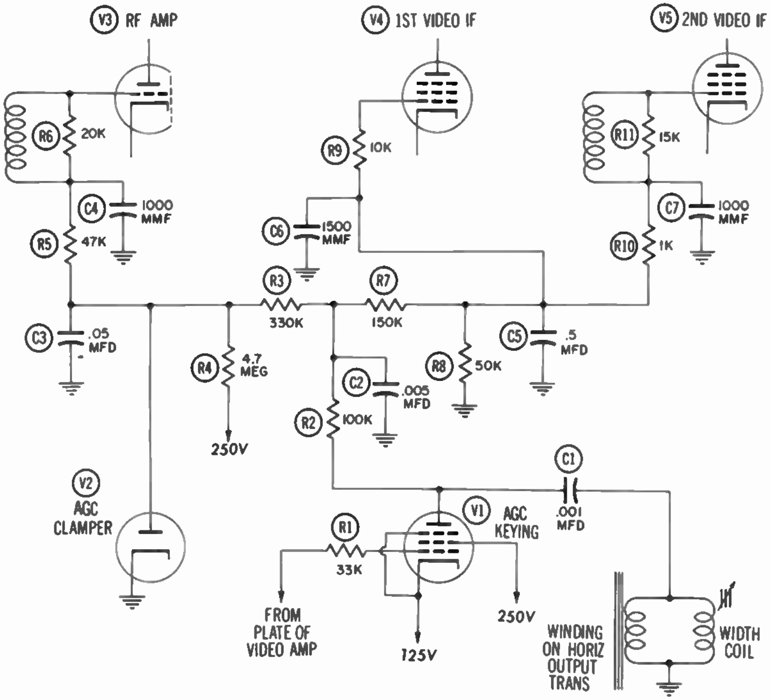
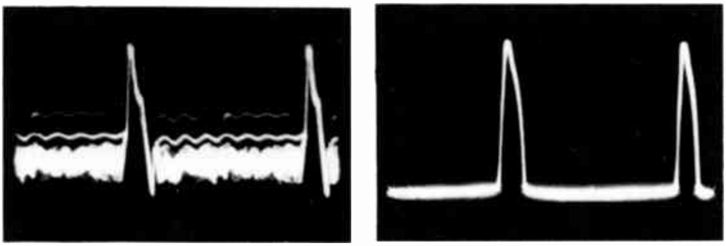


Fig. 3-3. Schematic Diagram of Typical Keyed AGC System.

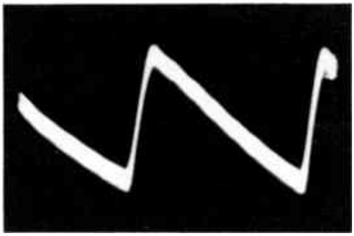
The process of converting the output of V1 to a DC bias voltage is fairly complicated in the circuit of Fig. 3-3. The plate voltage of the tube is partially filtered by R2 and C2 before the AGC line is split into RF and IF branches. The incompletely filtered voltage which is present at the junction of R2, R3, and R7 has a sawtooth waveform. This waveform appears in Fig. 3-4C.

The aforementioned junction is comparable to the plate of the AGC amplifier in the circuit of Fig. 2-3 because it is the negative end of a voltage divider for both the IF and the RF sections of the AGC line. The divider for the IF section is made up of R7 and R8, and that for the RF section is composed of R3 and R4.

A portion of the total AGC voltage is tapped off across R8 for application to the IF amplifiers. This voltage is filtered by the RC circuit made up of R8 and C5. Since the time constant of this filter is only .025 second, this circuit is able to respond to quick changes in signal strength.



(A) At Control Grid of V1. (B) At Plate of V1.



(C) At Junction of R3 and R7.

Fig. 3-4. Waveforms Observed in the Circuit of Fig. 3-3. Sweep Frequency Is 7,875 CPS.

The voltage divider and clamper in the RF section of Fig. 3-3 are similar to the corresponding circuit elements in Fig. 2-3, except that the sawtooth-shaped irregularity in the AGC voltage is filtered out by the .05-mfd capacitor C3.

Conventional decoupling filters are included in the grid circuits of the amplifiers which are controlled by the AGC system. These filters will be discussed in the next chapter.

Disadvantages of Keyed AGC

In spite of the excellent features of keyed AGC, the trend in the television industry is not toward the universal use of a keyed system. The chief drawback of keyed AGC in comparison with a simple filtered circuit is the greater complexity of the keyed type.

To the manufacturer, complexity means more parts in the receiver and therefore greater production cost. Since the simplest type of AGC circuit operates satisfactorily in most areas, a simple AGC circuit is still employed in those receivers for which unusually high sensitivity and noise immunity are not demanded. Keyed AGC is usually found in the more elaborate receivers which are designed to cope with weak or noisy signals in fringe areas or other problem locations.

To the technician and the consumer, complexity means that there are more potential sources of trouble. For example, a defect in the horizontal sweep system can disrupt the action of keyed AGC and complicate the process of trouble shooting.

The disadvantages of keyed AGC are unimportant when compared with the improved performance of the circuit under adverse conditions. Keyed AGC therefore continues to be a popular circuit, and service technicians will profit from a thorough knowledge of its operation.

PART II

Commercial AGC Circuits

CHAPTER 4

Simple AGC Circuits in Actual Use

A good way to round out the discussion of AGC theory would be to study some actual circuits that are typical of those which the technician encounters every day. The circuits described in the next four chapters have many features which are often seen during the course of servicing. The circuit designs of different manufacturers are not exactly alike in their details, but they achieve the same results by basically similar means. If the general purpose of the main parts of the various circuits is well understood by the technician, he has valuable knowledge that will make his work easier.

The Simplest AGC Circuit

The most basic or simplest type of AGC circuit is widely used at the present time. The system receives its input from the video detector, and the principal parts of the circuit are the AGC filter and a series of decoupling filters.

The features of this type of system are well illustrated by the circuit of Fig. 4-1. In this receiver, a single germanium diode is both a video detector and an AGC rectifier. The output of the diode is passed through the peaking coil L13 and is developed across the peaking coil L14 and the resistor R31. The AGC line is connected to the junction of L14 and R31. The AGC filter is comprised of C27, R29, R30, and the load resistor R31. The load resistor is in the network only during the discharge time.

Another AGC circuit which receives its input from the video detector is shown in Fig. 4-2. The detector itself is not a crystal but a triode section of a 6AN8 tube. The grid of the tube is connected to the plate, and therefore the tube acts as a diode. The AGC filter in this circuit includes R31 and C38; and in addition to their function as a load for the video detector, L14 and R32 provide a discharge path for the AGC filter capacitor.

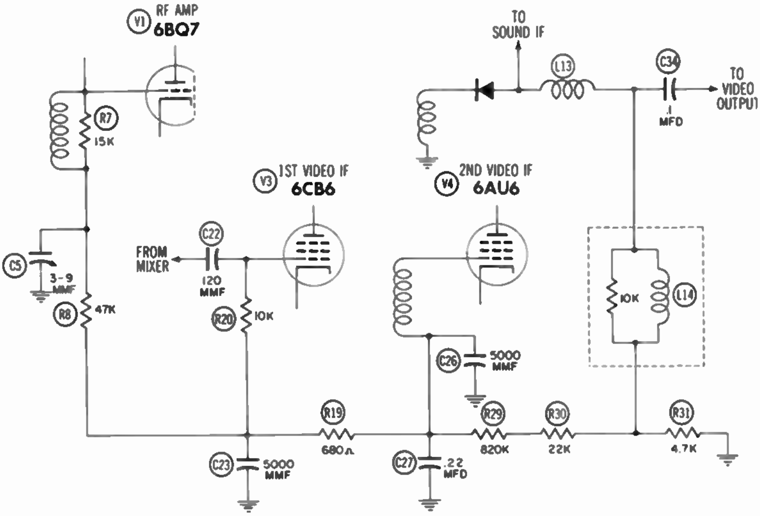


Fig. 4-1. Schematic Diagram of AGC System in Muntz Model 2763A Receiver.

Notice that the load resistor in both Figs. 4-1 and 4-2 is low in value – only 4,700 ohms in each case. This resistor is in the discharge circuit of the AGC filter but not in the charge circuit. The discharging time constant of the AGC filter is only slightly longer than the charging time constant because the 4,700-ohm resistor adds a relatively small amount of resistance to the filter circuit. The use of a larger load resistor would improve the action of the AGC system but would have an adverse effect on the video signal.

The output of the AGC filter is not connected directly to the grids of all the controlled amplifiers. Decoupling filters composed of capacitors and resistors are inserted into the AGC line. These filters keep the RF and IF signals out of the AGC line, and therefore they prevent feedback between the different amplifier stages. Examples of decoupling filters are R19 and C23 in Fig. 4-1 and R25 and C26 in Fig. 4-2.

If these extra networks were not added to the circuit, an RF or IF signal would be developed across the AGC filter capacitor and would be fed back to all the amplifier grids. If

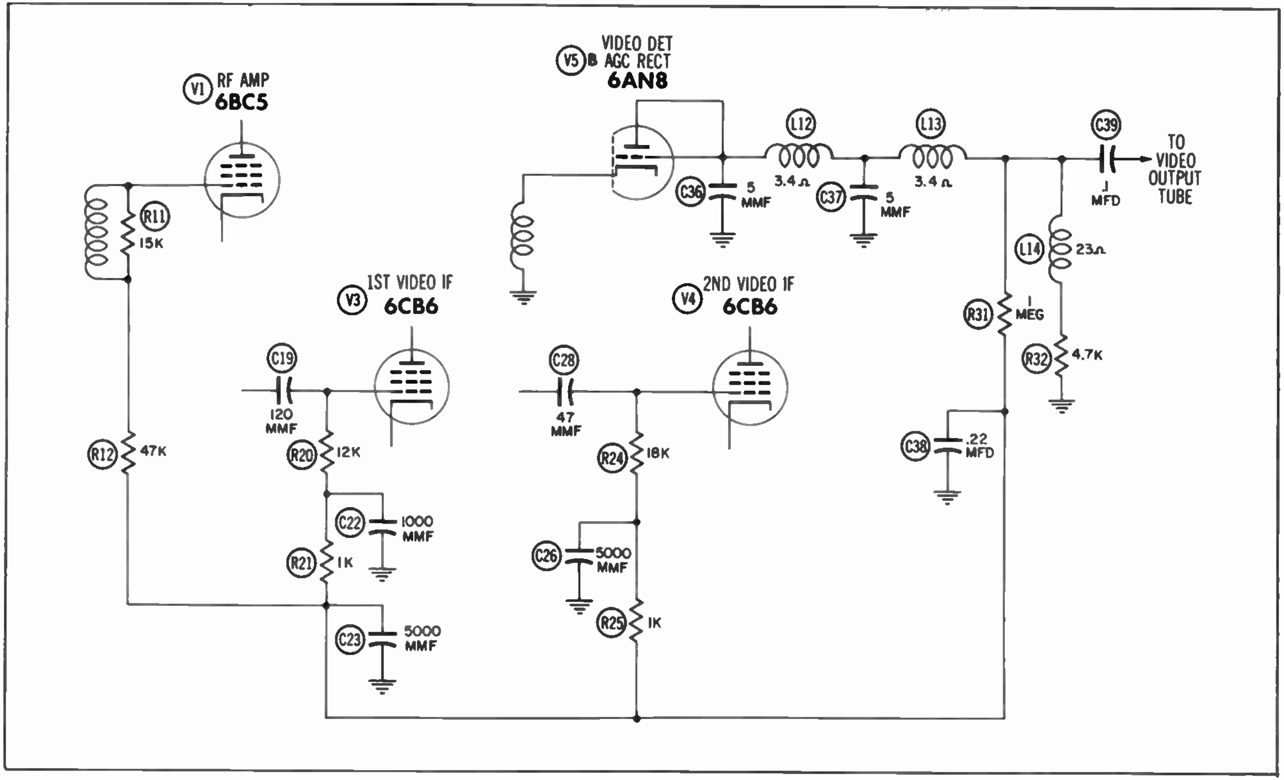


Fig. 4-2. Schematic Diagram of AGC System of Airline Model BR-4000A Receiver.

the first and third IF stages were controlled by AGC, the signal fed back from the third stage would be in phase with the input signal at the grid of the first stage; and regeneration would take place. On the other hand, if the first and second IF stages were controlled by AGC, degeneration would occur because the feedback from the second stage to the first stage would be out of phase with the input signal of the first stage.

A resistor or a capacitor can be used alone for isolating and decoupling purposes. Complete RC decoupling networks are not always necessary in every branch of the AGC line. Any combination of filters that eliminates undesirable feedback is sufficient from a practical standpoint.

If current were drawn in the grid circuits of the controlled amplifiers, voltage drops would appear across the decoupling resistors and would affect the value of the AGC voltage. Grid current is an abnormal condition, however; and such a voltage drop does not have to be taken into account when circuits are designed. The manner in which decoupling filters are connected depends upon the other design requirements of the various grid circuits. Differences in the circuit layout of the AGC line are important to the technician only insofar as they call for slight differences in the technique of locating defective components in the line.

System Using Dual Diode

The circuit that appears in Fig. 4-3 is an example of an AGC system that develops a control voltage based on the peak amplitude of the sync pulses in the video signal.

The video detector is one section of a 6AL5 dual diode, and the other section is used exclusively as an AGC rectifier. Since the high-frequency portions of the video signal are not needed in the AGC system, the load resistor R40 can be made very large in value. The 0.1-mfd filter capacitor is charged through a resistance of 1 megohm and is discharged through a total resistance of 3.2 megohms. The charging time constant is therefore 0.1 second, and the discharging time constant is 0.32 second. The charge is accumulated on the filter capacitor faster than it can leak off and nearly equals the peak value of the signal.

Delayed AGC is an additional feature of the circuit of Fig. 4-3, and this feature is made possible by the use of the separate AGC diode. No AGC voltage is developed in this circuit until the incoming signal that is applied to the plate of the AGC diode is strong enough to overcome the small positive bias that is placed on the cathode of the diode. The delay bias has a value of approximately 1.2 volts and is derived from the cathode circuit of the third video IF amplifier. The advantage of delayed AGC is that full gain of all the controlled stages is permitted when the incoming signal is so weak that every bit of gain is needed.

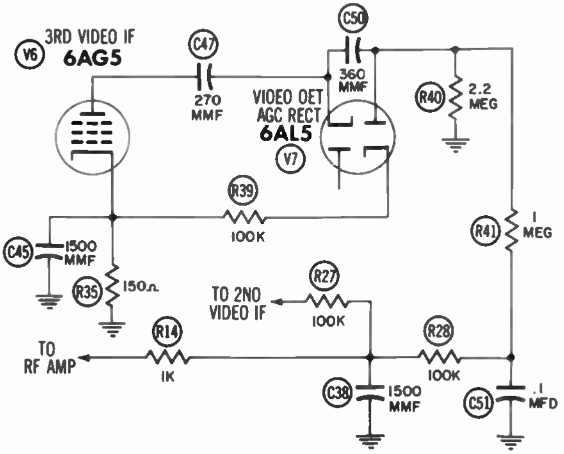


Fig. 4-3. Schematic Diagrqm of AGC System in Emerson Model 585 Receiver.

A number of other AGC circuits which are found in other models of receivers include a delay feature. The bias voltage which provides the delay is obtained from various points in the receiver.

AGC From A Sync Stage

Fig. 4-4 is a partial schematic diagram of a DuMont receiver in which the output of the last video IF transformer is amplified by a special sync amplifier before it is detected by the AGC rectifier. A 6AL5 dual diode is used as a combination of AGC rectifier and sync detector.

A variable delay voltage is obtained for the cathode of the AGC rectifier from the arm of the AGC potentiometer R8. The capacitor C2D filters this voltage.

The AGC line divides into two branches at the junction of R35 and R38. The voltage which appears at this point is developed across R35 and R36 in series. Only a portion of this voltage, that part which appears across R36, is applied to the IF branch of the line. An additional filter capacitor in the line is C35. The bias voltage is applied to two sound IF stages as well as to two video IF stages. The RF branch of the AGC line is similar to the circuit which was discussed in detail in Chapter 2.

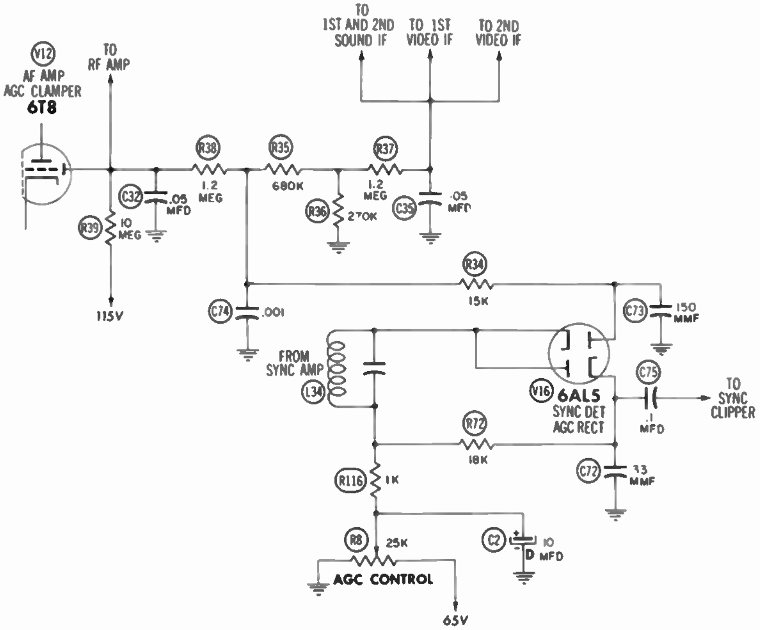


Fig. 4-4. Schematic Diagram of AGC System in DuMont Model RA-111A Receiver.

The circuit in Fig. 4-4 might technically be called a simple type, since there is no AGC amplifier following the AGC rectifier. The input voltage of the AGC system is built up before detection, however; and the output of the AGC rectifier is at a high enough level to supply the needs of a complex AGC line that is similar to the network found in amplified and keyed AGC systems.

CHAPTER 5

Area-Selector Switches

Some models of receivers are equipped with an area-selector switch that can be used as a coarse manual control of the AGC voltage. This switch is most often found in receivers which have a simple AGC system. The general purpose of the area switch is to make a receiver adaptable to different installations in order that the same model of receiver will perform almost equally well in fringe areas or in locations which are practically underneath a transmitter.

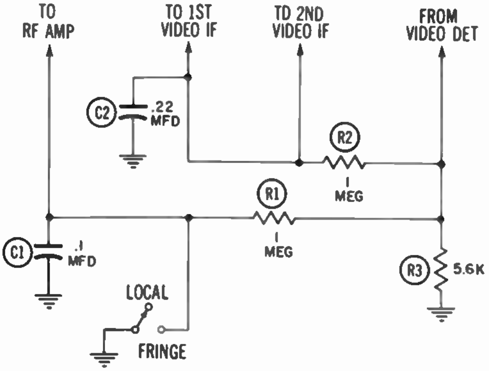


Fig. 5-1. Schematic Diagram of Fringe-Local Switch and Associated Circuit.

The area-selector switch often includes a second section which is used in regulating the amplitude of the input signal to the sync separator. This other section is of greatest advantage in the presence of very strong signals because it prevents overloading of the sync circuits.

The simplest type of area-selector switch has two positions. The operation of the AGC circuit is normal when the switch is in the LOCAL position; but when the switch is thrown to the FRINGE position, the grid circuit of the RF amplifier is grounded. The over-all gain of the receiver can therefore be boosted when the receiver is used in fringe areas. A switch circuit of this type is shown in Fig. 5-1.

A three-position switch is shown schematically in Fig. 5-2. Maximum control of receiver gain by the AGC voltage occurs when the switch is in the LOCAL position, control is somewhat reduced in the SUBURBAN position, and minimum control is available in the FRINGE position. A switch of this type is used in many Motorola receivers.

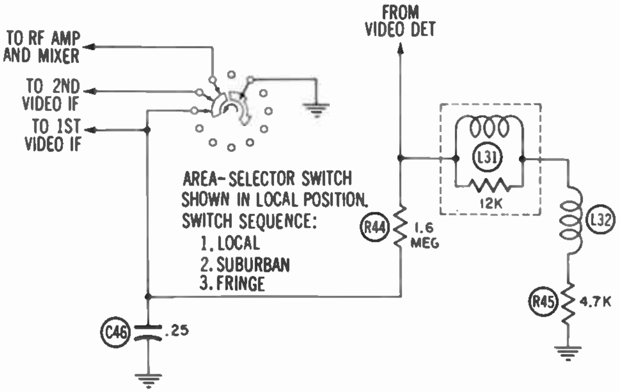


Fig. 5-2. Schematic Diagram of Area-Selector Switch in Motorola Chassis TS402.

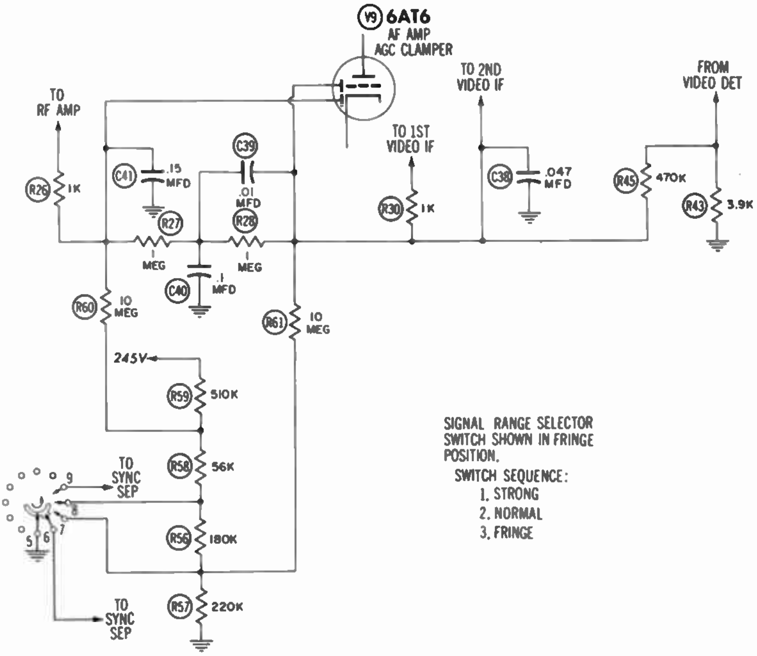
In the diagram, the switch is shown in the LOCAL position. The incoming AGC voltage is always connected to the grid circuit of the first video IF amplifier. In the LOCAL position, the AGC voltage is also connected to the second video IF, RF amplifier, and mixer stages.

When the switch is turned to the SUBURBAN position, the AGC voltage is removed from the RF amplifier and the mixer. These stages are connected instead to ground through another segment of the area switch. This SUBURBAN position provides for steady, snow-free reception of moderately weak signals, because full gain in the RF stages is combined with full AGC control in the IF stages.

Another turn of the switch places it in the FRINGE position, and the grid of the second video IF amplifier is disconnected from the AGC line and returned to ground. Receiver gain is maximum in this position, since the first IF stage is the only one which is still controlled.

A More Elaborate Circuit

An AGC system which contains a seemingly complicated area-selector circuit is shown in the diagram of Fig. 5-3. The network which filters the AGC voltage includes R45, R28, C38, C39, and C40; and the discharge circuit of the filter capacitor includes R43. The AGC line is separated into fairly independent RF and IF sections by R27 and R28, and the combination of R27 and C41 further filters the AGC voltage that is applied to the RF amplifier.



SIGNAL RANGE SELECTOR SWITCH SHOWN IN FRINGE POSITION.

SWITCH SEQUENCE:
1. STRONG
2. NORMAL
3. FRINGE

Fig. 5-3. Schematic Diagram of AGC System Including Area-Selector Switch in Philco Model 22C4016 Receiver.

A clamper diode is inserted into each section of the AGC line. Whenever the voltage on either the RF or IF section of the line tends to become positive, one of the clampers conducts and the affected section of the line is shorted to ground.

The three-position type of area-selector switch that is used in this receiver is called the signal-range selector switch. When the switch is in the FRINGE position, the circuit which is associated with the switch applies a small positive voltage to two points on the AGC line. This voltage might be called a bucking voltage because it opposes the AGC voltage that is developed by the filter circuit. The AGC line to the RF amplifier is subjected to a higher bucking voltage than the AGC line to the IF amplifiers, and therefore the resultant RF bias is less negative than the IF bias.

The bucking voltages are developed by a combination of voltage dividers. A B+ voltage of 245 volts is applied across the series resistors R59, R58, R56, and R57; and some intermediate value of voltage is present at each of the three junctions between resistors in the network.

The voltages which are actually applied to the AGC line are taken from supplementary voltage dividers that are connected in shunt across portions of the main voltage divider. The shunt divider in the IF section is made up of R61, R45, and R43; and it is connected across R57. The one in the RF section is composed of R60, R27, R28, R45, and R43; and it is connected from the top of R58 to ground. These shunt type of dividers have very little effect on the voltage ratios that exist within the main divider network because the dividers have an extremely high resistance. A 10-megohm resistor is included in each shunt network.

The bucking voltage for the IF portion of the AGC line is developed across R45 and R43. Since these two resistors are common to both of the shunt networks, each network contributes some of the bucking voltage for the IF stages. The voltage contributed by the network that includes R61 is relatively low because the voltage which is developed across R57 is only a small percentage of the total voltage across the main divider network.

The bucking voltage for the RF portion of the AGC line is developed across R27, R28, R45, and R43 in series; therefore, this voltage is high in comparison with the IF voltage which is developed across R45 and R43 only.

Remember that the voltage dividers are connected in the described manner when the signal-range selector switch is in the FRINGE position. It is desirable to have a comparatively large bucking voltage applied to the RF section of the AGC line under fringe-area conditions because the gain of the RF amplifier should be reduced as little as possible.

When the switch is changed to the NORMAL position, contact 7 of the switch is shorted to ground. This short grounds the junction of R56 and R57 and removes R57 from the main voltage divider. Since one end of R61 is also grounded, some of the bucking voltage is removed from the IF section of the AGC line; consequently, the gain of the IF strip is slightly decreased. The resistance ratios within the main voltage divider are altered in such a way that the voltage at the junction of R59 and R58 has a less positive value than formerly. As a result, the bucking voltage in the RF line is reduced and more RF bias is developed.

Placing the switch in the STRONG position causes contact 8 to be connected to ground. In this position, R56 as well as R57 is shorted. The voltage at the junction of R59 and R58 is further reduced, and a minimum amount of bucking voltage is developed at the junction of R60 and R27. In this switch position,the maximum amount of AGC bias is placed on the RF and IF amplifiers.

Other manufacturers who use area-selector switches connect them in various ways;. but the purpose of the switch in every case is to bypass some portion of the AGC system or to attenuate the AGC voltage when a reduction in the extent of AGC control is desired.

The more complex types of AGC circuits which will be discussed in the following chapters tend to use a potentiometer instead of a switch for the control of AGC action. If some kind of AGC amplifier is used, its gain can be regulated by use of a potentiometer to change the bias on the amplifier tube; therefore, the control of AGC voltage can be made continuously variable instead of being limited to two or three levels.

Many of the circuits in the diagrams in the next two chapters include a potentiometer. The most common label for it is simply the AGC CONTROL; but it may bear some other name such as FRINGE-LOCAL CONTROL, DX RANGE FINDER, or PERFORMANCE CONTROL.

CHAPTER 6

Amplified AGC Circuits in Actual Use

Amplified AGC has not been as widely used as other types, and there have been relatively few major differences among commercial amplified AGC circuits. The most common design is that which was discussed in Part I. The operation of that type of circuit will be covered again in this chapter but from a different viewpoint, and one other design will be presented in order to illustrate some of the differences which can be encountered.

A schematic diagram of the amplified AGC system of the RCA Victor Chassis KCS32 is shown in Fig. 6-1. This circuit is one modification of a general type which was used in a number of models of RCA Victor receivers and also in some Arvin and Magnavox receivers.

In the circuit of Fig. 6-1, a video signal containing positive-going sync pulses is applied to the grid of a triode AGC rectifier. The signal voltage that is developed at the cathode of the rectifier is filtered and is applied to the grid of the AGC amplifier. Amplitude variations in the video signal appear on the amplifier grid as slow variations in the DC bias voltage.

The cathode circuit of the rectifier tube is usually somewhat complicated. When comparisons of different models are made, the technician will find that a considerable number of variations exist in this section of the AGC circuit. The different designs are determined by the need for a level of DC cathode voltage which will furnish proper bias for the rectifier tube in each case.

The rectifier in Fig. 6-1 requires an average of -3 volts on the cathode with respect to ground. A voltage divider between -60 volts and ground is added to the cathode circuit in order that the cathode voltage will be at the desired level. The filter network made up of C74, R75, and R76 goes to ground. In some other receivers, the RC network is simply returned to a common point which has a negative potential. Such was the case in the circuit of Fig. 2-3.

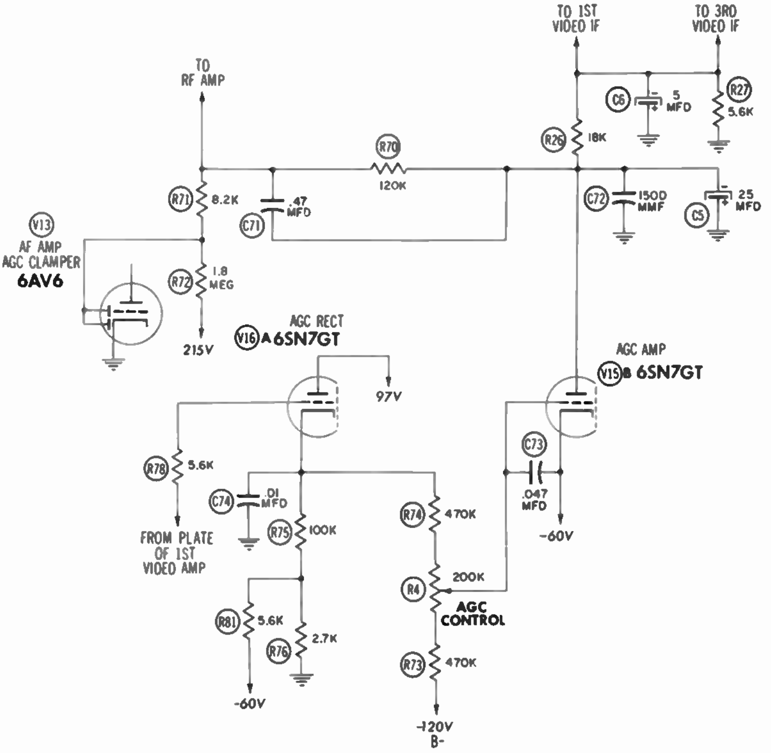


Fig. 6-1. Schematic Diagram of Amplified AGC System in RCA Victor Chassis KCS32.

High negative voltages are supplied to the cathode and grid of the AGC amplifier in the type of system that is illustrated in Fig. 6-1. The cathode voltage has a steady value that is usually equal to half of the B- voltage. The grid voltage must be slightly more negative than the cathode voltage, and the required voltage is tapped off from a voltage divider between B- and the cathode of the AGC rectifier. The grid voltage is variable by means of an AGC potentiometer in the voltage divider.

The presence of negative cathode and grid voltages causes the amplifier to conduct normally even though no B+ voltage is fed to the plate. A negative voltage is developed in the plate circuit by a filter network, and this voltage is used as AGC bias.

In Fig. 6-1, the plate voltage is developed across a network made up principally of C5 and the combination of R26 and R27. The full value of this voltage is fed to the RF section of the AGC line. The portion of the plate voltage which appears across R27 is further filtered by C6 and is applied to the first and third IF stages as AGC bias.

The delay circuit of Fig. 6-1 is somewhat more complex than the regular type which was discussed in detail in Part I. An extra resistor R71 is added to the circuit. The RF bias is taken from the junction of R71 and R70, a point which is at a more negative potential than the plate of the clamper. This extra feature is included in the circuit for the following reason.

When the clamper conducts, its plate voltage is theoretically zero. Actually, a slight positive voltage is present on the plate because the conduction path within the diode has some resistance. This positive voltage could be delivered to the RF amplifier if the AGC line were connected directly to the diode plate. Such a condition was thought to be undesirable, and therefore it was prevented by the addition of R71 to the circuit.

A Different Design

The circuit which is shown in the schematic diagram of Fig. 6-2 is an example of a different design of the amplified AGC system. The main difference between this circuit and the one in Fig. 6-1 concerns the operating voltages which are applied to the AGC amplifier tube.

In the circuit of Fig. 6-2, conduction is maintained in the AGC amplifier by the use of a B+ voltage on the plate; therefore, high negative potentials are not required on the grid and cathode. The cathode is grounded. The grid circuit is returned through a large resistance to a B- source, and the grid voltage is about -12 volts.

The input signal for the amplifier tube is developed at the cathode of the sync separator V16A. This tube performs as a conventional triode type of AGC rectifier at the same time that it functions as a sync stage.

The AGC output voltage is developed in the following manner. A voltage divider formed by the resistors R51 and R52 is connected between the amplifier plate and a source of -125 volts. A filter capacitor is tied to the intermediate point of the voltage divider. The positive plate voltage opposes the B- voltage, and the algebraic sum of the two voltages is applied to the capacitor. Rapid variations (such as sync pulses) in the plate voltage are filtered out, but slow changes can occur. The voltage which is present at the junction of R51 and R52 is applied to the AGC line. The first and second IF amplifiers are controlled directly by this voltage. A voltage divider (R22 and R23) reduces the amplitude of the AGC voltage to a level which is suitable for the RF amplifier. A clamper connects the entire AGC line to ground whenever the AGC voltage tends to become positive.

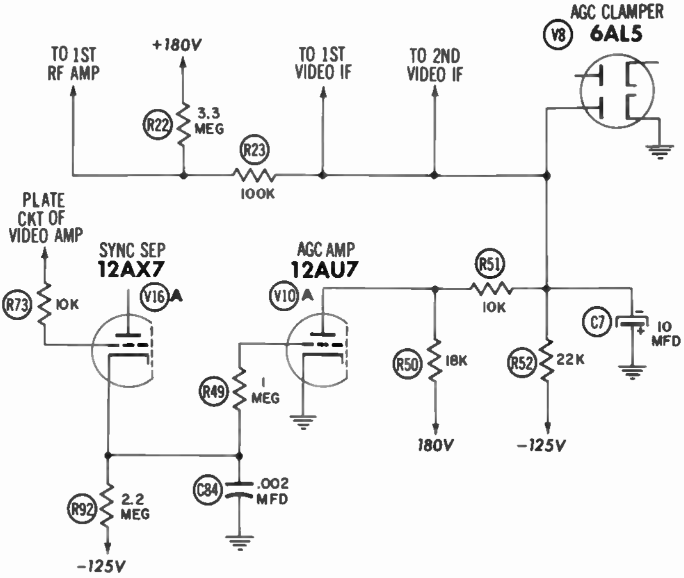


Fig. 6-2. Schematic Diagram of Amplified AGC System in Sylvania Model 1-075 Receiver.

Amplified AGC systems in general have many features in common with some types of keyed AGC systems. It may be hard to determine from a glance at some of the older schematic diagrams whether an AGC circuit is amplified or keyed because the AGC tube in both types of circuits was often labeled AGC AMPLIFIER. The technician can easily distinguish the keyed circuit from the other types, however, if he traces the plate circuit of the AGC tube. If a connection other than a simple B+ return is made to the horizontal sweep circuits, the AGC system is keyed.

CHAPTER 7

Keyed AGC Circuits in Actual Use

Because of the complicated nature and widespread use of the keyed AGC system, many varieties of circuits are employed in different receivers. The technician may occasionally encounter a circuit layout that looks unfamiliar, but he should be successful in servicing keyed AGC if he understands the fundamental requirements of the circuit because these requirements are the same in every case.

Some of the design features which are found in actual keyed AGC circuits will be discussed in this chapter. Diagrams of some typical AGC systems are included in order that the reader may see how various features are incorporated into different systems.

Review of General Features

Before the comparison of contrasting types of design features is begun, it would be wise to mention again a few facts which nearly all keyed AGC systems have in common.

1. A keying pulse with an amplitude of several hundred volts is obtained from the horizontal sweep circuits.

2. The grid voltage of the keying tube is determined by the requirement for direct coupling between the grid and the stage which furnishes an input signal to the keying tube. This requirement will be discussed more fully a little later in this chapter.

3. The cathode voltage which is needed is determined by the bias requirements of the keying tube, and therefore it depends upon the value of the DC grid voltage.

4. The input signal contains horizontal sync pulses which follow the variations in the amplitude of the video signal, and these variations alter the bias at the keying tube and govern the amount of AGC voltage that is produced.

5. A network of resistors and capacitors in the plate circuit of the keying tube filters the output of the keying tube.

Delivery of the Keying Pulse

The point has been brought out in Part I that the AGC winding of the horizontal output transformer may be connected to the keying tube in shunt or in series. If the shunt connection is used, keying pulses may be developed across an isolated winding of the transformer or across a section of the main winding. A shunt connection using a special AGC winding is shown in Fig. 7-1. The lower end of the winding may be grounded in circuits of this type because the DC path from the plate of the keying tube to ground is blocked by a capacitor. The width coil is connected directly across the AGC winding. This connection is very frequently used in commercial circuits.

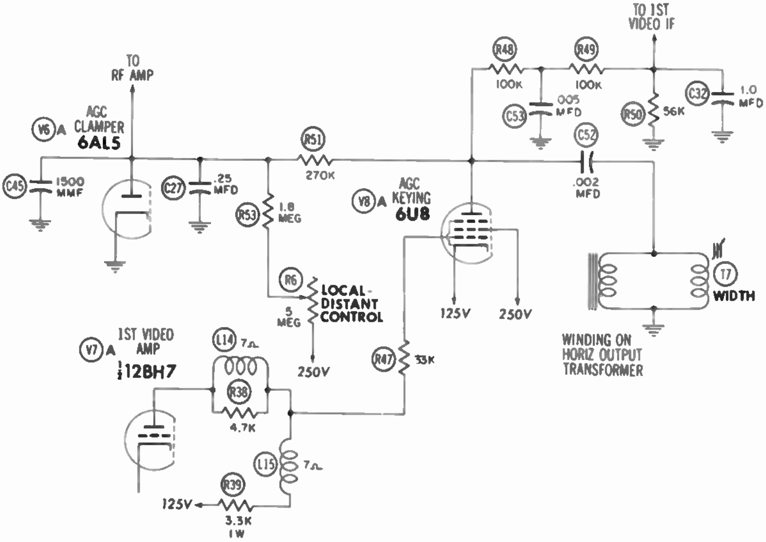


Fig. 7-1. Schematic Diagram of Keyed AGC System in CBS-Columbia Chassis 921-12.

Fig. 7-2 shows a shunt type of circuit which utilizes a part of the main winding of the horizontal output transformer

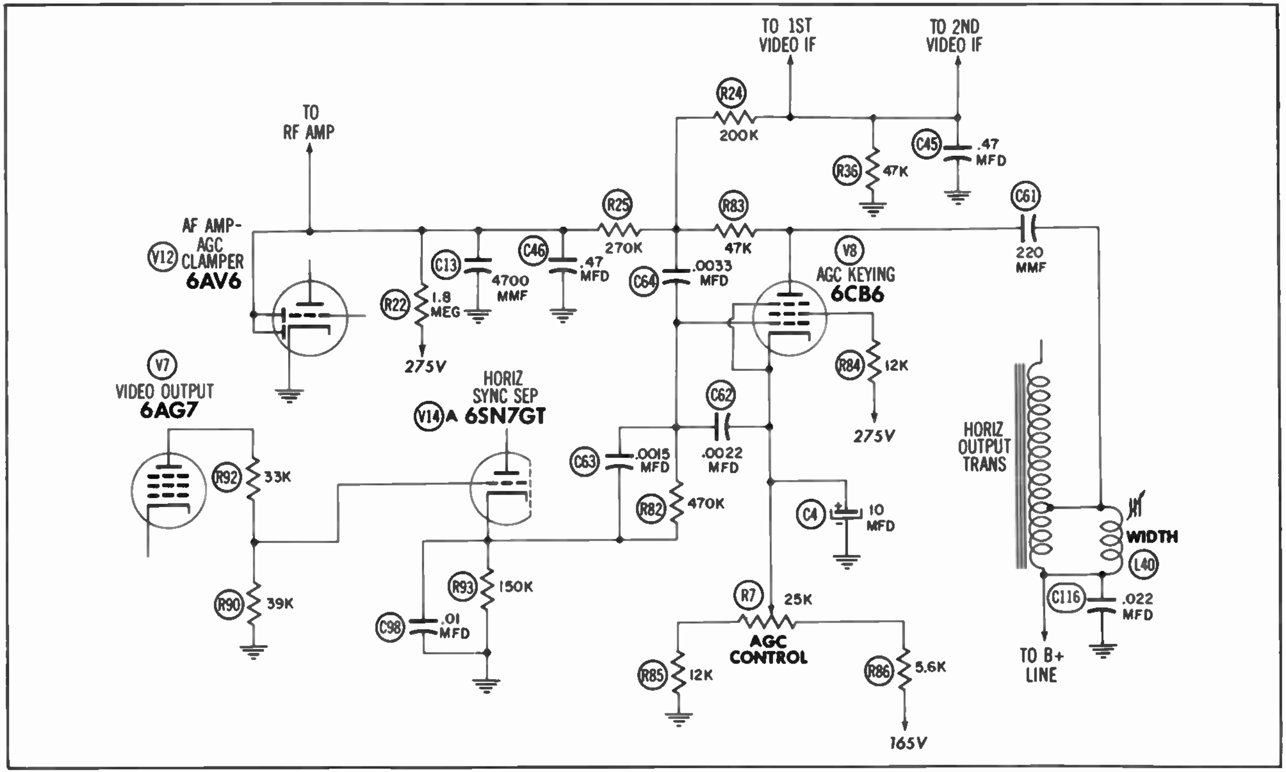


Fig. 7-2. Schematic Diagram of Keyed AGC System in RCA Victor Chassis KCS74.

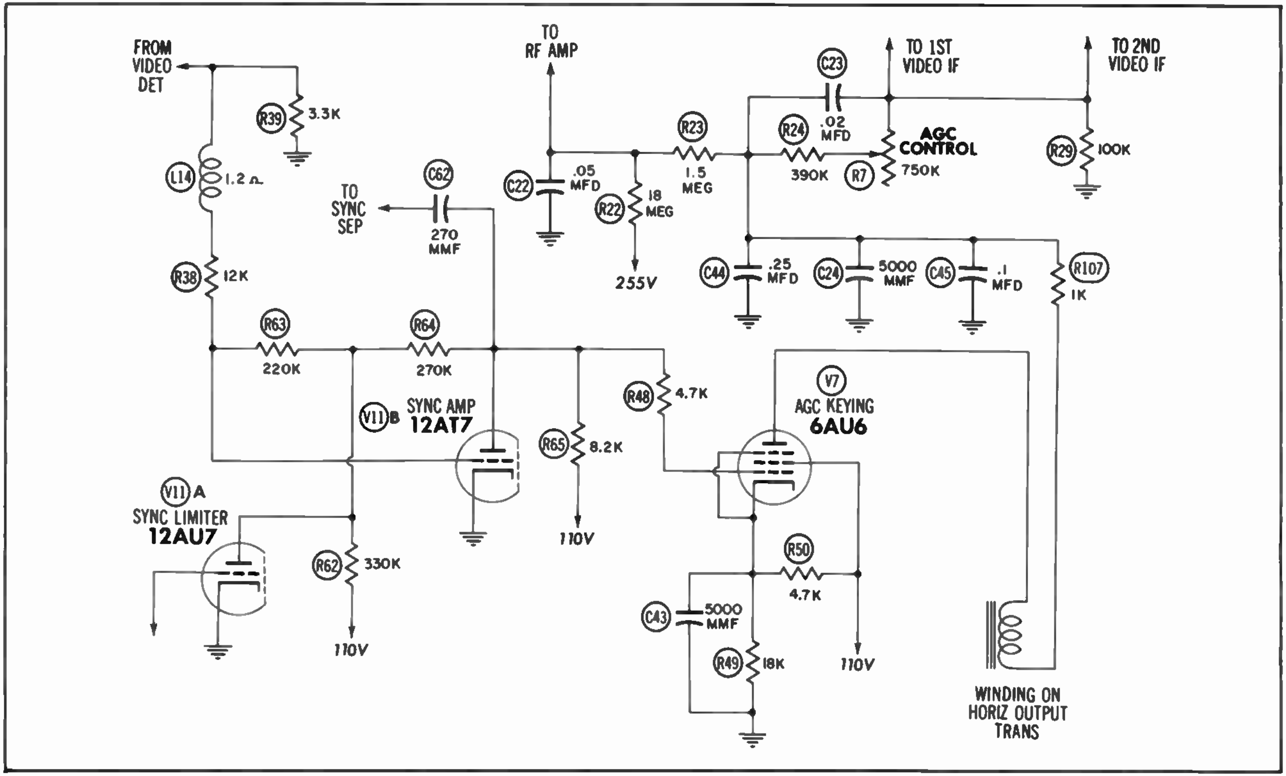


Fig. 7-3. Schematic Diagram of Keyed AGC Circuit in Westinghouse Chassis V-2314-15.

as an AGC winding. It can be seen in the figure that the capacitor C116 forms a return path to ground for the keying pulses. A direct ground cannot be used because the main winding of the transformer cannot be grounded. Note that the connection of the width coil is similar in both Figs. 7-1 and 7-2.

The series type of keyed AGC system employs a very simple connection between the keying tube and the high-voltage transformer. A typical series circuit appears in Fig. 7-3. The plate of the keying tube is connected to the AGC filter directly through a special winding on the high-voltage transformer.

Input to Grid of Keying Tube

The signal which appears at the grid of the keying tube must contain positive-going sync pulses which vary in amplitude as the signal amplitude varies and which act as an index of the strength of the incoming signal. Several points in the receiver are possible sources of the input signal for the keyed AGC tube.

Whatever the signal source may be, it must be directly coupled to the grid of the keying tube. If a capacitor were inserted in the input lead, the DC reference level of the sync pulses would be lost. The variations which the pulses produce in the DC grid voltage are fundamental to the operation of the AGC system. If direct coupling of the input signal were not employed, a DC restorer would have to be included in the AGC system. Direct coupling is much simpler; and in AGC circuits, its use is practical.

An isolating resistor is included in the input connection to the grid of the keying tube. This resistor provides direct coupling for the signal, and it limits the amount of current in the grid circuit in case the grid draws current. The impedance of the resistor isolates the input capacity of the keying tube from the video circuit, and therefore the loading effect of the AGC circuit on the video signal is greatly reduced.

A simple and widely used method of obtaining an input signal is that of connecting the grid of the keying tube to the plate circuit of the video output tube. See Fig. 7-1. The grid circuit is effectively connected across the plate-load resistance of the video stage. Since the DC grid voltage is obtained from a plate circuit, it has a high positive value in most designs of receivers. A strongly positive grid voltage is not in itself a requirement of the keying tube, however.

The cathode is supplied with a fixed or manually variable voltage which is several volts positive with respect to the grid voltage, and the tube is correctly biased in this manner. The absolute values of the grid and cathode voltages are not at all critical; it is the difference between these two voltages that is important.

In the type of circuit which has just been described, one point in the video amplifier usually serves as a source of input signal for both the AGC keying tube and the sync separator. Since each of these latter two stages requires essentially the same kind of input signal, a special amplifier may be used for the purpose of developing an input for both the sync and AGC systems.

The video signal may be obtained at a low level of amplitude at the output of the video detector. Instead of being developed by the regular video amplifier, this signal is passed through a special stage of amplification which might be called a sync preamplifier. This stage is similar to an ordinary sync amplifier in that it amplifies only the low-frequency portions of the video signal; but one function, that of clipping or limiting the tips of the sync pulses, of a normal sync amplifier must not be performed by the special preamplifier. Limiting is necessary at some point in the sync section of the receiver, but a limited signal would be unfit for use by the AGC system because the variations in the amplitude of the sync tips would be lost.

The input signal for the AGC tube is taken from the output circuit of the preamplifier. Positive-going sync pulses of adequate amplitude are present in this circuit and are fed to a sync-separator stage from the same take-off point.

A circuit in which an AGC input is obtained from a sync preamplifier is shown in Fig. 7-3. A signal that contains negative-going sync pulses is taken from the output of the video detector. The signal is amplified and inverted by V11B. The output, which is composed of positive sync pulses, is connected through an isolating resistor to the grid of the keying tube V7. (Another output connection is made to the sync separator.) Note that the grid circuit of V7 is directly coupled to the plate of V11B. The grid voltage of V7 therefore has a high positive value.

Another circuit in which the AGC input is obtained from a sync stage is shown in Fig. 7-2. In this receiver, the AGC signal is not actually amplified by the sync stage. The input to the horizontal sync separator V14A is a video signal of high amplitude and containing positive-going sync pulses. This signal is obtained from the plate circuit of the video output tube.

The conduction of V14A varies according to the amplitude of the incoming signal, and a signal which is suitable for application to the keying tube is developed in the cathode circuit of V14A. This signal has a peak-to-peak amplitude of 15 volts and contains pulses which occur at the horizontal sync rate. The average DC grid voltage is about 50 volts.

Location and Function of AGC Control

A variable resistor is often included in a keyed AGC circuit in order that the output of the keying tube may be varied in some manner. This provision is useful in adapting the receiver to different installations in much the same way that an area-selector switch is helpful in receivers of other designs. The control may also be used to compensate for slight differences in the values of components among individual receivers of the same model. The exact location of the control in the AGC circuit is not standardized, and it would be impractical to try to cover all the possibilities in this book. Several commercial designs will be mentioned, however.

The variable resistor R6 in the circuit of Fig. 7-1 is called a local-distant control and is a part of the voltage divider in the RF branch of the AGC line. The setting of R6 determines how much AGC voltage is required to stop the conduction of the clamper diode; therefore, R6 can be used to regulate the amount of time delay in the application of AGC to the tuner.

In Fig. 7-2, an AGC potentiometer R7 is present in the cathode circuit of the keying tube V8. Control R7 is part of a voltage divider between 165 volts and ground, and the DC level of the cathode voltage of V8 depends upon the setting of this control. R7 therefore regulates the bias of V8 and controls the amount of AGC voltage that is applied to the controlled tubes.

The placement of a control in the plate circuit of the keying tube is shown in Fig. 7-3. In this case, the AGC control R7 is a variable resistor which is inserted in the DC path from the plate of the keying tube V7 to ground. A change in the setting of R7 alters the total resistance of this DC path. Since the control alters the resistance ratio of R24, R7, and R29, it would seem at first that this control provides a means of varying the bias on the IF amplifiers. Actually, it is the RF bias that is varied.

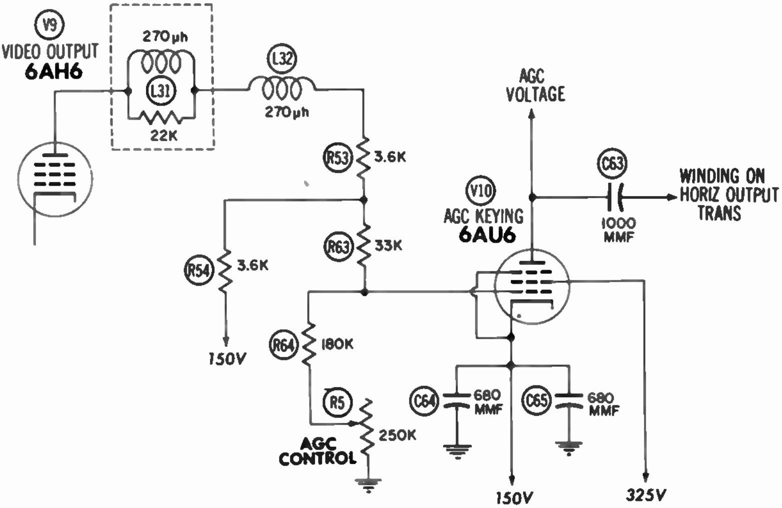


Fig. 7-4. Schematic Diagram Showing AGC Control in Grid Circuit of AGC Keying Tube of Bendix Chassis T-14-3.

A change in the resistance of R7 does not alter the amount of current through the resistance path to ground because the factor that determines the amount of current is the level of conduction of the keying tube. If the resistance of R7 is made low, a given current produces a comparatively small voltage at the junction of R23 and R24; and a correspondingly low bias voltage is applied to the tuner. The IF bias voltage is not abnormally low because R29 has a relatively large proportion of the total resistance of R24, R27,and R29 when the resistance of R7 is low. Although the total voltage across the three resistors is less than usual, a greater share of this voltage appears across R29.

The AGC control may also be located in the grid circuit of the keying tube, and one possible connection of this type is shown in Fig. 7-4. In this case, the control is a variable resistor in the DC path from the grid to ground. The resistors R53, R63, and R64 together with the control form a voltage divider for the plate voltage of the video output tube. The setting of the control fixes the value of the DC voltage at the grid. Since the cathode voltage of the keying tube is constant, the bias of the keying tube is controlled entirely in the grid circuit.

Plate Circuit of Keying Tube

The plate circuit of the keying tube is extensive, and there is room for a great deal of variety in its design.

Different combinations of IF stages are controlled in different models of receivers. Some have AGC bias on the first and second stages, others have it on the first and third stages, and still others have it on only the first stage. Control of all the IF stages at once is seldom found.

It may be observed in the various figures in this section that the time constant of the AGC filter network is not standardized. It is usually much shorter for keyed AGC than for simpler types of AGC systems, but the length may be any value from less than 1/25 second to as long as 1/3 second.

In older types of keyed AGC circuits, the keying tube usually feeds an output network which is similar to the AGC line that is used in the simple AGC system. In most of the recently designed keyed circuits such as those in Figs. 7-1, 7-2, and 7-3, the AGC line is divided into more or less independent RF and IF sections. As a result, the RF and IF control voltages are developed in different ways and can be effectively tailored to fit the needs of the RF and IF amplifiers.

An output circuit that is unusual in its simplicity is presented in Fig. 7-5. In this circuit, the same AGC voltage is applied to both the RF amplifier and the first IF amplifier. The output of the keying tube is filtered by R47, C67, and R48; and a DC voltage is present at the junction of R47 and R49. These two resistors function as a voltage divider and control the operation of a clamper diode. If the AGC voltage is not sufficiently negative to buck the high positive voltage which is at the bottom of R49, the plate of the clamper becomes positive and the entire AGC voltage is shorted to ground by the conduction of the clamper.

Delay circuits are used in a large proportion of the newer keyed AGC circuits, but the delay is commonly used only on the control voltage that is applied to the RF amplifier.

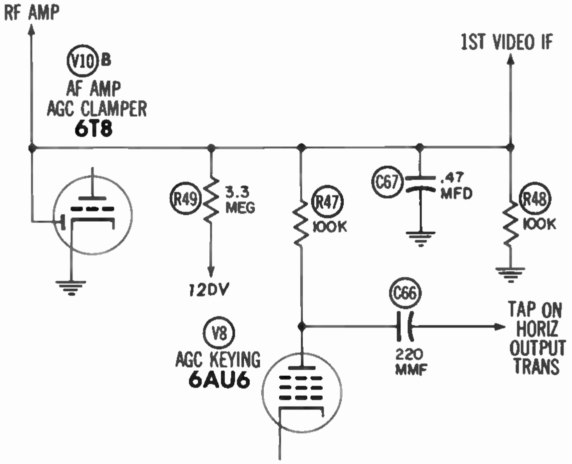


Fig. 7-5. Schematic Diagram of Plate Circuit of AGC Keying Tube in Truetone Model 2D1353A.

The clamper tube which is usually included in the delay circuit is often a diode section of a 6AV6, 6AT6, or 6T8 tube; and the triode section of the tube is used as an audio amplifier. An occasional circuit will be found which uses half of a 6AL5 dual diode as a clamper. (See Fig. 7-1.) A crystal diode may even be used in this application.

Highly Unusual Designs

A few keyed AGC systems are radically different from ordinary keyed circuits in many features of their design. These systems merit a special discussion because they are unique.

A schematic diagram of a circuit which is part of the Zenith Chassis 21L21 appears in Fig. 7-6A. Some of the features of this system include the method of obtaining the keying pulses and the control by AGC of special 41-mc IF stages in the UHF tuner.

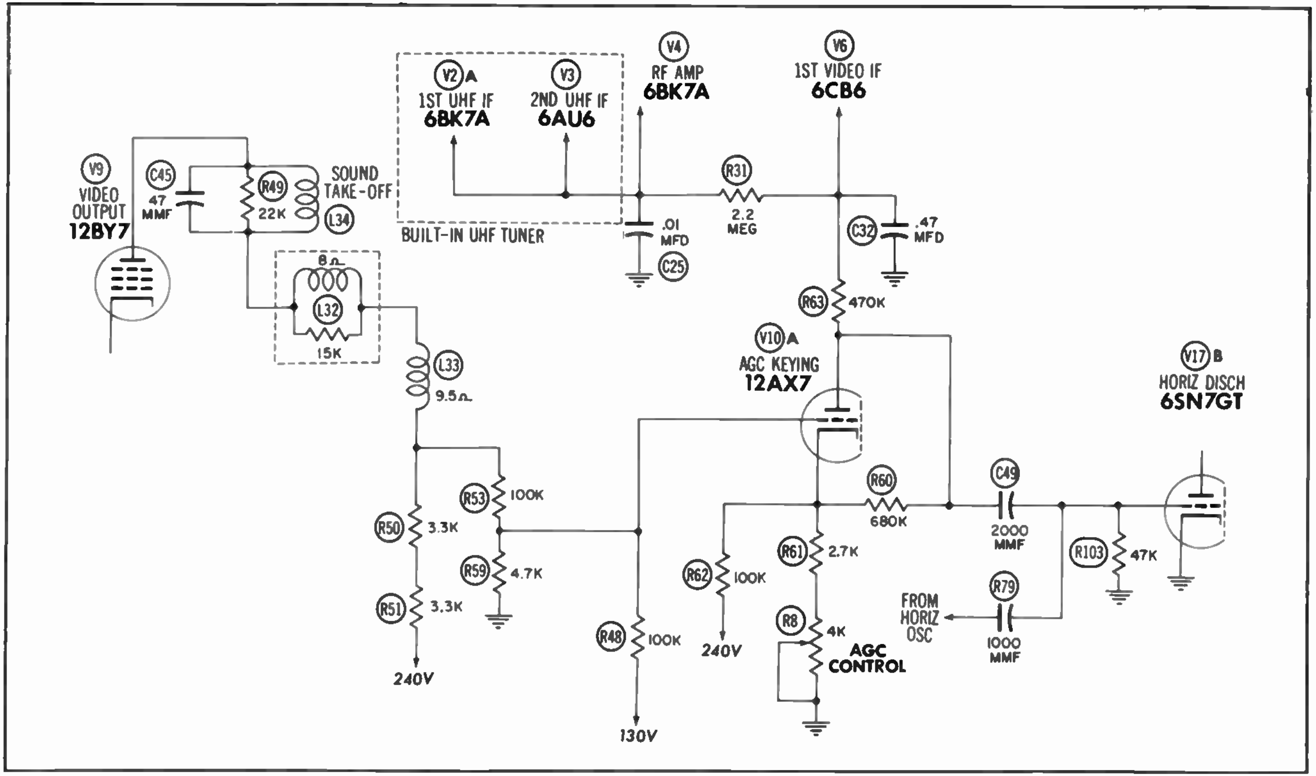


Fig. 7-6A. Schematic Diagram of Keyed AGC Circuit in Zenith Chassis 21L21.

At first glance, it might appear that the cathode and grid voltages of the keying tube V10A are high since the cathode circuit is connected to a source of 240 volts and the grid is returned to 130 volts. In each case, however, the tube element is connected to an intermediate point in a voltage divider between the supply voltage and ground. The dividers are composed of R48 and R59 in the grid circuit and of R62, R61, and R8 in the cathode circuit. Close examination of the diagram reveals that most of the resistance of each voltage divider is present between the tube element and the source of high voltage. Only a small percentage of the total voltage is developed between the tube element and ground, and low operating voltages are actually being applied to the tube.

The DC potential on the grid is a little less than 10 volts, and the potential on the cathode is slightly greater than 10 volts. The bias on the tube may be varied by adjustment of the AGC control R8 in the cathode circuit.

A video signal that contains positive-going sync pulses is fed from the plate of the video output tube to the grid of the keying tube. Although the total amplitude of the signal which is developed across R53 and R59 is great, only a small portion of this signal is developed across R59 and applied to the keying tube. The peak-to-peak amplitude of the signal waveform at the grid of V10A is only about 2.5 volts.

Keying pulses which have an amplitude of only 100 volts are sufficient for proper operation of this circuit. Such pulses are obtainable at the grid of the horizontal discharge tube V17B. This is a tube which receives the output of the horizontal oscillator and shapes it into a sawtooth wave for application to the horizontal output stage. The high-voltage transformer is not involved in this AGC circuit.

The special IF amplifiers which have been mentioned are part of a plug-in type of UHF tuner. A 6AF4 oscillator and a crystal mixer are used to convert the UHF station signal to a 41-mc IF signal. This IF signal is then amplified by a dual triode V2 and a pentode V3, and it is finally applied to the video IF strip without passing through the VHF tuner. The special IF stages are acted upon by the same AGC voltage which is fed to the RF amplifier in the VHF tuner.

The AGC bias is effectively delayed by a method that is not apparent in Fig. 7-6A. The partial schematic diagram in

Fig. 7-6B is presented so that this feature can be seen. Note that the cathode circuit of the first video IF amplifier V6 is connected to a point in the cathode circuit of the third video IF amplifier V8. The positive voltage that is developed across R43 by the conduction of V8 is applied to the cathode of V6. The cathodes of the other stages that are controlled by AGC are returned to ground through small resistors of either 47 or 82 ohms.

If the incoming signal is weak, the control voltage which is produced at the plate of V10A is slightly positive. No appreciable bias is present on the RF and special IF amplifiers, but V6 is biased because its cathode is more positive than its grid.

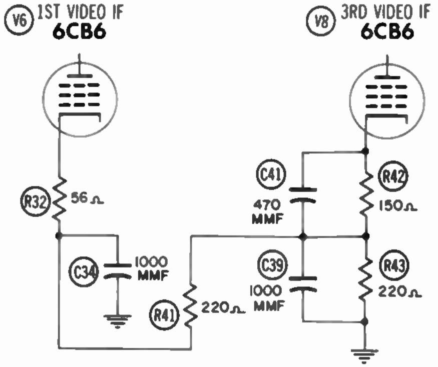


Fig. 7-6B. Cathode Circuit of First and Second Video IF Amplifiers in Zenith Chassis 21L21.

If the amplitude of the incoming signal is somewhat greater than 500 microvolts, the control voltage which is produced by V10A becomes negative. The grid bias on the first video IF amplifier increases, and a negative voltage is applied to the grids of the other controlled amplifiers. The gain of each of these stages is consequently reduced.

The cathode-coupled AGC system of a deluxe Crosley chassis is shown schematically in Fig. 7-7. The output of the video detector is used as an input signal for the AGC circuit. This signal is applied to the grid of the first section of a 6J6 dual triode, and the conduction of the first section generates in the cathode circuit a DC voltage which varies according to the strength of the input signal. The DET. LEVEL potentiometer R9 is an AGC control which may be used to vary the DC grid bias of the first AGC triode. This control makes it possible to adjust the average value of the AGC output voltage.

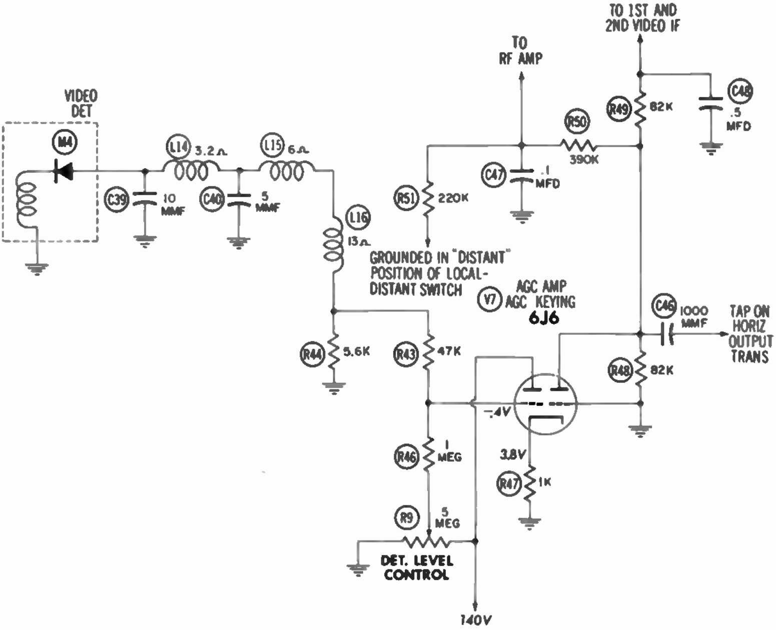


Fig. 7-7. Schematic Diagram of Keyed AGC Circuit in Crosley Chassis 412.

The second section of the 6J6 is connected as a grounded-grid amplifier, and it is driven into conduction by a pulse from the horizontal output transformer. This section is much the same as an ordinary keying tube in many respects, but its bias is determined by the voltage which is developed across the common cathode resistor by the conduction of the first section of the tube.

In the plate circuit of the keying tube, the RC network made up of C48, R49, and R48 develops a bias voltage for two IF amplifiers; and the combination of C47, R50, and R48 develops the AGC bias for the RF amplifier. The resistor R51 is connected to a local-distant switch. When the switch is in the DISTANT position, the lower end of R51 is grounded; therefore, the RF portion of the AGC voltage is considerably reduced.

Conclusion

Some of the many possible solutions to the problems of AGC circuit design have been mentioned in this part of the book. The circuit features which have been discussed will be found in various forms and combinations in a great majority of the television receivers now in service. It is hoped that the reader will find Part II especially helpful as a reference whenever he is trying to analyze the operation of an AGC circuit that looks unfamiliar.

PART III

Trouble Shooting

CHAPTER 8

Principles of AGC Trouble Shooting

Trouble in the AGC system produces characteristic symptoms which show up as defects in the television picture, but these particular symptoms do not always point to AGC trouble. Many other parts of the receiver are closely tied in with the AGC system, and trouble which originates outside the AGC system can interfere with the normal production of AGC voltage. Some typical symptoms of malfunction of the AGC system will be described in this chapter, and other possible causes of these symptoms will be pointed out. Finally, this chapter will bring forth some general techniques which are useful in trouble shooting the AGC system.

Overloading

A variety of picture faults are caused by overloading. The symptoms of this trouble develop if any amplifier in the video channel is operated with insufficient bias or if too large a signal is applied to the grid of an amplifier. When there is a lack of bias, the positive peaks of the signal are distorted because the tube operates in the region of saturation during these peaks. If the input signal is excessive, the positive and negative peaks may both be distorted because the tube is driven into both saturation and cutoff.

The sync pulses which form the peaks of the signal are flattened or removed in most cases of overloading; and therefore, synchronization of the sweep circuits is partially or totally lost. Many times, a simple case of sync instability may be traced to a loss of bias on amplifier grids. This loss is a result of a defect in the AGC system even though AGC would not appear to be an obvious cause of the trouble.

The causes of overloading are interrelated. If one amplifier had inadequate grid bias, the sync pulses might be only

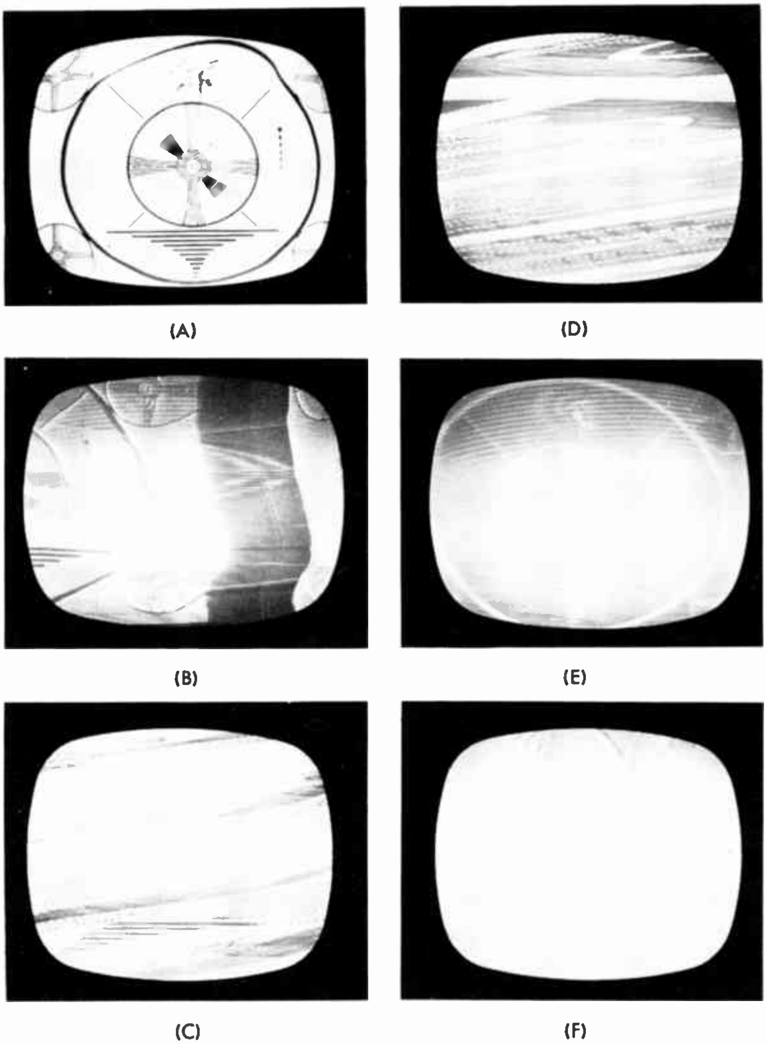


Fig. 8-1. Pictures Illustrating Progressive Degrees of Overloading From Slight to Severe.

slightly flattened; nevertheless, the signal might be amplified to a greater degree than normal by the defective stage. A later stage would then become overloaded, and the sync pulses would undergo further clipping. Even if the effect is slight at first, overloading of a low-level stage is serious because the distortion is built up by the action of several later stages.

Some of the effects which are visible on the picture tube in different cases of overloading are shown in Fig. 8-1. The pictures in Figs. 8-1A through 8-1F represent the results in sequence of a gradually increasing degree of overloading.

Moderate overloading often disturbs the horizontal sync stages slightly and induces the effect called pulling, a condition in which some of the horizontal lines are displaced slightly to the left or to the right. The sides of the picture may take on a ragged appearance. See Fig. 8-1A for a case of slight pulling. Increased blackness of the picture sometimes accompanies pulling, and this blackness gives the viewer the impression of increased contrast.

Synchronization becomes poorer as overloading becomes worse. At first, the pictures are fairly stationary but improperly framed. The vertical or horizontal blanking bars become visible as broad stripes across the screen. More severe overloading brings on a total loss of synchronization which is evident in Figs. 8-1C and 8-1D. A reversal of the dark and light parts of the picture takes place at this stage. Notice that the blanking bars in Fig. 8-1D are whitish in appearance and that the visible parts of the test pattern are white designs on a dark background.

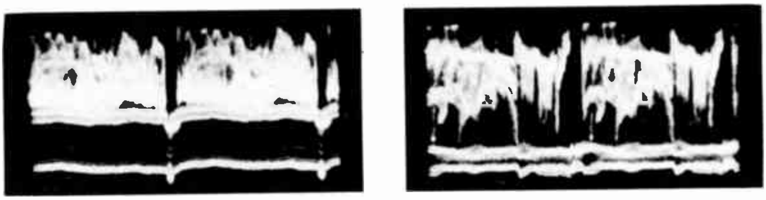
Synchronization improves as overloading progresses beyond this stage, but the picture has the appearance of a photographic negative. (See Fig. 8-1E.) An even worse degree of overloading may produce a picture such as that in Fig. 8-1F. The extreme lack of contrast in this picture might be termed a "white-on-white" effect. In some receivers, the picture becomes almost completely blacked out instead of turning white. Whether or not the picture turns black depends upon the manner in which the plate of the video output tube is connected to the driven element of the picture tube.

In Fig. 8-2, the waveforms of several video signals which correspond to different degrees of overloading are shown at a sweep rate of 30 cps. The output of the video detector is shown in all cases. The normal appearance of this signal is shown in Fig. 8-2A. Notice that it contains negative-going sync pulses. The normal amplitude of this signal is approximately 5 volts from peak to peak.

A defective video signal which would cause moderately severe pulling in the picture is shown in Fig. 8-2B. The amplitude of this waveform is approximately normal, but the sync pulses occupy only a small portion of the total signal amplitude. The total amplitude of the signal increases slightly at points in the waveform which correspond to large dark areas in the picture. Irregularities therefore appear in the bottom edge of the waveform, and the worst pulling occurs in the parts of the picture that are represented by these irregularities.

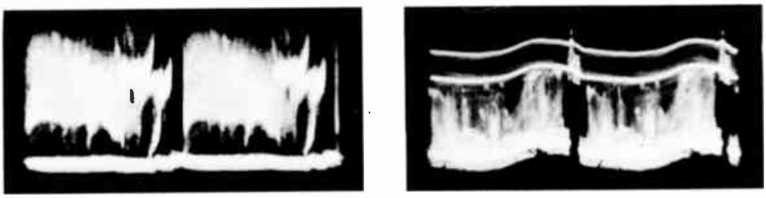
The waveform in Fig. 8-2C displays extreme compression of the sync pulses. When the video waveform has this shape, the TV picture shows a loss of synchronization. This effect is shown in Fig. 8-1C.

The waveform in Fig. 8-2D corresponds to the negative picture in Fig. 8-1E. Note that the waveform looks more or less normal but that the polarity of the whole signal has been reversed. The peak-to-peak amplitude of this waveform is only one volt.



(A) Normal Signal.

(B) Horizontal Pulling.



(C) Loss of Synchronization.

(D) Negative Picture.

(E) White-on-White Effect.

Fig. 8-2. Waveforms Corresponding to Various Conditions of Overloading. Waveforms Were Taken at Output of Video Detector.

Fig. 8-2E illustrates the waveform that corresponds to the white-on-white effect which was shown in Fig. 8-1F. The relative polarity of the sync pulses and of the video signal is uncertain. The amplitude of the entire signal is only 0.3 volt.

A side effect which may be produced when the video signal is overamplified is a 60-cps buzz in the sound. Amplitude modulation of the sound IF input signal by the sync pulses results when the video IF strip is overloaded, and the sound detector may no longer be able to suppress the AM variations. The resulting buzz cannot be eliminated by realignment of the sound detector; instead, the cause of the overloading must be found and corrected.

A perfectly normal receiver can be affected by overloading if the signal at the antenna terminals is extremely strong. Such a signal is present in the vicinity of high-powered television transmitters. Too much signal may also be applied to the receiver if the gain of the antenna is considerably higher than necessary for a given location. The level of the signal becomes so high that the gain of the receiver cannot be controlled by the AGC bias on the RF amplifier.

A test for this condition can be made if a step attenuator is connected between the antenna and the receiver. The use of this accessory makes it possible to reduce the strength of the incoming signal gradually and in precise steps. The technician can determine by this test exactly how much attenuation is required to obtain a signal of the correct strength.

A fixed attenuator pad may be connected in series with the transmission line in order that overloading on one station may be corrected. If the antenna is used for the reception of several signals of varying strengths, provisions should be made for switching the attenuator in and out of the antenna circuit. In some locations in which reception of weak signals is not desired, the use of an antenna with a lower gain may be a good remedy for overloading.

Overloading may be caused by numerous defects within the receiver. These may be in either the AGC system or the various amplifier stages.

Consider the causes of insufficient bias. A lack of bias may come about because the AGC system is failing to develop an adequate control voltage or because the control voltage is not reaching some amplifier stage. On the other hand, a loss of bias voltage may also be traced to a fault in an amplifier tube or in some component that is not considered a part of the AGC system. If an amplifier tube is gassy, some of the AGC voltage will be lost as a result of the effect of negative grid current. The bias on the tube will be reduced, and overloading will probably take place in the faulty stage or in later stages.

Overloading which is no fault of the AGC system may be caused by various component failures. For example, an increase in the value of the plate-load resistor of an amplifier would result in a lowering of the plate voltage. Under these conditions, a signal of normal amplitude would be sufficient to overdrive the stage and produce distortion.

If the amplitude of the signal is abnormally increased within the receiver from some cause other than AGC failure, the AGC system may put out a stronger control voltage in an attempt to compensate for the signal increase. In this case, the amplification in the tuner and in the IF strip is reduced; then distortion that is due to overloading may be lessened at the expense of good sensitivity. Snow may be introduced into the picture, and the technician may be misled into suspecting that a weak amplifier tube is present in the receiver.

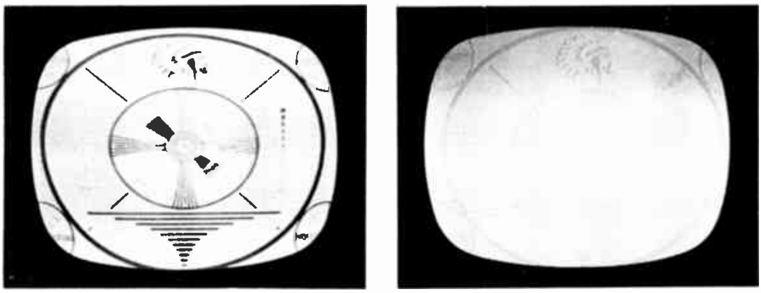
Weak Picture

A reduction in the over-all gain of a television receiver may result in an excessively weak and washed-out picture, an abnormally snowy picture, or the complete loss of both sound and picture. In fringe areas, the amount of snow that should be considered normal can be gauged by the average performance of receivers in a particular neighborhood.

When a picture is weak, one possible cause which should be promptly investigated is the presence of a weak tube in the tuner, in a video IF stage, or in a video amplifier stage. Another highly probable trouble is a defect in the antenna or transmission line. These two things should be checked by the technician before he attempts any trouble shooting underneath the chassis.

It is conceivable that an oversupply of AGC voltage is at the root of a condition of insufficient receiver gain, and the AGC system should be checked if an investigation of the obvious possible causes of a weak picture does not bring the trouble to light.

A failure of a component in a simple type of AGC system is much more likely to remove the AGC voltage from the amplifier grids than to increase that voltage. The more complex AGC circuits behave differently in that the bias voltage can be increased and the picture weakened as a result of several types of defects in components.


(A) Snowy Picture Produced by Excess of Bias to the Tuner.

(B) Weak Picture Produced by Excess of Bias to All Controlled Stages.

Fig. 8-3. Effects of Excessive AGC Bias.

There are some defects in which the control voltage which is applied to the tuner is too high at the same time that the control voltage to the IF stages is normal. Such is the case if a delay clamper fails to conduct when a moderately weak signal is being fed to the receiver. The tuner bias may also be abnormally negative if an open circuit develops in the connection which is made in many receivers from the RF branch of the AGC line to B+. Typical symptoms of excessive bias on the RF amplifier are the same as the indications that are produced by a weak tube in the tuner. These symptoms are an increase in snow in the picture and a loss of reception of originally weak stations. See Fig. 8-3A for a view of a snowy picture that was produced by an excess of AGC bias to the tuner.

Excessive voltage might be developed along the entire AGC line, and a strong incoming signal would produce a washed-out picture like the one in Fig. 8-3B. One explanation for an excess of AGC voltage might be that there is abnormally heavy conduction of some tube which is a part of the AGC system. This tube could be an AGC amplifier or keying tube, or it might be a sync amplifier used as a source of AGC input. Insufficient bias is a common cause of heavy conduction in any tube. If a receiver has an AGC control which permits the bias either of the keying tube or of the AGC amplifier to be varied, a change in the setting of this control may clear up a trouble which is caused by excessive AGC voltage.

An excess of AGC voltage might be traced to excessive amplitude of the AGC input signal from causes within the receiver. For example, a gassy video amplifier would produce too large an output. If this output were fed to the AGC system, a correspondingly large AGC voltage would be developed.

Even though the antenna and tubes are in good condition, and a satisfactory transmitted signal is available, the technician may find that a receiver still has a weak picture and a low AGC voltage. In this case, a further search for trouble is necessary. Loose connections, misalignment, and a faulty video amplifier circuit are a few of the defects which could be responsible for the weakness of the picture.

Fading

Slow and intermittent fading of the picture, a great difference in the contrast levels of the signals on different channels, or both often indicate that the AGC system is not functioning properly. This statement does not apply to fringe-area locations, to many installations of built-in antennas, or to other situations in which the signal is so weak that it develops only a minimum amount of AGC voltage. Since fading is connected with a loss of AGC bias voltage, the symptom of overloading will probably be more obvious than fading in most signal areas.

Fading should not be confused with the rapid picture variations called airplane flutter. These effects are produced by changes which occur in the signal strength at a fast rate, and even a normally operating AGC system cannot always correct these conditions.

Trouble-Shooting Techniques

Component failures in the simple type of AGC system are not major causes of faulty operation in the receivers which employ this type of circuit. This statement is based upon the fact that the components are relatively few in number and that they are not normally subjected to high currents or voltages which could shorten their lives; nevertheless, failures sometimes do occur from such causes as heat radiated from adjacent parts or from leakage which develops in capacitors when they get old.

The more complex AGC systems have many potential sources of trouble because they include many more parts than the simple systems. An additional stress is applied in the form of keying pulses to many parts of a keyed AGC system. Several hundred volts are applied to the components of the AGC filter by these pulses.

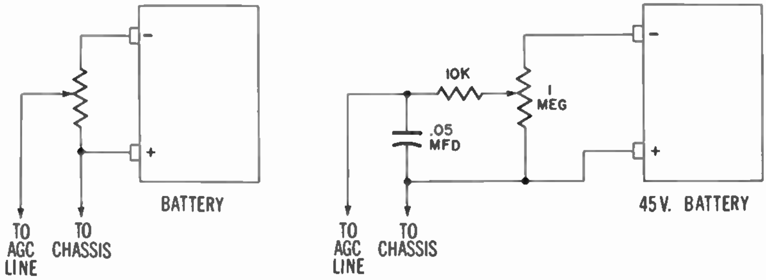
A rapid method of checking the operation of any type of AGC system is to place on the AGC line a DC voltage which is a substitute for the bias that should be developed in a normal system. This process is known as clamping. Resourceful use of clamping will give the technician considerable information about the performance of the AGC system.

Some of the batteries which are used in portable radios are suitable as sources of clamping voltage. A fixed value of -3 volts is often recommended for stabilization of the AGC voltage when a receiver is being aligned, but a larger clamping voltage is usually needed when a transmitted signal is being supplied to a receiver.

For the servicing of AGC circuits, the clamping voltage must be of a value that would cause a normal picture to appear on the picture tube if the set were otherwise capable of producing a normal picture. This voltage varies widely according to the strength of the received signal, and the value of bias voltage which will produce a good picture is fairly critical; therefore, the clamping bias should be variable.

A means of obtaining a variable bias voltage from a battery is shown in Fig. 8-4. The basic circuit which appears in Fig. 8-4A consists of a potentiometer placed across the battery terminals. The positive terminal of the battery is grounded to the chassis of the receiver, and the arm of the potentiometer is connected to the AGC line. This bias supply is suitable when simple AGC systems are being serviced. The battery should be able to supply at least -4 1/2 volts, and -6 volts would be preferable in strong signal areas.

Fig. 8-4B shows some refinements that can be added to the basic circuit in order to make the bias supply suitable for use in keyed AGC circuits. A 45-volt battery is used because DC voltages as high as -35 or -40 volts are sometimes required at the plate of the keying tube when strong signals are being received. The .05-mfd capacitor is placed across the output leads for the purpose of keeping the keying pulses out of the bias supply. The authors were convinced of the usefulness of this capacitor when an unbypassed potentiometer in a bias supply which they were using burned out during the course of servicing a keyed AGC system. The 10,000-ohm resistor is included in the circuit so that a short will not be placed across the leads when the potentiometer is at its minimum setting.



(A) Basic Circuit.

(B) Circuit for Use in Servicing Keyed AGC Systems.

Fig. 8-4. Potentiometer Connected Across a Battery to Provide a Source of Variable Clamping Bias.

In certain pieces of test equipment, a variable bias voltage is available. The Hickok Model 695 TV-FM alignment generator is one such instrument. A bias voltage that is adjustable from 0 to -12 volts may be obtained at a special jack on the front panel.

Whatever bias supply is used, the negative lead is connected to a point on the AGC line. In simple AGC systems, the negative terminal of the AGC filter capacitor is the best point of attachment; and in complex AGC systems, the point which should be clamped is the junction of the RF and IF branches of the AGC line. In many keyed circuits, this junction is at the plate of the keying tube.

There are occasional cases in which it is helpful to apply a clamping voltage to only one branch of a complex type of

AGC line. This procedure may serve to localize a defect that is suspected of being present in some part of the AGC line. An example of the way in which this technique can be applied will be given in the next chapter under the heading of Case History No. 10.

In simple AGC systems, the clamping voltage suppresses the AGC voltage which is developed by the receiver. This is true even when the clamping voltage has a smaller value than the natural AGC voltage; therefore, the technician does not have to worry about disabling the AGC system.

In keyed AGC systems, however, the keying tube should be disabled to prevent the conduction of the tube from affecting the clamping voltage. The simplest method is to remove the keying pulses from the plate. The bias supply which is shown in Fig. 8-4B accomplishes this by shunting the pulses to ground through the capacitor if the negative lead of the bias supply is attached directly to the plate of the keying tube. Since the tube does not have to be removed, this bias supply is very useful when receivers which have tube filaments connected in series are being serviced. Of course, the AGC system may be disabled if the keying tube is pulled from its socket when the filaments are powered by a transformer. If the technician desires to disable the keying tube in a series-filament receiver completely, he may substitute a dummy tube which may easily be made by taking an old tube of the same type as the original and removing the cathode pin.

It has been said that information about the condition of the AGC system is readily furnished by the process of clamping. Suppose that a defect such as overloading is apparent on the picture tube of a TV receiver. If the symptom of trouble can be removed by the application of clamping bias, it is evident that a normal AGC voltage was not being developed or that a defect in another part of the receiver existed and could be remedied by the application of an abnormal value of AGC bias. In the latter case, it might be helpful to measure the clamping voltage which is required to clear up the picture and to compare this voltage with the value of voltage that should normally be developed by the AGC system.

If it is impossible to clear up the picture by means of clamping, two possibilities are indicated. One is that the trouble does not involve the AGC system, and the other is that the presence of a shorted or open component in the AGC line is preventing the development of bias on the controlled amplifiers regardless of the source of the bias voltage. In this last case, the technician will have to make further tests in order to locate the point at which the AGC voltage is figuratively going down the drain.

If a trouble is alleviated when clamping bias is applied, the bias supply should be left connected while several tests are being made. The AGC input signal should be checked with an oscilloscope for both shape and amplitude. If the picture is normal when the clamping voltage is applied, the AGC system would be receiving an input signal that is normal according to service information. The lack of a normal AGC input signal indicates that trouble exists in the video channel of the receiver.

In complex AGC systems, other tests that may have to be made are the observation of signal waveforms and the measurement of DC voltages at the various elements of the AGC tube. Some of the troubles that may be present include either a loss of keying pulses at the plate of the tube in keyed systems or incorrect DC voltages on the grid or cathode of the AGC tube in any complex system.

If the AGC line is not clamped in order that the defect will be removed from the picture, it is difficult to localize the exact source of trouble. The technician's thoughts may run as follows: "The set is overloaded. Is the overloading caused by a loss of AGC voltage? . . . The AGC voltage is low. Is it that way because the AGC input signal is compressed by overloading?" Clamping is a good way to break this vicious circle.

When trouble is localized to the distribution line of the AGC system, the defect usually has to be uncovered by the use of a VTVM and an ohmmeter. A clamping voltage may be applied to the circuit, and the VTVM can be used to find out whether the voltage is being applied to all parts of the line. If the voltage which should be present at a particular point is missing, an ohmmeter reading should answer the question, "Why is it missing?"

The oscilloscope is useful in revealing the presence of hum on the AGC line, and it may also be used to see whether the AGC filter is eliminating all sync or keying pulses.

In the next chapter, we will discuss a number of case histories of AGC servicing. The principles and generalities that have been set forth in this chapter will be illustrated in much greater detail in the pages which follow.

CHAPTER 9

Case Histories of Trouble Shooting

This chapter contains numerous case histories of defects in AGC systems and associated circuits. Each discussion will include a step-by-step description of the actual procedure which was used in trouble shooting. The reasoning which prompted the technician to follow this procedure will also be pointed out.

Each case will be presented in the following order:

1. Complaint — a statement of outward symptoms of trouble.
2. Tracing — the course of action taken by the technician while he traced the source of trouble.
3. Analysis — a discussion of other defects which could have caused the same trouble and of other servicing techniques.

Pictures of test patterns as well as waveforms will be presented wherever they contribute to a better understanding of a servicing problem.

It will be assumed in these cases that defects in tubes have been ruled out and that all possible adjustments of the operating controls of the receiver have been made. Faulty tubes should have been eliminated before a search was made for defective parts on the underside of the chassis. An adjustment of an operating control also might have cleared up a symptom of trouble if the customer had failed to make such an adjustment before requesting service.

Simple AGC

The first three case histories involve a simple AGC filter. Refer to the schematic diagrams in Figs. 9-1 and 9-2 during these three discussions. Fig. 9-1 is a diagram of the AGC system of a receiver, and Fig. 9-2 is a diagram of the sync-separator and vertical-oscillator circuits of the same receiver.

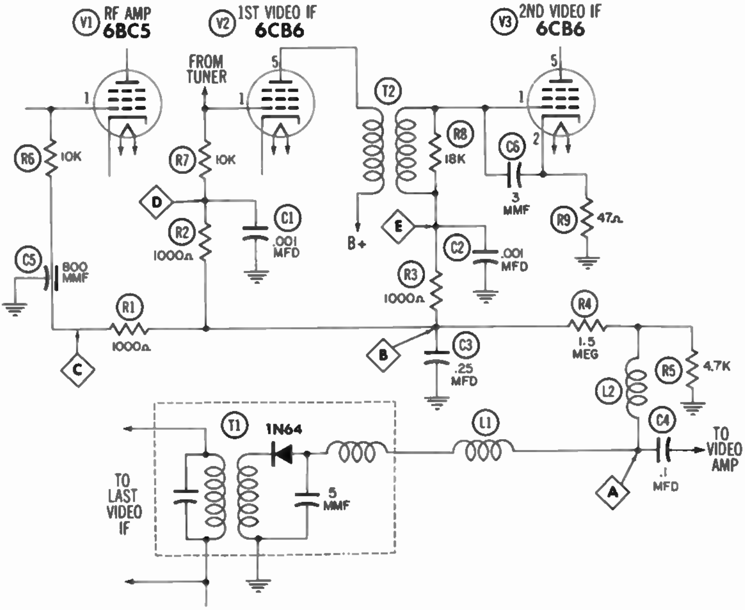


Fig. 9-1. Schematic Diagram of a Simple AGC System.

Several points in each schematic diagram are marked with letters and arrows for the sake of quick reference. This chapter includes a number of voltage measurements and waveforms of the signals which appear at these points in the circuits. The locations of these points in the circuits are as follows:

A. Input to AGC filter from video detector circuit.
B. Output of AGC filter.
C. Grid end of decoupling resistor in grid circuit of RF amplifier.
D. Grid end of decoupling resistor in grid circuit of first IF amplifier.
E. Grid end of decoupling resistor in grid circuit of second IF amplifier.
F. Input to vertical oscillator from integrator network.
G. Plate of phase inverter.

H. Grid of sync separator.
J. Input to grid circuit of sync separator. (This is the same point as the output of the video amplifier circuit.)

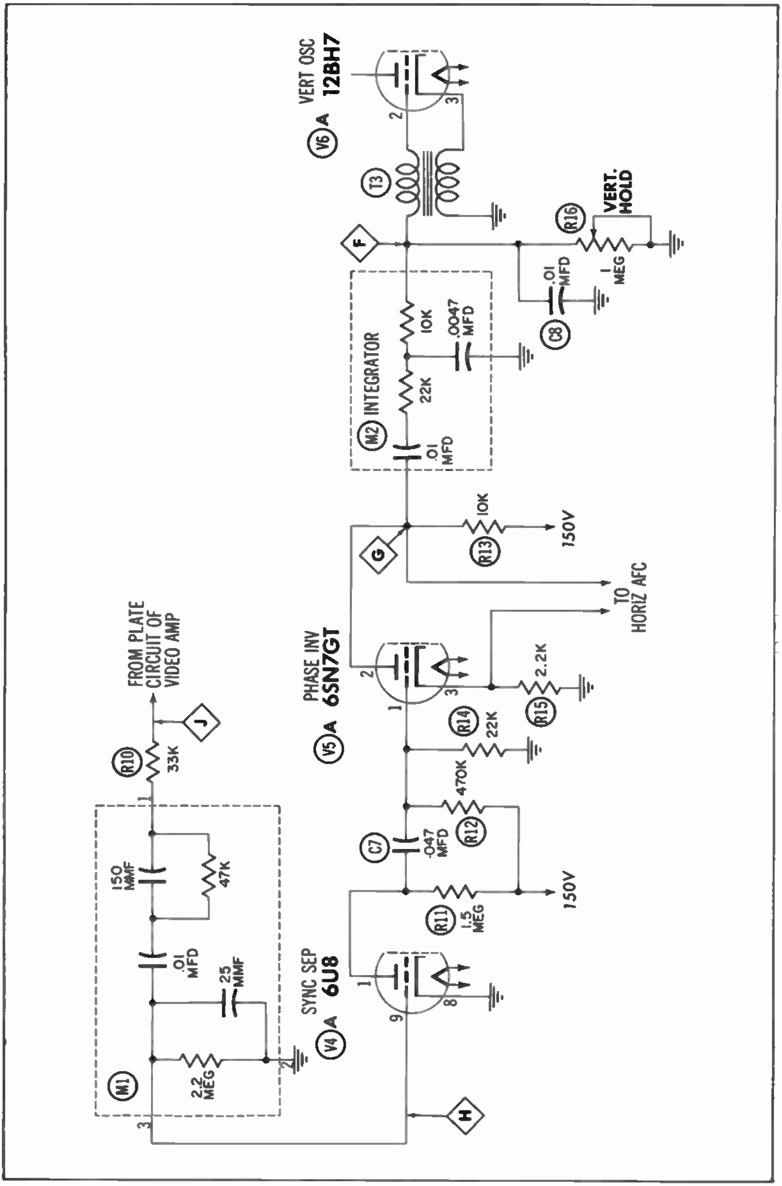


Fig. 9-2. Schematic Diagram of Vertical Sync Circuits in Receiver of Fig. 9-1.

Case History No. 1

COMPLAINT. — The dark and light parts of the picture were reversed at high settings of the contrast control. When the control setting was reduced enough to eliminate the negative effect, the picture was extremely weak.

TRACING. — Since the receiver developed a negative picture, it was suspected that the signal was overloading one or more amplifiers. Trouble in the AGC system is a possible cause of overloading, and the technician clamped the AGC line in order to see whether it was at fault. The picture returned to normal when a clamping bias of -4 volts was applied. It was apparent that the AGC system was the source of the trouble.

The clamping bias was removed from the circuit, and several voltage readings were taken with a VTVM. The reading at point B was only -1.8 volts. A check of points C, D, and E revealed that the same voltage was present in all parts of the AGC line.

The next question that had to be answered was whether the amplitude of the input signal to the AGC system was normal or not. The voltage at point A, which voltage is an index of the signal amplitude, was -12 volts. This reading indicated that the signal was more than adequate; in fact, the video signal was evidently being overamplified in the IF strip.

Since the output voltage of the AGC filter seemed to be unreasonably low in comparison with the input, it was decided that a leakage path must exist from point B to ground. The resistance between these two points was checked and found to be approximately 1.5 megohms, but this value of resistance would be accounted for by the presence of R4 and R5 in series. If the amount of leakage from the AGC line to ground were sufficient to reduce the AGC voltage, the resistance reading from point B to ground should have been materially lower than the normal reading of 1.5 megohms.

The connection of the AGC line to R4 was unsoldered, and the resistance from the line to ground was measured. A finite but extremely high reading of approximately 20 megohms was obtained. The technician then undertook the task of searching for a leak, even though he was puzzled because the reading indicated that the leak was apparently very slight.

The capacitors in the AGC circuit were checked, but they were all in good condition. The next step was to unsolder the connections to the various branches of the AGC line and to measure the resistance from each isolated branch to ground. By this method, an infinite resistance was found to exist at points C and D; but the resistance at point E was about 20 megohms.

The capacitors in the grid circuit of the second video IF amplifier had all passed a leakage test, and no shorts which might be permitting leakage to the chassis were visible. The technician decided to check the IF transformer T2. Before unsoldering the secondary connections of the transformer, he checked the resistance between the primary and the secondary windings. This resistance measured approximately 20 megohms. When the transformer was completely disconnected from the circuit, the primary-to-secondary resistance did not change appreciably.

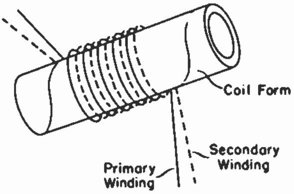


Fig. 9-3. Construction of a Bifilar-Wound Transformer.

The IF transformer was bifilar wound. The method which is used in winding this type of transformer is shown in Fig. 9-3. The wires which become the primary and secondary coils are placed side by side and are wound on the coil form in such a way that a single layer of wire is deposited on the form. Since each turn of the primary winding lies very close to the corresponding turn of the secondary winding, leakage can develop over a period of time.

ANALYSIS. — Some time could have been saved after the technician disconnected the AGC line from the AGC filter. Upon finding a leakage resistance as high as 20 megohms from the line to ground, he should have reasoned that only a very small percentage of the AGC voltage could have leaked through such a high-resistance path to ground. If leakage existed between the AGC line and a source of high positive voltage, however, the AGC voltage would be considerably reduced because of the positive voltage applied to the AGC line. The action would be similar to that of the voltage divider in the circuit which controls the bias of the tuner in a typical keyed AGC system. (See R3 in Fig. 9-7.)

The technician would have been wise to have searched for a possible leak to B+ before he began unsoldering components one by one. The possible leakage paths to circuits which carry B+ voltages are relatively few. The transformer T2 is one path, and another is the coupling capacitor which connects the plate of the mixer tube to the grid of the first video IF amplifier.

Case History No. 2

COMPLAINT. — Vertical synchronization was unstable. The picture could be locked in by adjustment of the vertical hold control, but after a few seconds the picture would drift out of synchronization again. Contrast and brightness were normal.

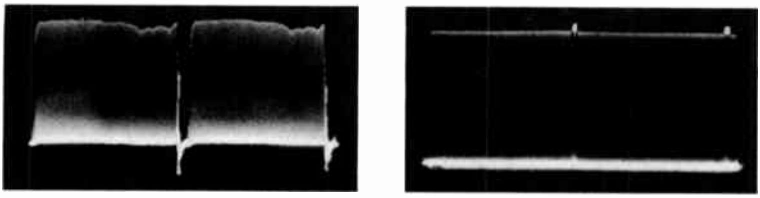
TRACING. — Since the trouble obviously affected only the vertical synchronization of the picture, the vertical oscillator tube was the first item to be checked. Replacement of this tube did not correct the trouble, and the chassis was removed and taken to the shop. The next step was to observe the waveforms of the signals in the sync circuits.

The sweep rate of the oscilloscope was set at 30 cycles per second during the observation of all waveforms. The signal at point F was checked first. The waveform which was obtained is shown in Fig. 9-4A, and the waveform that would have been seen if the receiver had been operating normally is shown in Fig. 9-4B. The peak-to-peak amplitude of Fig. 9-4 A was normal, and the waveform was only slightly abnormal in shape. The most significant feature is the lack of the small pip at the positive peak of the waveform. This pip, which can be seen in Fig. 9-4B, represents the vertical sync pulse. The rest of the signal is composed of feedback from the vertical oscillator.

The incoming pulses were evidently not arriving at the vertical oscillator. The waveform of the signal which was present at point G was checked in order to see whether the pulses were also absent at that point. This waveform appears in Fig. 9-4C, and the normal waveform is presented in Fig.

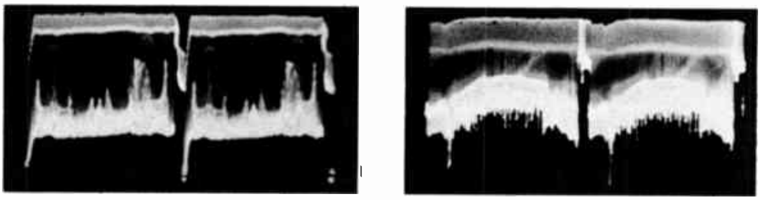
(A) Abnormal Signal at Point F.

(B) Normal Signal at Point F.



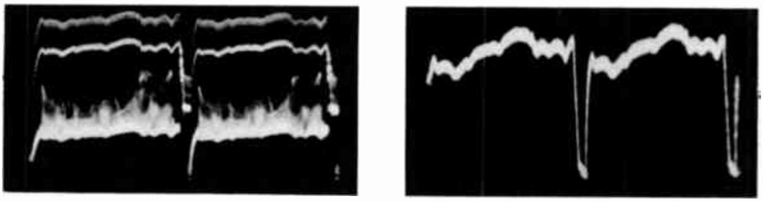
(C) Abnormal Signal at Point G.

(D) Normal Signal at Point G.



(E) Abnormal Signal at Point H.

(F) Normal Signal at Point H.



(G) Abnormal Signal at Point J.

(H) Abnormal Signal at Point B.

Fig. 9-4. Waveforms of Signals Present in the Circuit of Fig. 9-2 in Case History No. 2.

9-4D for the sake of comparison. The vertical sync pulses were evidently being inverted or suppressed.

The probe of the oscilloscope was next moved to point H, and the waveform which was observed is shown in Fig. 9-4E. Compare this waveform with the normal one that is shown in Fig. 9-4F, and note in the former picture that the horizontal pulses are almost normal but that the vertical pulses are distorted. After this waveform was observed, it was apparent that a normal signal was not being applied to the sync circuits.

The waveform of the signal at point J was also checked by the technician in order that he might be sure that the distortion was not being caused by a defective component in the printed circuit M1. This circuit was evidently in good condition because this last waveform (shown in Fig. 9-4G) displayed the same defect that was observed in Fig. 9-4E.

The degeneration of the vertical pulses in an otherwise normal signal was a very puzzling symptom, and it would have baffled the technician if he had not recalled a certain fact about simple AGC systems. If the vertical sync pulses are not removed by the AGC filter from the input signal to the AGC system, negative pulses will be present in the control voltage that is produced by the AGC system; and the gain of the controlled stages will be sharply reduced during these pulses. The cause of this condition might be failure of a component in the filter, or the cause might simply be that the time constant of the filter is too short to level out the vertical pulses.

A quick check of the waveform of the signal at point B revealed that vertical pulses were indeed present on the AGC line. See Fig. 9-4H. It appeared that a fault existed in the filter. The most probable trouble was that the filter capacitor C3 was open or that its capacitance had decreased sufficiently to shorten the time constant drastically. The capacitor was replaced with a new part, and the trouble disappeared.

ANALYSIS. — In this case, the use of an oscilloscope saved the technician much time which he might otherwise have wasted in taking voltage and resistance readings in the sync circuits. It was promptly discovered that the input signal to the sync separator was defective, and therefore it was decided that the source of trouble must be in some part of the circuit other than the sync section.

Luckily, the technician immediately saw a possible connection between faulty AGC action and distortion of the vertical pulses; and he was able to go almost directly to the root of the trouble. He saved additional time by using the oscilloscope to check the AGC voltage. A measurement of the voltage at point B using a VTVM would have yielded a normal reading because only the shape of the waveform of the AGC voltage was faulty. This case illustrates the great usefulness of signal tracing with an oscilloscope whenever defects which involve pulses of voltage occur.

Case History No. 3

COMPLAINT. -- Both vertical and horizontal synchronization were very unstable.

TRACING. — Since the obvious symptom of trouble was a loss of synchronization, the sync-separator and phase-inverter tubes were checked. These were in good condition. An oscilloscope was then used to check the input signal at the grid of the sync separator. The waveform which was observed is shown in Fig. 9-5A. Note that compression of the sync pulses had occurred.

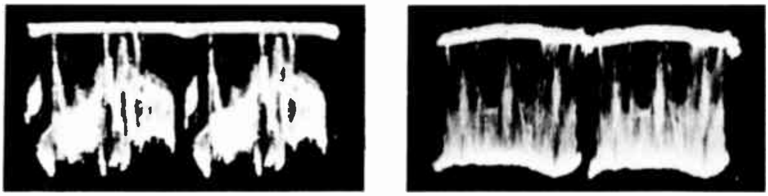

(A) At Point H.
(B) At Point J.

Fig. 9-5. Waveforms Observed in the Circuit of Fig. 9-2 When R4 of Fig. 9-1 Is Open.

The signal at point J in the plate circuit of the video output tube was also checked. The amplitude of this signal was 100 volts peak to peak at an average setting of the contrast control. This amplitude is considerably greater than normal. The sync pulses were also greatly compressed. See Fig. 9-5B. The signal was evidently being distorted before it reached this part of the receiver.

The appearance of the waveform in Fig. 9-5B suggested to the technician that overloading was the basic cause of the unstable synchronization. After checking the video amplifier circuit without success, he reasoned that the overloading might be caused by a lack of AGC voltage. This seemed especially possible because the receiver was tuned to a strong incoming signal.

The technician decided that the easiest check on the action of the AGC system would be to tune in a weak station. The symptoms of inadequate AGC bias would be expected to clear up if the incoming signal were too weak to require much AGC voltage. In fact, the contrast range of a weak picture might even improve if the AGC voltage were lower than normal.

When a weak station was actually tuned in, the picture regained normal synchronization; but it appeared even weaker than normal. This appearance of the picture made it seem that the receiver was generating too much AGC voltage during the reception of a weak signal. This behavior was not typical of ordinary cases of overloading, and the technician therefore decided to measure the value of AGC voltage that was being produced by the receiver.

When the lead of a VTVM was placed on point B, the contrast ratio of the picture was markedly improved. This change in the quality of the picture was so surprising to the technician that he switched the receiver back to the strong station in order to see how the presence of the meter lead would affect the picture on that channel. When the lead was again touched to point B, the picture became negative! The meter indicated the presence of -3 volts on the AGC line. The meter lead was moved to point A where a reading of -15 volts was obtained. While this latter measurement was being made. the receiver developed sync instability. The meter lead was again moved to point B, and the picture once more became negative.

It appeared that the normal discharge path of some capacitor in the AGC line was broken. It also appeared that the capacitor discharged through the meter movement each time the technician tried to measure the AGC voltage. A comparison of the voltage at point A with that at point B suggested that the normal input signal was not reaching the AGC line.

A close study of the schematic diagram showed that both of these conditions would exist if the filter resistor R4 were open. If that defect were present, both the charge circuit and the discharge circuit of the filter capacitor C3 would be interrupted. Grid current drawn by the amplifier tubes could charge C3 to some extent, and the capacitor would hold this charge for a considerable length of time because of the lack of a discharge path. Applying a meter to the AGC line would quickly discharge C3.

The resistance from point A to ground was measured and found to be normal, but the resistance at point B was so high that it could not be measured. These readings supported the conclusion that R4 was open.

ANALYSIS. — The discharge path of C3 also would have been broken if R5 instead of R4 had become open. The symptom in that case would have been a total loss of video signal because R5 is the load resistor for the video detector.

The sync instability which was the symptom of trouble in this case is one of several possible symptoms of overloading. Before attempting to search for trouble in the sync circuits, the technician should have tried to manipulate more of the operating controls in an effort to find out more about the indications of trouble. An adjustment of the contrast control or a look at the picture on another channel probably would have told him that overloading was involved in the defect in this case.

Case history No. 3 was not a simple case of insufficient AGC voltage. Some bias voltage was developed because the AGC filter capacitor held the charge that was placed upon it by grid current from the controlled stages. This voltage was completely inadequate on some channels, and overloading resulted; but there was too much bias on the IF stages during reception of weak signals, and there was consequent exaggeration of the weakness of these signals.

Keyed AGC

The next eight case histories deal with defects in keyed AGC systems. During the discussion of each case, reference will be made to one of the two typical keyed systems that are shown schematically in Fig. 9-6 and Fig. 9-7. These two systems are fundamentally alike in most respects, but the circuit of Fig. 9-6 is slightly more complicated than the other. Note that it includes a clamper diode and a delay control in the RF branch of the AGC line. Since the keying tube in the circuit of Fig. 9-6 is a triode, its DC grid and cathode voltages are much lower than the voltages on the corresponding elements of the pentode type of keying tube that is employed in the circuit of Fig. 9-7.

The association of any certain defect with one or the other of the two circuits is purely coincidental. The authors wish to make it clear that the different circuits are not necessarily prone to particular types of defects.

Several test points have been designated on each diagram in order that references to various key points in the circuits may be made quickly and clearly. Since the two designs are similar, corresponding points in both circuits are designated by the same letter. The test points are as follows:

A. Plate of keying tube.
B. Junction of RF and IF branches of AGC line. (Point A is identical to point B in the circuit of Fig. 9-7.)

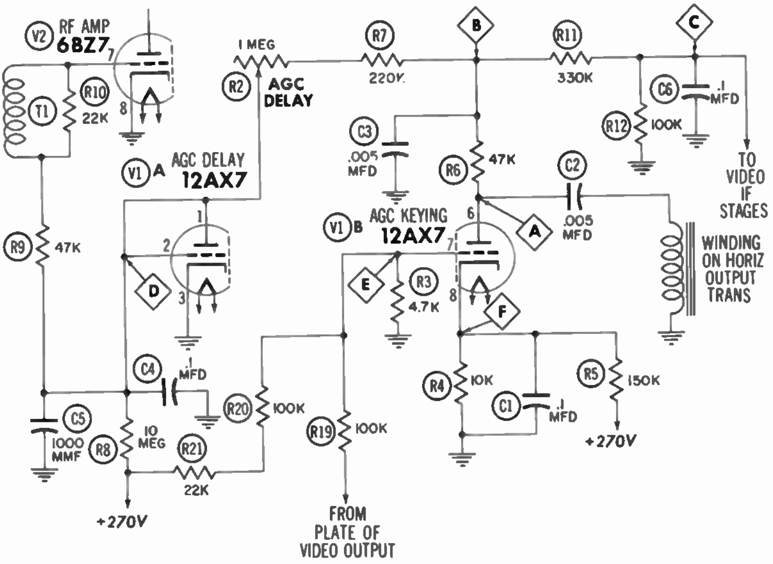


Fig. 9-6. Schematic Diagram of Keyed AGC System With a Control in the Plate Circuit.

C. Negative terminal of filter capacitor in IF branch of AGC line.
D. Negative terminal of filter capacitor in RF branch of AGC line.
E. Grid of keying tube.
F. Cathode of keying tube.

Case Histories No. 4 to No. 7

These four cases are grouped together because all concern overloading. The degree of trouble varied from case to case, but the nature of the trouble was fundamentally the same in each case because some or all of the AGC voltage was being lost.

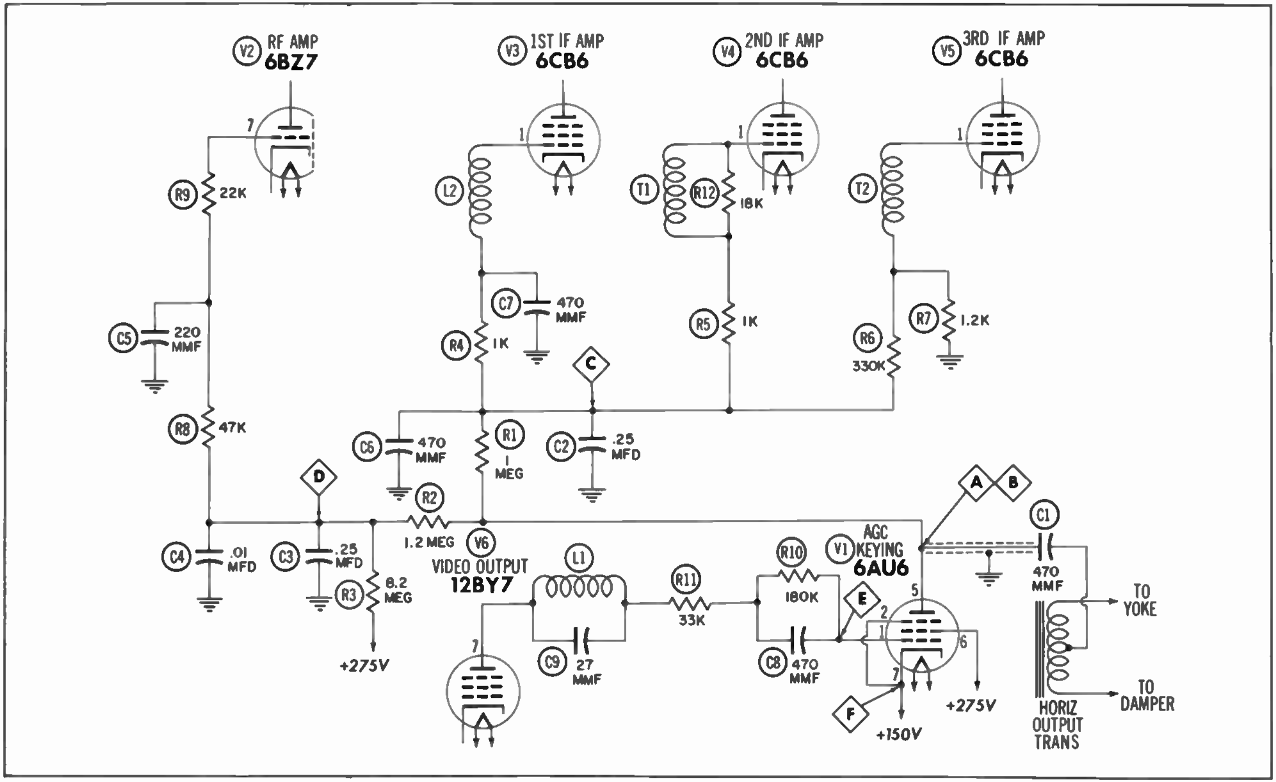


Fig. 9-7. Schematic Diagram of Keyed AGC System Without a Control in the Plate Circuit.

One step in the trouble-shooting procedure was the same in all cases. Sooner or later, the technician attempted to remove the symptoms of overloading by means of clamping the AGC line at some level of voltage. Beyond this step in the procedure, the various cases were handled differently according to the results that were obtained from clamping. The symptoms that were observed in each case were also taken into account.

The bias supply which was shown in the diagram in Fig. 8-4B was used as a source of clamping voltage in all cases. This device was very convenient because it furnished a widely variable bias voltage and also because it disabled the keying tube by shunting the keying pulses to ground.

The negative lead of the bias supply was attached to point A (the plate at the keying tube) in each circuit. When this connection was made, the keying tube was properly disabled and the entire AGC line was controlled in the required manner. The clamping voltage that was required at point A was approximately -35 to -40 volts when a strong incoming signal was being applied to the receiver. If the technician had failed to use an adequate clamping voltage, he would not have been able to obtain a clear picture and might have been misled into overlooking the possibility of a defect in the circuit of the keying tube.

COMPLAINT FOR CASE NO. 4. — When the receiver was tuned to a strong signal, a negative picture such as the one in Fig. 8-1E was produced. Synchronization was not greatly disturbed. (During the discussion of this case, refer to Fig. 9-6.)

TRACING FOR CASE NO. 4. — The technician found that the picture would return to normal when a clamping voltage of -35 volts were applied to the circuit at point A. Since this was the approximate value of voltage that would have been present at point A in a normally operating receiver, it was assumed that the AGC line would function properly as long as it had the correct input signal. Evidently, this input signal was not being supplied. The severity of the overloading suggested that the keying tube might not even be conducting.

The tube itself had been replaced without success. The next most probable defect was a loss of the keying pulses at the plate. Since the clamping device removes the pulses from the plate circuit, the lead from the device had to be disconnected while the plate circuit was being tested for the presence of pulses. Even when that precaution was taken, a check with an oscilloscope showed that the pulses were missing.

One of the most logical causes of this type of trouble was that the coupling capacitor C2 might have become open. When this component was unsoldered and checked, it was found to be open.

COMPLAINT FOR CASE NO. 5. — Overloading in this case was moderate. The worst symptom was a loss of synchronization, and the appearance of the picture was similar to Fig. 8-1B or 8-1C. (During the discussion of this case, refer to Fig. 9-6.)

TRACING FOR CASE NO. 5. — When a clamping voltage was applied to the circuit, the picture became normal. The technician had the impression that the keying tube was developing some output voltage but not enough. Since the overloading was never extreme, it was doubted that there was a complete loss of input signal either at the grid or at the plate of the keying tube. The technician decided to investigate the voltages and waveforms at the grid and cathode of the tube because a moderate defect in the waveform or in the DC level could upset the normal bias of the tube.

The grid and cathode voltages were measured with a VTVM. The readings which were obtained were not abnormal enough to provide definite information about the cause of the overloading. The technician turned to the oscilloscope for the next step in the process of trouble shooting. He checked the waveform at point E and found that it was normal. When he placed the probe of the oscilloscope at point F, he observed a signal which contained positive pulses. These pulses had the same frequency as the horizontal sync pulses, and their peak-to-peak amplitude was 5 volts. The waveform of this signal is shown in Fig. 9-8. Notice that the signal contained some video in addition to the pulses.

A waveform with an amplitude of less than one volt might have been observed at point F if the receiver had been operating normally, but this signal would have been composed chiefly of stray pickup from the high-voltage circuits. Actually, a nearly pure DC voltage should be present at the cathode of the keying tube. The bypass capacitor C1 should level out the AC variations that are produced in the cathode circuit by the conduction of the tube.

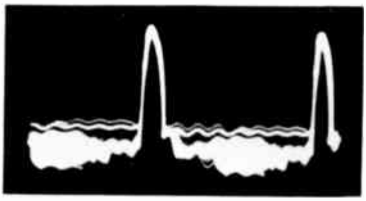


Fig. 9-8. Waveform of Pulses in the Cathode Voltage of the Keying Tube in Case History No. 5.

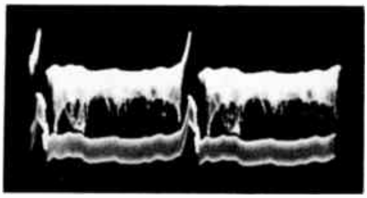


Fig. 9-9. Waveform of the Signal at the Grid of the Keying Tube in Case History No. 6.

Since the bypass capacitor C1 in the cathode circuit was apparently not doing its job, it was unsoldered and tested. The capacitor was open. The failure of the capacitor was allowing degeneration to occur in the circuit of the keying tube, and less than the normal value of AGC voltage was being produced.

Degeneration occurred because the sync pulses in the signal at the grid developed corresponding pulses in the cathode circuit. Since the cathode pulses had an amplitude of 5 volts, the cathode voltage was being increased by 5 volts during each period of conduction of the tube. The grid voltage remained at a normal value, and the bias on the tube was effectively increased just during the intervals when the value of the bias was important to the operation of the circuit. The average value of the cathode voltage would not have been increased much by the presence of the pulses, and a DC measurement of that voltage therefore would not have revealed that the bias was abnormal.

COMPLAINT FOR CASE NO. 6. — A negative picture such as the one in Fig. 8-1E was present on the picture tube in this case. (During the discussion of this case, refer to Fig. 9-7.)

TRACING FOR CASE NO. 6. — The application of a clamping voltage to point A restored the receiver to normal operation; therefore, the circuit of the keying tube was throughly tested for defects.

The clamping voltage was temporarily removed, and an oscilloscope probe was applied to point A. Normal keying pulses which had an amplitude of 350 volts were present. The clamping voltage was applied again, and the grid and cathode waveforms were checked. The waveform of the input signal at point E appeared to be distorted. (See Fig. 9-9.) The amplitude of this waveform was about three fourths of the normal value.

The DC voltage measured at point E with a VTVM was only a fraction of a volt. Since the grid of the keying tube receives its DC bias only from the plate circuit of the video amplifier, it was suspected that the DC path in the grid circuit was open. When the resistance across the combination of R10 and C8 was measured, the reading was infinite. The resistor R10 was replaced, and the circuit returned to normal operation.

The DC path between the grid of the keying tube and the plate of the video amplifier might also have been broken if R11 or L1 had become open, but the symptoms of trouble would have been different. An open condition in R11 would have removed the signal completely from point E; but the opening of R10 did not prevent the AC coupling of the signal through C8 to the grid. If L1 had been open, the video signal would have become seriously distorted even if the AGC line were clamped.

COMPLAINT FOR CASE NO. 7. — The symptoms of trouble ranged from severe pulling to a reversal of the dark and light parts of the picture. See Figs. 8-1B through 8-1D. (During the discussion of this case, refer also to Fig. 9-7.)

TRACING FOR CASE NO. 7. — Since the trouble appeared to be definitely caused by overloading, the AGC line was clamped; but clamping was no help in this case. Recalling that a lack of success in clamping may be due to trouble in the AGC line as well as to trouble not connected with the AGC system, the technician thought that the wisest move would be to find out whether the clamping voltage was being dissipated within the AGC line.

The voltage at point A was measured with a VTVM while the clamping voltage was still being applied to that point. The reading was zero! An ohmmeter reading indicated that a short existed from point A to ground.

The most probable defect that could cause a short circuit at this point would be a fault in the wiring. For example, there might be a large blob of solder on the plate pin of the tube socket and in contact with the chassis. A defect of this type was not visible when the circuit was examined.

There was one other possibility. The lead which connected the plate of the keying tube to the high-voltage circuit was shielded, and an internal short in this shielded wire could be grounding the AGC line. The shielded wire was disconnected from point A, and the short circuit disappeared. It was concluded that the insulation inside the shielding had broken down under the stress of the keying pulses.

ANALYSIS. — These four cases illustrate that a wide variety of defects in the AGC system can cause overloading. Many of the relatively improbable causes of overloading have been omitted from this discussion, but it is conceivable that components such as C6 in Fig. 9-7 could fail and cause troubles similar to the ones that have just been discussed.

Also omitted were various possible defects in amplifier stages. Some of the symptoms of overloading may be produced by any defect which renders an amplifier tube unable to develop an undistorted output signal.

During the servicing of receivers that are suspected of having AGC trouble, one important point to remember is that the receiver should be supplied with the strongest signal which it is ever required to handle. Some minor deficiencies in the performance of the AGC system are bothersome only during the reception of strong signals because the AGC system must supply its greatest control voltage when a strong signal is applied to the receiver. If the strongest signal that is available at the service shop is weaker than the strongest signal that is received at the customer's home, such complaints as pulling and sync buzz may not show up after the chassis is removed to the shop for servicing. Inadequate production of AGC voltage while signals of moderate strength are being received sometimes results in nothing worse than a slight darkening of the picture, and this effect would not be especially noticeable in most cases.

At an early stage in the process of trouble shooting, the technician should also test the performance of the receiver on several channels in order to observe the effects that are produced by incoming signals of various strengths. Suppose, for example, that capacitor C2 in the circuit of Fig. 9-7 became shorted. A strong incoming signal might produce the faded white-on-white picture that is characteristic of extreme overloading in many receivers, and this effect might be misinterpreted as a weak picture that was being caused by insufficient gain in the video channel of the receiver. If the latter trouble existed, a weak incoming signal would probably fail to produce any picture at all on the face of the picture tube; but if the trouble were a result of overloading, the receiver might develop a good picture from the weak signal.

Miscellaneous defects in keyed AGC systems will be discussed in the next four case histories in this chapter. A different symptom of trouble was produced by each defect.

Case History No. 8

COMPLAINT. — Neither picture nor sound were developed on any channel. (During the discussion of this case, refer to Fig. 9-6.)

TRACING. — The tubes which were substituted without success were the video output, video detector, and all IF amplifiers. The tuner tubes were not checked because noise generated within them would have produced snow in the raster if the IF and video stages had been operating normally.

A thorough inspection of the chassis was made in search of an open or short circuit that might be visible. This inspection also included the tapping of components in an effort to uncover any intermittent defects which might exist. No abnormalities were found. Before making a detailed examination of the amplifier circuits, the technician decided to test the operation of the AGC system. It would be easy to clamp the AGC voltage, and there was a possibility that too much AGC voltage was being developed. When the keying tube was disabled and the clamping voltage was applied to point A, the receiver was restored to normal operation. This indicated that the defect was in the circuit of the keying tube.

The waveform of the plate voltage was not checked for the reason that defects in the keying pulses would be expected to reduce or eliminate the AGC voltage instead of increasing it.

An increase in the amplitude of the pulses might at first be considered as a possible source of trouble, but an increase would not actually have much effect upon the conduction of the keying tube.

The first waveform that was observed was the one at the grid (point E). The waveform had a peak-to-peak amplitude of 15 volts or two and a half times the amplitude of a normal signal. Remember that the AGC line was being clamped while this waveform was being observed. If no clamping voltage had been applied, no signal would have been present at point E because no video signal was being developed.

The DC voltage which was measured with a VTVM at point E was 75 volts. This value was unusually high in comparison with the normal value of 12 volts. The presence of such a high positive voltage on the grid would permit extremely heavy conduction of the keying tube at all times, and this condition would obviously lead to a considerable excess of AGC voltage.

The manner in which the grid obtains its DC bias is apparent in Fig. 9-6. A voltage divider composed of R3, R20, and R21 is connected between a source of 270 volts and ground; and only the voltage which is developed across R3 is applied to the grid. Since the resistance of R3 is normally a very small proportion of the total resistance of the voltage divider, only 12 volts normally appear at point E.

A change in the value of one of the resistors would affect the level of the voltage at point E. When the technician began to check the resistors with an ohmmeter, he found that the resistance from point E to ground had increased from 4,700 ohms to 47,000 ohms. This reading indicated that R3 had increased in value. Since the other resistors had not changed, an abnormally large percentage of the total of 270 volts was being developed across the faulty resistor R3. The normal bias of the keying tube was therefore removed because the grid voltage became strongly positive with respect to the cathode voltage.

ANALYSIS. — If R5 in the cathode circuit had increased in value, the bias of the keying tube would also have been removed because the cathode voltage would have become less positive than normal. An increase in the value of any of the other resistors in the circuit would have caused an increase in the bias on the keying tube. The conduction of the tube then would have decreased, and some degree of overloading would have been the result. The possibilities of a short circuit or a decrease in value in a resistor will not be considered because such defects rarely occur.

Case History No. 9

COMPLAINT. — The picture contained snow on all channels regardless of the setting of the AGC control. (During the discussion of this case, refer to Fig. 9-6.)

TRACING. — The antenna circuit and the tuner were checked, but the problem was not solved. The application of a clamping bias at point A did not improve the picture.

The bias supply was disconnected from the AGC line, and some voltage readings were taken with a VTVM. The indication at point A was -4 volts. The presence of such a low AGC voltage at this point was not alarming. Since the picture was weak and snowy, it stood to reason that the input signal at the grid of the keying tube would have a low amplitude; consequently, very little AGC voltage would have been produced. The fact that the AGC voltage was low did not explain why the picture was weak, however.

The voltage at point D was measured in order to test for proper functioning of the delay circuit. Since only -4 volts were present at point A, the clamper diode should have been conducting and the voltage at point D should have been nearly zero. Actually, a reading of -4 volts was obtained. The delay circuit was not operating, and the voltage drop which normally occurs across R2 and R7 was not present because of some malfunction of the circuit.

The connection of R8 between the AGC and B+ lines is made for the purpose of reducing the voltage at point A to a value that is suitable for application to the RF stage. The electron flow that produces the voltage drop would be interrupted if the connection to B+ were broken. It was found that the resistor R8 was open; therefore, this fault actually existed.

ANALYSIS. — Snow was present in the picture because considerable bias was being applied to the tuner, and R2 failed to exert its normal control over the amount of snow in the picture on account of the lack of a voltage drop across the control.

Failure of the clamper tube in the delay circuit would have caused weak incoming signals to produce abnormally snowy pictures, but there would have been no effect upon strong signals. When R8 became open, signals of all strengths were affected.

A moderate increase in the value of R8 would not have had a serious effect upon the circuit for the reason that the fault could be counteracted to a great extent by an adjustment of the delay control R2. Some other keyed AGC circuits which do not provide a delay control would be noticeably affected by a change in the value of a resistor corresponding to R8.

Case History No. 10

COMPLAINT. — Vertical synchronization was unstable, and the picture rolled erratically. The picture was also jittery and had a tendency toward horizontal pulling. A very odd fault which was present in the picture is visible in Fig. 9-10. The vertical blanking bar contained a white stripe. Normally, this bar is all black. (During the discussion of this case, refer to Fig. 9-7.)

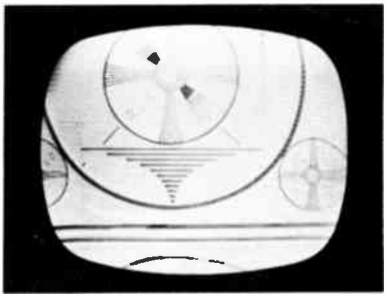
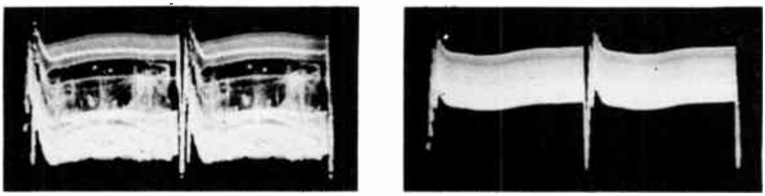


Fig. 9-10. Appearance of the TV Picture in Case History No. 10.

TRACING. — The presence of the white stripe in the vertical blanking bar was a clue that this defect was highly unusual. When the waveform of the signal at the plate of the video output tube was checked, the reason that the white stripe was produced was evident. Refer to Fig. 9-11A, and note that the vertical sync pulses are greatly distorted.

Positive-going vertical sync pulses that are relatively square should appear in a normal waveform, but the waveform in Fig. 9-11A contains M-shaped vertical pulses. The leading and trailing edges of each pulse are normal, and therefore the top and bottom edges of the blanking bar in the picture are normal; but the middle portion of each pulse is deeply indented by a very sharp negative pulse with an amplitude that is equal to the peak-to-peak amplitude of the whole signal. When this negative-going spike was applied to the cathode of the picture tube during the vertical blanking interval, the central portion of the blanking bar turned white.



(A) At the Grid of the Picture Tube. (B) At Point C on the AGC Line.

Fig. 9-11. Waveforms of the Signals in Case History No. 10.

Other defects are visible in the waveform in Fig. 9-11A. The height of the horizontal sync pulses is less than normal, and the DC level of the entire video signal appears to increase for a brief time after the conclusion of each vertical sync pulse. These two defects would tend to cause unstable horizontal synchronization.

The technician saw that this abnormality of the video signal was the immediate cause of the unstable synchronization, but he still had the problem of locating the fault which was causing the negative pulses to be injected into the video signal. A suspicion that the AGC system might be at the root of the trouble was borne out when the AGC line was clamped. The operation of the receiver returned to normal.

In the usual case of trouble, a defect in the circuit of the keying tube would have been suspected when clamping removed the symptoms of trouble. The possibility that the AGC line was defective would not ordinarily have been considered because it would have been reasoned that the line was in good condition if it did not dissipate the clamping voltage. The technician thought it was necessary to make further tests on the AGC line in this case since the problem involved pulses of voltage.

Pulses would have to be present on the AGC line in order to be introduced into the video signal by way of the AGC system. The AGC filter might have lost its ability to remove pulses of voltage from the output of the keying tube. Clamping the AGC line would appear to correct a defect of this type for the reason that the clamping battery presents an extremely low impedance to any voltage other than its own, and the pulses could not develop.

A different approach to clamping was attempted for the sake of finding out all possible information about the defect. Using a low voltage, the technician tried to clamp one branch of the AGC line at a time in the hope that the trouble might be further localized. When a few volts of clamping bias were applied at point D, the symptoms of trouble were not eliminated. When clamping was tried at point C, the picture became normal. If it were assumed that the clamping voltage would override any pulse voltage which might be present, this latest evidence would indicate that the source of the offending pulses was in the IF branch of the AGC line.

The clamping voltage was removed from the circuit, and the voltage at point C was checked with an oscilloscope. Although no AC signal should have been present at this point, the waveform which is shown in Fig. 9-11B was observed. The signal contained negative-going pulses which occurred at the vertical sweep rate and which had an amplitude of 3 volts. The rest of the waveform had an amplitude of 1.5 volts and was composed of pulses which occurred at the horizontal sweep rate. Notice that the shape of the large pulses in Fig. 9-11B appears to correspond closely to the shape of the interfering pulses in the waveform of Fig. 9-11A.

Since the presence of a signal at point C indicated that something was wrong with the AGC filter, the components of the filter were checked. The capacitor C2 was open.

ANALYSIS. — The distorted signal which was present at the output of the video amplifier might be considered to be the resultant of two signals. The signal which was present on the AGC line was effectively subtracted from the normal video signal; therefore, the horizontal sync pulses were reduced in height and a part of each vertical sync pulse was completely cancelled.

The pulses on the AGC line occurred in response to the conduction of the keying tube. Theoretically, no large pulses should have been developed because the keying tube does not conduct continuously throughout the duration of the incoming vertical sync pulses. Its conduction is triggered only by a pulse that is developed in the horizontal sweep circuits. Actually, the keying tube did respond to the vertical pulses to some degree; but the output pulses had the degenerated appearance that is evident in the waveforms. Even though C2 was defective, some filtering was accomplished in the AGC line by the other filter components; but the time constant of the remaining portion of the filter was considerably shortened.

In the case which has just been discussed, some time was saved by applying a clamping voltage to only one branch of the AGC line at one time. The trouble was successfully traced to the IF branch of the line in this manner. This servicing technique is somewhat limited in its usefulness because it is easy to obtain misleading indications if the entire AGC line is not controlled by the clamping voltage. Partial clamping is sometimes practical, though, if the technician is wary of the conclusions which he draws from the results he obtains.

Case History No. 11

COMPLAINT. — Snow was present on even the strongest stations when the contrast control was set near the center of its range. When the contrast control was placed at an abnormally high setting, the snow disappeared but the picture was weak. (During the discussion of this case, refer to Fig. 9-7.)

TRACING. — All of the tubes in the tuner, IF, and video stages were good. When the tuner voltages were checked at all accessible test points, it was discovered that the input to the tuner from the AGC line was -30 volts.

The technician stopped to reflect upon the possible causes of this extremely high AGC voltage. He thought that the most probable trouble would be an open circuit in the resistor R3 and a consequent failure of the delay circuit. On the other hand, the trouble might be that the input signal at the grid of the keying tube was exceptionally strong.

The voltage at point A (measured with a VTVM) was -75 volts. When this reading was obtained, it became clear that R3 was not defective. The delay circuit would have been disabled if R3 had been open, and the voltage at point A would have been equal to the voltage at point D. Actually, the difference of potential between these two points was 45 volts.

Since the voltage at point A was abnormally high, it appeared that the keying tube was conducting too heavily. Two possible reasons for excessive conduction were considered first — that the circuit of the keying tube might be defective or that the IF and video stages might be overamplifying the video signal.

The latter possibility seemed to be improbable because the high voltage which was present at point A would be expected to be matched by an abnormally high IF bias voltage at point C. If the bias voltage were indeed high, the IF amplifiers should have been cut off; and no picture at all should have been developed by the receiver.

The technician thought that the IF bias was not being controlled in the normal manner. The voltage at point C was measured and was found to be only -2.5 volts. Most of the output voltage of the keying tube was being dissipated somewhere within the IF branch of the line, but the RF branch of the line was evidently not affected. Moreover, the output voltage of the keying tube was still too high.

The technician resorted to ohmmeter checks. The reading from point C to ground through R6 and R7 in series should have been approximately 330,000 ohms. The actual reading was well within tolerance at 340,000 ohms. The resistance from point A to ground should have measured 1.33 megohms because the resistance of R1 was added to that of R6 and R7. The reading at point A actually was more than 10 megohms. When R1 was unsoldered and checked, its resistance measured 10 megohms.

ANALYSIS. — The output voltage of the keying tube must be reduced to a value which is suitable for application to the IF stages. The circuit of Fig. 9-7 accomplishes this reduction by developing the output voltage across R1, R6, and R7 in series. The voltage which appears across the latter two resistors is normally sufficient to bias the IF amplifiers.

When R1 became defective, too much voltage was dropped across it. The IF bias then was inadequate, and the gain of the IF strip was increased. Too much input signal was fed to the grid of the keying tube as a result, and the keying tube produced far too much output voltage.

Since R1 was defective, the IF bias was still inadequate. Normally, the receiver would be overloaded under these conditions; but the picture appeared weak and snowy because an extremely high bias was applied to the RF amplifier.

If R6 or R7 had increased in value, the AGC bias on the IF stages would have been abnormally increased. The receiver would have developed a weak picture, but it would not have been greatly troubled with snow.

If R3 had increased in value, the RF bias voltage would have been more negative than usual and amplification in the tuner would have been reduced. The symptoms of trouble would have been superficially similar to those which were observed when R1 increased in value; in other words, the picture would have been weak and snowy. The input and output of the keying tube would have been moderate, however. The presence of -30 volts on the RF branch of the AGC line would have been highly unlikely if R3 had been bad.

In the case history which has just been discussed, the technique of clamping the AGC voltage could also have been employed with good results. The technician did not bother to try clamping in this case because voltage measurements were yielding sufficient information.

If a clamping voltage had been applied at point A, the picture would not have cleared up. On the other hand, the application of several volts of artificial bias at point C would have improved the appearance of the picture. Notice that clamping only a part of the AGC line would have been a worthwhile step in the servicing process in this case as well as in Case No. 10.

A number of case histories of AGC troubles have been covered in this chapter in an attempt to illustrate the procedure that is useful in servicing AGC systems on the shop bench. The authors have tried to emphasize those component failures which have been known to occur in actual receivers. Two types of failures have not been given much consideration:

1. Tube failures have been treated briefly because they can usually be discovered promptly. An AGC tube can even be replaced by someone who has no understanding of its operation.

2. The more improbable types of component failures have been mentioned only in passing because of their rarity.

CHAPTER 10

Rewiring AGC Circuits in Special Cases

An aspect of AGC servicing which goes one step beyond the mere replacement of defective parts and involves actual modification of a circuit will be considered in this chapter.

The changing of values of components in the AGC circuit in order to repair an ailing receiver is not recommended because it is not a sensible practice. An alteration of the AGC circuit for repair purposes serves merely to disguise a defect which is still present in another section of the receiver. If the symptoms of trouble were to be removed by such an alteration, it might seem for a while that "two wrongs make a right"; but bypassing the real source of trouble is only a temporary expedient. Considerable grief at a later date is the probable result of haphazard tinkering with the AGC circuit, and the man who finally repairs the original defect may be confronted with AGC trouble of a somewhat puzzling nature.

Installation of a Cascode Tuner

There are some instances in which rewiring could be justified. Sometimes a new tuner which requires different AGC voltages than the original may be installed in a set, and the set may overload on very strong signals. In another instance, a customer who lives near an airport might have chronic difficulty with airplane flutter. This situation might call for a keyed AGC system in place of a simple system. We shall cover two such cases.

If a receiver that is being serviced contains a pentode type of tuner which is in very bad condition, it is sometimes profitable to replace the entire tuner with a new cascode tuner instead of trying to repair the old tuner. The performance of the receiver may be markedly better when the new tuner is used, and the cost of the complete cascode tuner may be no greater than the cost of repair parts.

Most of the receivers that are originally equipped with a pentode tuner also have a simple type of AGC system. In most instances, this system will continue to supply a satisfactory amount of AGC voltage after a cascode tuner is installed. The AGC system will adjust itself automatically to the requirements of the new tuner.

This last statement may cease to be true if an extremely strong signal is applied to the receiver. A peculiar characteristic of the cascode tuner is that it requires a much higher bias voltage than the pentode tuner does in order to maintain control over excessively strong input signals. In other words, the cascode tuner will overload more easily than the pentode tuner; nevertheless, the fact that many models of receivers use cascode tuners together with unmodified simple AGC systems is evidence that the risk of overloading is not great.

In the rare instances in which overloading becomes a problem after a cascode tuner has been installed, the technician will have to find some means of placing an increased bias voltage on the AGC line to the tuner. Since the full output of the AGC filter is already being used, a supplementary source of negative bias must be found.

One method of obtaining additional bias voltage is illustrated in the schematic diagram of Fig. 10-1. The circuit which is shown is actually used in a recently designed CBS-Columbia receiver as a precaution against overloading. The two separate AGC filters that are used in this circuit both obtain an input signal from the video detector in the conventional manner. One filter develops a bias voltage for the IF amplifiers, and the other filter develops a bias voltage for the tuner.

An area-selector switch is included in the AGC line that controls the tuner. When the switch is in the MEDIUM position, the RF branch of the AGC system is returned to ground through a 4.7-megohm resistor. In the DISTANT position of the switch, the resistance from the AGC line to ground is reduced to 270,000 ohms. The use of a resistor of lower value has the effect of reducing the bias voltage.

If the receiver has a tendency to overload while the switch is in the MEDIUM position, the switch should be changed to the LOCAL position. In this latter position, the AGC line is linked to the grid circuit of the horizontal output tube through the 10-megohm resistor R7. The value of this resistor is very high so that the AGC circuit will be prevented from affecting the operation of the sweep circuits. The presence of -27 volts in the grid circuit of the horizontal output tube tends to increase the AGC voltage.

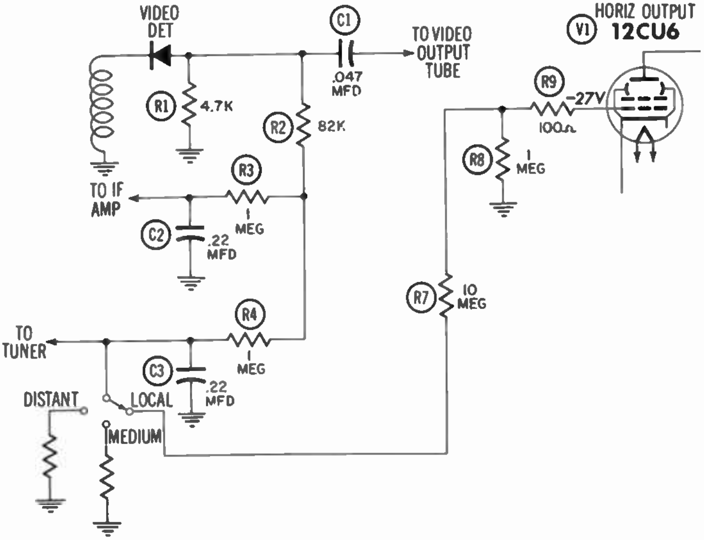


Fig. 10-1. Partial Schematic Diagram of the AGC System in a CBS-Columbia Chassis 1610.

Conversion to Keyed AGC

Before a technician decides to replace a simple AGC system or manual gain-control system with a keyed system, he should give considerable thought to whether the conversion is economically practical. The cost of the parts that are needed is not the chief problem in this case because a conversion usually requires only one tube and a handful of parts. The time that will be consumed in planning, rewiring, and experimenting is the biggest factor that must be considered when a price is being quoted for a conversion job.

As long as a simpler system of gain control gives acceptable performance, the change-over to keyed AGC is

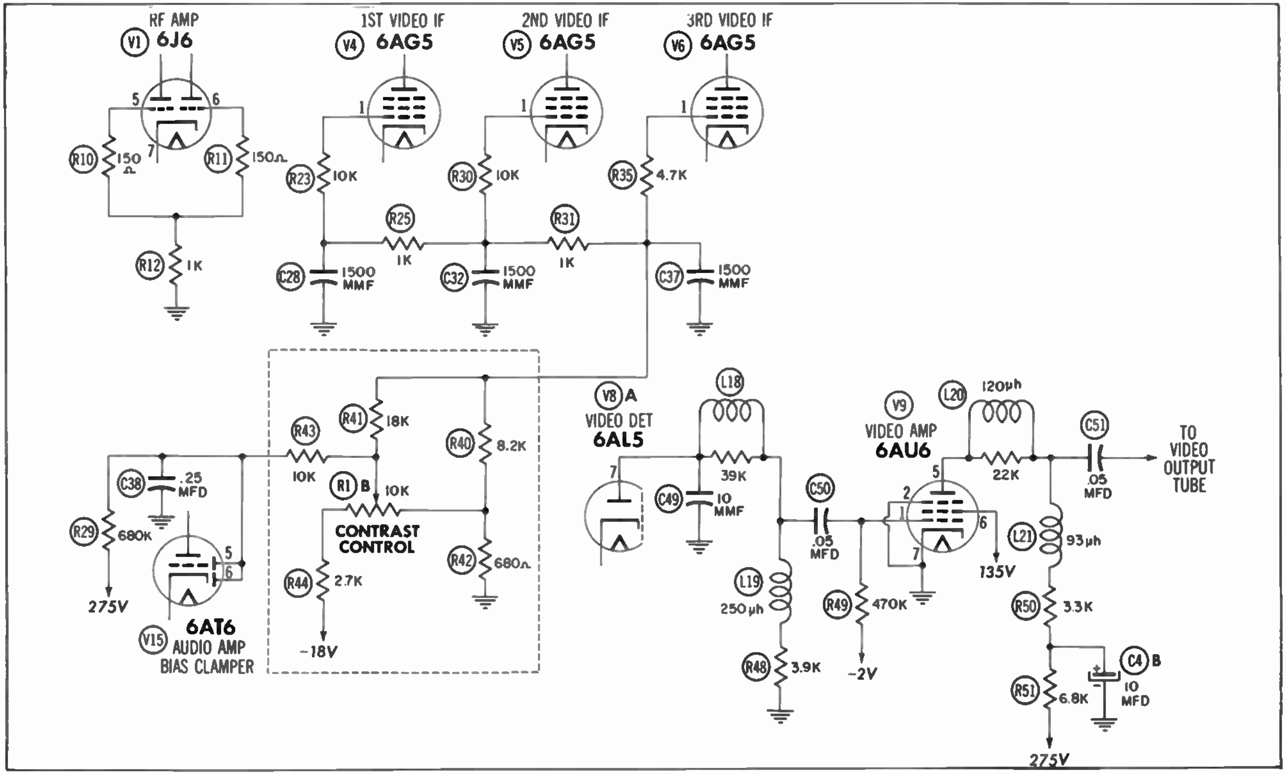


Fig. 10-2. Original Contrast and Video Amplifier Circuits of the 630 Type of Chassis.

more trouble than it is worth. On the other hand, a customer who is constantly bothered by interference noise and airplane flutter may be willing to pay the price for a conversion if it results in an improvement in his television picture. This is especially true if he wishes to keep his receiver for a long time instead of trading it in on a new set.

The technician may occasionally come across an early model of the 630 type of chassis in a custom installation. The owner might value this receiver enough that he would like to have keyed AGC installed in it. The following paragraphs will describe the installation of a keyed AGC system which worked satisfactorily in a receiver of this type.

Fig. 10-2 is a schematic diagram of the original circuits. This receiver had no true AGC system. The gain of the IF stages was manually governed by the setting of the contrast control R1B. The RF amplifier V1 was not included in this control system, and no provisions were made for varying the gain of the video amplifier. A schematic diagram of the keyed system which was installed is shown in Fig. 10-3. The components for which no encircled numbers are shown are the parts which were added to the circuit. The 6AU6 tube requires a seven-pin miniature socket which should be installed before the rewiring is begun. The ideal location for the socket is a point as near as possible to the video amplifier V9. The lead that will connect the plate circuit of V9 to the grid of the keying tube must be kept as short as possible. If the length of this lead is minimized, there will be much less risk that the video signal will be distorted by interference from stray signals.

Once the socket for the keying tube has been mounted, the circuit may be rewired. The new parts which will be needed are as follows:

RESISTORS (1/2-WATT)

Number Needed	Value (ohms)
1	4.7K
1	47K
3	100K
1	4.7 meg

CAPACITORS (600-VOLT)

Number Needed	Value (mfd)
1	.1
1	.25
1	.01

TUBES

1	6AU6

MISCELLANEOUS

Shielded cable
Hookup wire
New width coil

One 10K-ohm resistor rated at a half watt, one .05-mfd capacitor, and the contrast control are salvaged from the original circuits and are used in the new circuit.

Refer to Fig. 10-2 during the first step of the following procedure and to Fig. 10-3 during the rest of the steps:

1. Remove all the fixed resistors that are enclosed within the dotted lines in Fig. 10-2. Leave the contrast control R1B mounted on the chassis.

2. Rewire the contrast control so that it will be in the screen circuit of the video amplifier V9. Connect one end terminal of the control to the 135-volt line, and connect pin 6 of V9 to the arm of the control. Bypass this latter connection to ground with a .1-mfd capacitor. The 10K-ohm resistor that was removed from the receiver should be soldered between the remaining terminal of R1B and ground.

3. Direct coupling should be substituted for capacitive coupling between the video detector V8A and the video

amplifier V9. The grid of V9 will then obtain its bias from the incoming signal instead of from a fixed source. Remove the components R49 and C50, and substitute a 4,700-ohm resistor for the 3,900-ohm resistor R48. Connect the junction of L18 and L19 directly to pin No. 1 of V9.

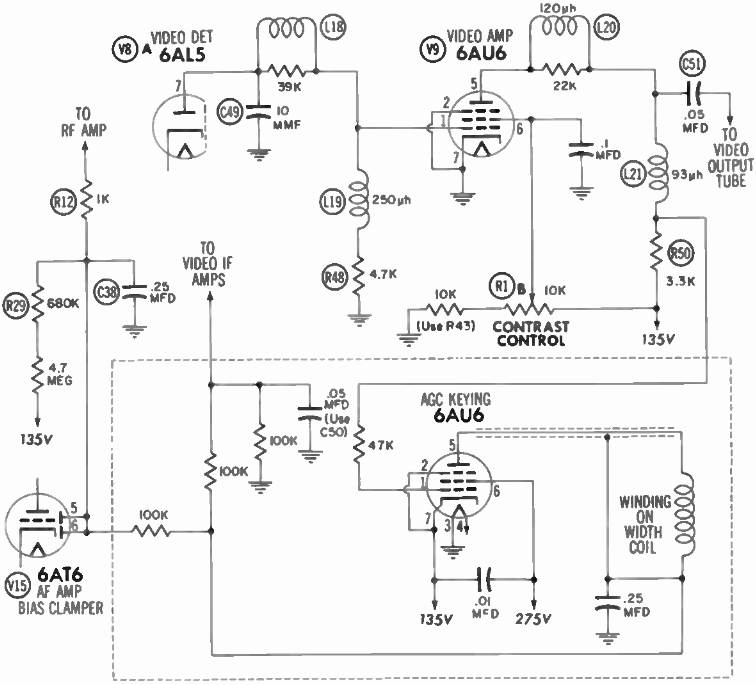


Fig. 10-3. The Keyed AGC Circuit Incorporated Into the 630 Type of Chassis.

4. Wire together the circuit which is enclosed within the dotted lines in Fig. 10-3. Connect pin No. 7 of the keying-tube socket to the 135-volt B+ line, and connect pin No. 6 to the 275-volt B+ line. Connect a .01-mfd capacitor between these two pins. Apply filament voltage across pin No. 3 and No. 4.

5. A width coil which includes an AGC winding must be substituted for the original width coil. The inductance of the primary of this new coil must match the inductance of the original width coil. Connect the plate of the keying tube to the AGC winding through a shielded cable in order that the high pulse voltages will not be radiated. Do not

ground the shield, but connect it to the low side of the AGC winding. Connect a .25-mfd bypass capacitor to the same point. If positive pulses are not developed at the plate of the AGC tube when the receiver is finally tested, the connections of the secondary of the width coil must be reversed.

6. Connect the AGC winding through a 100K-ohm resistor to the original bias-clamper tube V15, and install new AGC filter components. The three 100K-ohm resistors are connected as shown, and the former coupling capacitor which was removed in the third step is used again as a filter capacitor. The capacitor should first be checked for value and leakage. Leave the original grid circuits of the IF amplifiers as they were, and connect the new AGC filter to the IF strip at the same point that was formerly used.

7. Connect a 47K-ohm resistor from the junction of L21 and R50 to pin No. 1 of the keying tube. This connection supplies a video signal to the AGC system. Disconnect the components R51 and C4B from the plate circuit of V9, and attach the free end of R50 to the 135-volt B+ line.

8. Disconnect the resistor R29 (in the bias-clamper circuit) from the 275-volt line, and connect a 4.7-megohm resistor between the free end of R29 and the 135-volt line.

9. Unsolder the ground connection of the resistor R12, and connect the resistor instead to the diode plates (pins No. 5 and No. 6) of V15. This connection brings the RF amplifier under the control of the AGC system.

When the foregoing connections have all been made, the operation of the receiver should be tested. The values of some of the components in the AGC circuit may have to be altered in order that the best performance may be obtained.

The process of converting the simple AGC systems of other models of receivers into keyed AGC systems is not much different from that described. The same basic keying-tube circuits and filter circuits can be employed, although the values of some components may have to be changed to suit the requirements of the receiver. The original AGC line can be used as the IF section of the new AGC line with minor modifications.

The former input connection to the AGC line from the video detector must be removed, and a new input should be taken from the plate circuit of a video amplifier or video output stage. A precaution to be observed is that the sync pulses must form the most positive portion of the video signal.

It is recommended that a clamper diode be included in the RF branch of the AGC line. If the receiver already has an extra diode which can be utilized, all is well; but if no diode is available, the technician is faced with the choice of installing one or of trying to design a system that will work without one.

In case the receiver uses series-string filaments, the technician may find it very difficult to satisfy the filament - voltage requirements of the keying tube which he wishes to add to the circuit.

Conclusion

Rewiring AGC circuits is worth the trouble only in exceptional cases. Ordinary difficulties that involve the AGC system can be solved by conventional servicing methods if the technician is thoroughly familiar with AGC circuitry. It has been the aim of this book to offer its readers a detailed treatment of the subject of AGC so that they can service AGC systems more effectively.

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