

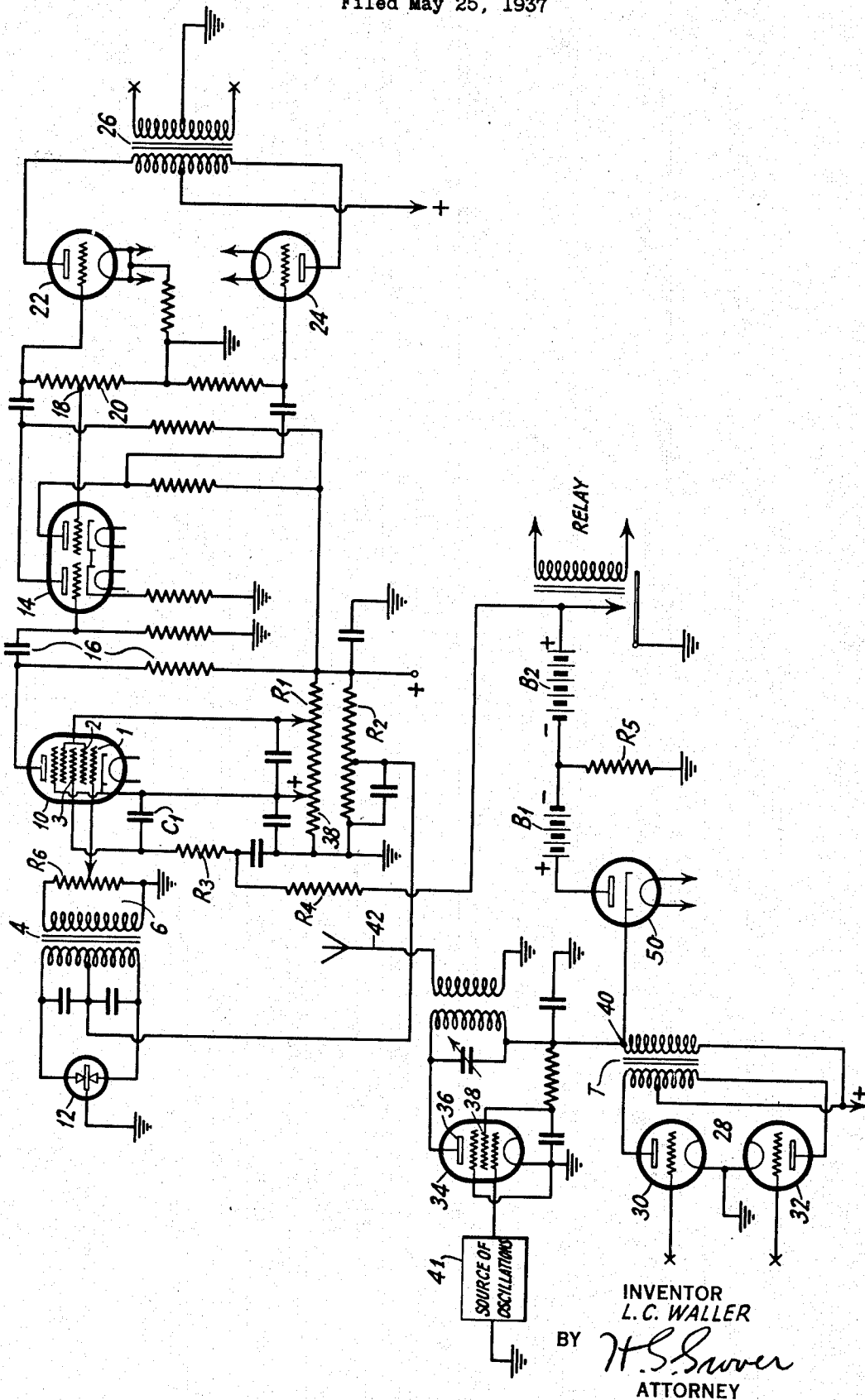
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AUTOMATIC MODULATION CONTROL

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AUTOMATIC MODULATION CONTROL

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In the operation of amateur radio telephone transmitters, it has always been a source of considerable annoyance to me that the speech amplifier gain control can seldom be set at just the right point to produce heavy modulation of the carrier without a considerable percentage of the audio peaks passing over the 100% modulation value. This overmodulation is quite troublesome with voice waves, because if the gain control be set so that only an occasional audio frequency peak exceeds the 100% modulation value, then the average modulation of the carrier will be quite low. Furthermore, different people usually do not talk at the same audio level, and the same person does not always talk at the same level. Therefore, the setting of the speech amplifier gain control is seldom optimum. The usual amateur practice is to set the gain control so that the average modulation is reasonably high without permitting an excessive percentage of peaks to overmodulate. This "ideal" setting is very difficult to hold once it is obtained, and cannot even be obtained without a very accurate and rapid-acting, slow-recovering type of overmodulation indicator. Even the cathode-ray oscillograph is none too good for modulation monitoring, because of the difficulty in observing and in evaluating the effect of the overmodulated peaks flicking instantaneously across the screen. The Federal Communications Commission recognizes this fact in that it does not consider an oscillograph as a "suitable means" for the modulation monitoring of broadcast transmitters.

With these considerations in mind, I recently set about to produce a new and improved automatic modulation control, or modulation limiter device. Two basic factors are involved; the first, to provide means for automatically varying the gain of the speech amplifier with reasonable rapidity and without introducing appreciable audio distortion; the second, to obtain an automatic control voltage directly from the modulator or from the modulated radio frequency amplifier to actuate the variable gain audio frequency system. The first problem seems to be quite logically solved by employing an electron discharge device such as the 6L7 in the familiar volume-expander circuit (see circuit No. 10 on page 183 of the RC-13 Manual) operating "backward"—that is, as a volume compressor. The second problem can be solved in a number of different ways. One method is to use a diode rectifier with a delay bias of such value that rectification occurs only when the modulated

radio frequency peaks exceed a value predetermined to represent 100% modulation, or some other percentage close to 100. This arrangement, however, is a positive-peak-operated device, which has several well known shortcomings. One is that it will not readily take care of carrier shift; another, that it is the negative over-modulation peaks which cause carrier cut-off, extreme modulation distortion, and a broad, side-splashing, interfering signal. The control voltage, therefore, should be independent of all carrier shift effects and should preferably be derived from the negative audio frequency modulation peaks—not from the positive peaks.

The attached circuit used for illustrating the system which I have developed and tested in practice, incorporates the principal desired design features discussed above, is exceedingly simple and positive in operation, and works on an actual transmitter in a way that exceeds my original expectations.

The speech amplifier employs any appropriate electron discharge device 10 (such as for example a 6L7) as an audio amplifier stage. This amplifier stage has its controlling electrode connected to a potentiometer 6 on a transformer 4 connected with a microphone 12. The amplifier 10 drives an additional amplifier 14 by way of a resistance and condenser coupling 16. The additional amplifier stage 14 also converts single ended operation to double ended operation in its output, as shown by means of resistances 18 and 20. This amplifier forms no part of the present invention and will not be described in detail here. The resistances 18 and 20 are in the input circuit of a pair of discharge devices 22 and 24 which include in their output circuit, a transformer 26 that supplies driving potentials to the push-pull modulator 28. The secondary of the transformer 26 indicated as being broken by the crosses, may be connected to the grids of the tubes in push-pull modulator stage 28, as indicated by corresponding crosses in the leads to the grids of said tubes. The tubes 22 and 24 may be of any appropriate type such as for example the type known as the 2A3 tube. The 2A3 type of tubes provide the driving power for the modulator 28. The modulator 28 may include, as shown, a pair of push-pull tubes 30 and 32, of any appropriate type such as for example the type known as the 838 tube operating class B. The modulation output transformer T provides the modulated power to a class C radio frequency amplifier 34 which may be a tube of any appropriate type

such as for example a pentode known as the 803 tube employing modulation on the plate 36 and screen 38 both of which are connected as shown to a point 40 on the high audio potential end of the secondary of transformer T. While it will be understood that any appropriate tubes may be used in the various stages described above, the tubes mentioned above give good satisfaction in operation and in the remaining description of the invention reference to the tubes of the type used will be made for purposes of illustration.

If the tube 10 is of the 6L7 type it normally operates, under no signal conditions, with a #1, or control-grid bias, of -10 volts supplied by way of R_6 from the portion 38 of bleeder resistance R_1 , a screen grid voltage of 100 volts, a #3 grid bias of $-2\frac{1}{2}$ volts supplied by way of 38, R_5 , B_2 , R_4 , and R_3 , and a plate supply of 300 volts, obtained through a $\frac{1}{10}$ megohm plate resistor in the unit 16. The bias battery B_2 which in the example given is $7\frac{1}{2}$ volts, opposes the -10 volts derived from the portion 38 of R_1 and provides the no-signal bias of $-2\frac{1}{2}$ volts on the #3 grid of tube 10. Under these conditions this tube (being of the 6L7 type) is capable of quite high audio frequency gain. The amplified wave energy from 10 is supplied to 14 and from 14 to the stage 22 and 24 and from 26 to the stage 28 to modulate in 34 the wave energy from 41. The modulated wave energy may be impressed on additional amplifiers or on a load circuit indicated at 42.

The method of and means for obtaining negative potentials for automatic modulation control will now be described. The negative automatic modulation control voltage is derived by means of a rectifier tube 50 which may be of any appropriate type such as for example an 836, connected in a half-wave rectifier circuit as shown. Let the direct supply voltage to the anode of tube 34 be B and let S be the peak value of voltage developed in the secondary of transformer T in the direction which reduces the anode voltage supplied to tube 34. Then the lowest potential that can occur at point 40 is B-S. Since the cathode of tube 50 is connected to point 40, and since the anode of tube 50 is normally maintained at $+B_1$ volts, current will flow through tube 50 when, and only when, the potential B-S is less than potential B_1 . When this occurs the current flowing through tube 50 and through resistor R_5 builds up a negative voltage across R_5 which, as stated above, is included in the bias circuit of the #3 electrode of tube 10, which circuit includes R_5 , B_2 , R_4 and R_3 . This direct current voltage built up at the terminals of R_5 is applied to the #3 grid of tube 10 through the filter and time constant circuit R_3 , R_4 , C_1 . This negative voltage acts to reduce the gain of the speech amplifier tube 10 and consequently the gain of the entire speech amplifying system whenever the negative modulation peaks exceed -1160 volts which, in the problem used to illustrate the invention, that is, with $B=1250$ $S=1160$ and $B_1=90$, corresponds to 93% modulation. Thus, the modulation in the system is held substantially at this level as the limiting condition. Even though the main gain control R_6 is varied over a considerable range, the modulation is essentially prevented from exceeding the 100% level, except for a few surges which may pass before condenser C_1 has time to accumulate some charge. When the higher-amplitude signals have passed, the gain of the 6L7 slowly increases, due to the discharge of con-

denser C_1 through R_3 , R_4 , and R_5 . Thus, the gain rises somewhat more slowly than it decreases, since the charging time of C_1 is limited only by R_3 and R_4 .

In operation, gain control R_6 is set so that the carrier would be somewhat overmodulated if the automatic modulation control (a. m. c.) voltage were not present. The carrier can then be modulated at a fairly high average percentage without the evil effects of distortion caused by carrier cut-off and (frequently) an overloaded audio frequency system. After test communications had been held with 6 other amateur stations at distances from 1100 to 2500 miles, the net consensus of opinion seemed to be as follows:

(1) The signal had an outstanding ability to penetrate the terrific heterodyne and other interference so plentiful on the 14-mc. 'phone band. This is due to the high average modulation.

(2) The quality of the speech was noticeably improved with a. m. c., due to the elimination of overmodulation distortion and distortion due to an over-loaded audio frequency system.

(3) The signal was sharp and clean, due to the absence of side-splashing effects caused by carrier cut-off.

(4) Due to the greatly improved intelligibility of the signal, audio distortion and "mushing" caused by natural selective fading was considerably reduced. This effect is usually very bad when a shortwave signal starts to fade, and is sometimes noticed even on a distant station operating in the range 550-1550 Kc.

(5) Carrier shift due to overmodulation was eliminated.

The advantage, in the station, of having the speech amplifier gain always correct for various sound levels has already been mentioned. However, probably the most worthwhile advantage of the a. m. c. circuit from the amateur point of view, is that its universal adoption in amateur 'phone stations will have the practical effect of greatly widening the amateur 'phone bands.

That is, many stations as now operated take up almost twice as much space in the congested bands as they should. With a. m. c., they will not only take up less space, but will also put across a stronger, more penetrating signal than with the side-splashing type of transmitter.

The time constant of the attached 6L7 circuit may be somewhat too long for optimum results. This constant was used to eliminate feedback, believed to be due to regenerative effects caused by phase shift at low frequencies. This phase shift can be readily eliminated by simple changes in the amplifier design, so that a shorter time constant can be employed if desired.

The purpose of the relay associated with R_5 and B_2 is to prevent C_1 from accumulating a high negative charge from B_1 when the positive high voltage is removed temporarily from the secondary of "T." The relay operates to short R_4 to ground when B_+ is removed from "T." Thus C_1 can only accumulate a voltage of -10, due to section 38 of R_1 . This is but a detail of operation, however and does not affect the actual operation of the a. m. c. in normal, steady use.

In describing my invention in detail I have designated types of tubes appropriate for use in the various stages and have set forth operating potentials and voltages for said tubes which I have found satisfactory. Obviously any other appropriate types of tubes may be used. Moreover, when the types of tubes referred to above are used, or other types of tubes are used, in the

various stages, different operating conditions may be desired, in which case operating voltages and potentials and conditions other than those given above may be used without departing from the spirit of the invention as claimed. Moreover, the value of the elements used in the circuits and in particular in the time constant circuits used in the automatic modulation control system may be other than those given, without departing from the scope of the invention.

I claim:

1. In a system for maintaining a high degree of modulation of carrier wave energy, without substantial over-modulation by controlling the degree of modulation of energy in a modulation energy amplifier, means for initially biasing said amplifier and exciting the same by modulating potentials such that overmodulation of the wave energy would be accomplished on maximum peaks of the modulation energy, means for deriving negative potentials characteristic of negative swings only of the envelope of the modulated wave which exceeds selected negative peak values, and means connected with said last named means and with said modulation energy amplifier for adding said derived negative potentials to said initial bias to reduce the gain of said modulation energy amplifier when said maximum peaks occur.

2. In a system for maintaining a high degree of modulation of carrier wave energy, without causing substantial over-modulation, by controlling the degree of modulation of the wave energy in a modulation energy amplifier, means for initially negatively biasing said modulation energy amplifier and exciting the same by modulating potential such that over-modulation of said carrier wave energy would be accomplished on selected values of the modulation energy, means for deriving negative potentials from negative swings only of the modulating potentials greater than said selected value, and means connected with said last named means and with said modulation energy amplifier for adding said derived negative potentials to said initial negative bias and increasing said negative bias to reduce the gain of said modulation energy amplifier in the presence of modulating potentials which exceed said selected value.

3. In means for modulating wave energy in accordance with modulating potentials and for maintaining the degree of modulation relatively high without introducing appreciable distortion, a source of modulating potentials, a wave energy amplifier system having an electrode which may be modulated to control the character of the wave energy amplified by said system in accordance with modulating potentials, amplifying means having an input connected to said source of modulating potentials, said amplifying means having an output circuit, means coupling said output circuit to said electrode in said system for modulating therein the wave energy in accordance with modulating potentials, and means responsive to peak negative swings only of said modulating potentials coupled to an electrode in said amplifying means to control the gain thereof in accordance with peaks of the negative swings only of the wave energy in said system.

4. A system as recited in claim 3 wherein said last named means includes time constant elements to control the time lag in said gain control action.

5. In means for modulating wave energy in

accordance with modulating potentials and for maintaining the degree of modulation relatively high without causing distortion due to over-modulation, a source of modulating potentials, a wave energy relay system including a tube having an electrode which may be modulated to control the character of the wave energy in accordance with the modulating potentials, a modulation potential amplifier tube having electrodes connected to said source of modulating potentials, and having an output circuit, means coupling said output circuit to said electrode in said tube in said relay system for modulating therein the wave energy in accordance with modulating potentials, a rectifier biased to respond only to negative voltages which exceed a selected peak value coupled to said output circuit, and a time control circuit connecting said rectifier to electrodes in said amplifier tube to control the gain thereof in the presence of negative swings of said modulating potentials which exceed said selected peak value.

6. In a system for modulating wave energy in accordance with modulating potentials and for maintaining the degree of modulation relatively high without causing substantial over-modulation, a source of modulating potentials, a wave energy relay tube having an electrode which may be modulated to control the character of the wave energy relayed in accordance with the modulating potentials, a modulation potential amplifier tube having electrodes connected to said source of modulating potentials and output electrodes connected in an output circuit, means coupling said output circuit to an electrode in said relay tube for modulating therein the wave energy in accordance with said modulating potentials, a rectifier coupled at its input to said output circuit, said rectifier being biased to cut-off in the presence of positive modulations of said wave energy and negative modulations on said wave energy below a selected peak value, and means connecting said rectifier output to an electrode in said amplifier tube to lower the gain thereof only in the presence of negative modulations of said wave energy which exceeds said selected peak value.

7. In a system for modulating wave energy in accordance with modulating potentials and for maintaining the degree of modulation high, a source of modulating potentials, a wave energy relaying tube having an electrode the potential on which may be modulated to control the character of the wave energy in accordance with the modulating potentials, a modulating potential amplifier tube having a cathode and a plurality of controlling electrodes, one of which controlling electrodes with said cathode is connected to said source of modulating potentials, an output electrode in said amplifier tube and an output circuit connected therewith, amplifying means coupling said output circuit to said electrode in said wave energy relaying tube for modulating therein the amplitude of the wave energy in accordance with amplified modulating potentials, a rectifier coupled to said amplifying means, said rectifier being biased to cut-off in the presence of negative swings of said wave energy below a selected peak value and conductive only for negative wave energy peaks above said selected value, and a time control circuit connected said rectifier to a controlling electrode in said modulating potential amplifier tube to lower the gain thereof in the presence of negative swings which exceeds said selected peak value.

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