

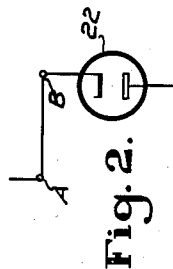
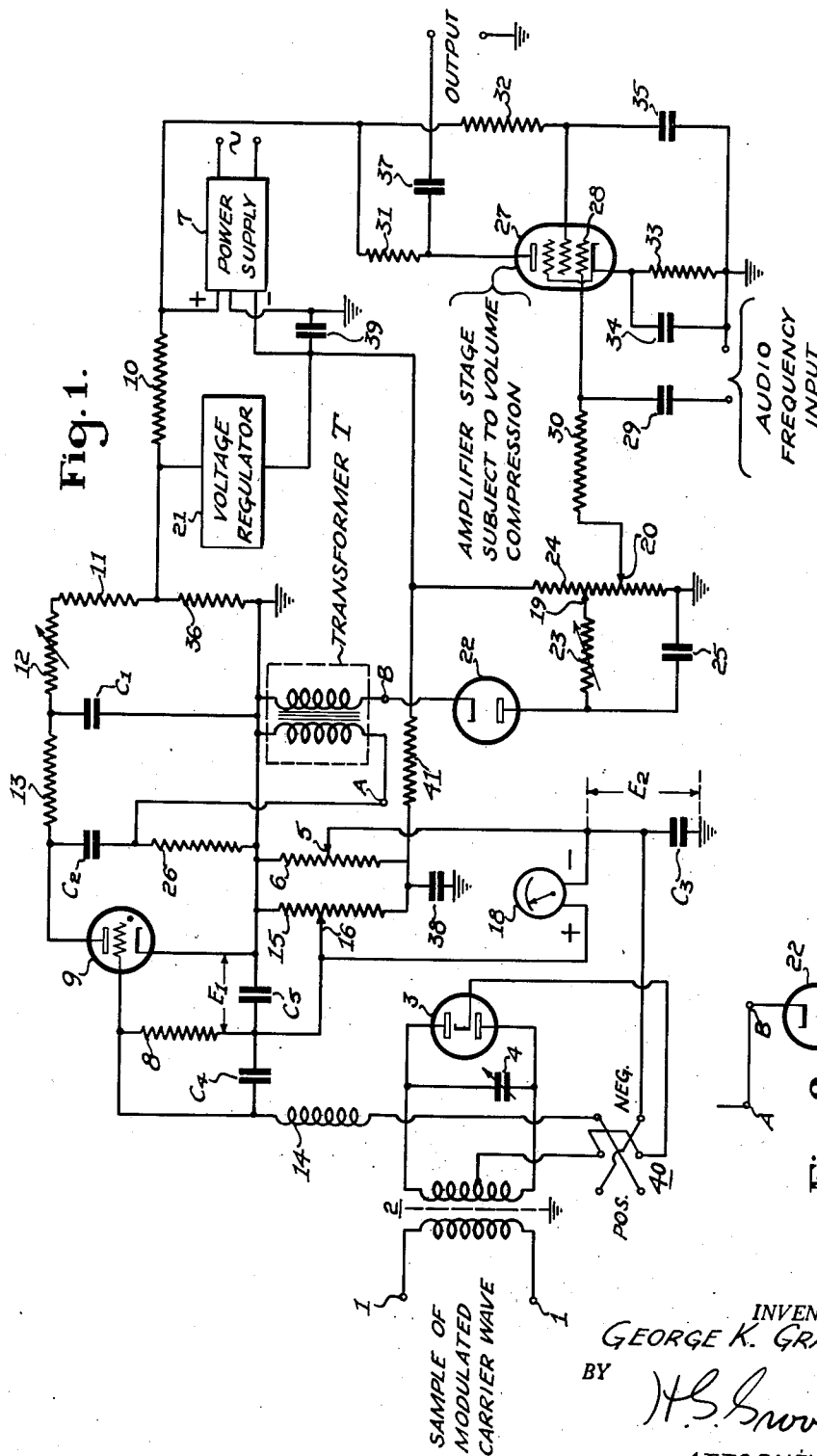
June 21, 1949.

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2,474,103

SYSTEM FOR VOLUME COMPRESSION

Filed Oct. 27, 1944



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2,474,103

SYSTEM FOR VOLUME COMPRESSION

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Application October 27, 1944, Serial No. 560,679

9 Claims. (Cl. 332—38)

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This invention relates to a system for volume compression and has more particularly to do with the use of a volume compressor in a radio transmitter. In carrying out my invention I provide a circuit arrangement which is designed to operate upon the line amplifier of a transmitter in such a way as to limit the amplitude of the modulations applied to the carrier wave.

Under ideal conditions in which the line amplifier, speech amplifier and transmitter have uniform transmission characteristics throughout the desired frequency spectrum it should be possible to adjust the compression amplifier so that the compression just occurs at the point where the transmitter closely approaches 100 percent modulation. In practical installations, however, considering the transmitter as a whole, from line amplifier to antenna, there will tend to be a departure from the ideal straight line characteristic, particularly at the two ends of the transmitted spectrum. Under these conditions the incoming program material may contain peaks which will cause compressor action with its attendant reduction in gain, when in fact a large part of the energy representing the peaks may occur in those bands of frequencies which are destined to be attenuated in the transmitter and would not necessarily cause overmodulation if transmitted at the actual incoming level without compression.

In the usual type of compression amplifier a delayed recovery after compression is necessary to prevent volume reductions occurring at a syllabic rate. Under these conditions repeated compressor action as a result of peaks containing a large percentage of those frequencies which will be attenuated by the transmitter may defeat the purpose of the compression type amplifier and result in a reduction in transmitter output rather than an increase.

It is an object of my invention to provide a compression type amplifier for a radio transmitter wherein full scope is given to the modulation capabilities of the transmitter without overmodulation.

It is another object of my invention to provide means in a compression type amplifier for protection against sudden peaks which might cause over-modulation.

Still another object is to provide a circuit, the function of which is to enable the carrier wave output of a transmitter to be modulated as much as possible without compressor action, the circuit being arranged to automatically introduce

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volume compression whenever the modulation peaks reach an amplitude which is close to the maximum modulation capability of the transmitter.

5 My invention will now be described in more detail, reference being made to the accompanying drawing in which

Fig. 1 shows a complete circuit diagram of a typical volume compressor arranged in accordance with my invention and constituting a preferred embodiment, and

Fig. 2 shows a modification of one portion of the circuit more fully shown in Fig. 1.

Referring first to Fig. 1, I show input terminals 1 for a circuit which applies volume compression to an amplifier stage in a radio transmitter. The input terminals 1 receive a sample of the modulated carrier wave energy and apply the same across the primary winding of a transformer 2. The secondary of this transformer is connected to the anodes of a twin diode rectifier tube 3. Across the secondary terminals of the transformer 2 I also connect an adjustable capacitor 4 in order that the output from this transformer may be tuned to the frequency of the carrier wave.

Rectified potentials which are developed between the cathode of tube 3 and the mid-tap on the secondary of transformer 2 are used to control the bias on the input circuit of a gaseous discharge tube 9. The rectified peaks of the modulation frequency component of a modulated carrier wave are directly proportional to the modulation percentage. By means of a reversing switch 40 my device may be made to operate on an increase in amplitude of the rectified modulation component in either the positive or the negative direction.

The following description of circuit connections will be given for the condition where switch 40 is thrown to the right, and where the rectifier 3 is so connected as to deliver rectified modulation components which vary in direct proportion to the negative peaks of the modulated carrier wave. The alternative connections and mode of operation when the switch 40 is thrown to the left will be obvious. It should be understood, however, that the position in which the switch 40 should be placed is largely determined by the type of service in which my invention is applied.

The cathode of the tube 3 is connected through switch 40 to a tap 5 on a potentiometer 6, one end of which is connected to ground and the other end of which is connected to the negative

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terminal of a direct current power supply 7. The cathode of the rectifier tube 3 is also coupled to ground across a capacitor C₃.

The gaseous discharge tube 9 possesses a cathode, an anode and a control grid. The cathode is grounded. The anode is supplied through resistors 10, 11, 12 and 13 with direct current potential from the source 7. Resistor 12 is adjustable. The control grid in tube 9 is connected to a center tap on the secondary winding of transformer 2, this connection being made through a choke coil 14 and switch 40. The cathode of the tube 9 is also connected to its grid through a portion of a potentiometer 15 which has a tap 16 connected to one end of an input circuit resistor 8, the other end of this resistor being connected to the grid in tube 9. A voltmeter 18 is connected between the cathode of tube 3 and the potentiometer tap 16.

In the anode circuit of the gaseous tube 9 is a condenser C₂ which, in conjunction with resistor 13 and another condenser C₁, also in combination with resistor 12, will cause a series of pulses to be applied to the primary of a transformer T when the required grid-to-cathode potential is applied to the tube 9. The discharge circuit for condenser C₂ includes a resistor 26 and the space path of tube 9 when the latter becomes conductive. The potential drop across resistor 26 supplies energy to the primary of transformer T, they being connected in parallel.

A voltage regulator 21 is provided for maintaining a constant potential to be applied to the condenser C₁ and C₂, also across potentiometers 15 and 6, so that the firing conditions can be accurately controlled. When the required grid-to-cathode potential is applied to the tube 9 then the above described action ensues and the output of the transformer T is rectified in a diode tube 22. This tube has its cathode connected to ground through the secondary of transformer T. The anode in tube 22 is coupled to ground across capacitor 25 and is also connected to one end of a variable resistor 23 and thence to a tap 19 on a potentiometer 24. This potentiometer has its terminals connected respectively to ground and to the negative terminal of the source 7. The tap 19 is settable to a position where a suitable threshold bias is applied to the anode in tube 22, thus rendering this tube non-conductive until the bias is overcome by rectified energy from the secondary of transformer T. The junction between resistor 26, the cathode of tube 9, and the primary winding of transformer T is grounded.

The function of the time constant circuit comprising capacitor 25, resistor 23 and that portion of potentiometer 24 between tap 19 and ground is to control the gain recovery period, as will be readily understood by those skilled in the art.

The capacitive value of condenser C₁ is greater than that of condenser C₂ and its charging rate is made slower than the discharge rate of C₂, the time constants being determined by a suitable choice of resistance values of the elements 11, 12, 13, 26 and 36. Hence, it is possible to produce a succession of discharges of condenser C₂, by firing the gaseous tube 9 during periods of over-modulation, or whenever volume compression is desired. The charge of condenser C₂ which is drained off is replaced by energy stored in condenser C₁ until the potential of the charge in condenser C₁ falls below the ignition point of the tube 9. If the period of required volume compression is caused by overmodulation to exceed the discharge time of condenser C₁, then that condenser

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will re-charge and the action of repeated firing of the tube 9 will be continued. This circuit arrangement may be likened to a self-oscillating circuit oscillating only when gas tube 9 is fired.

When the charge on condenser C₂ equals that of condenser C₁ then no current flows through resistors 13 or 26 until tube 9 becomes ignited by a reduction in the potential drop across resistor 8, a condition resulting from the occurrence of over-modulation, or near approach to 100% modulation.

An amplifier stage subject to volume compression is shown as a tube 27 which may be of the pentode type, although any tube having a variable mu characteristic may be used. The gain in this tube is subjected to volume compression in response to the activation of the gaseous tube 9, the control being obtained by rectification components of the diode tube 22 which are reflected in variations in the potential drop through that portion of potentiometer 24 which extends from the tap 19 to ground.

The control grid 28 in tube 27 is coupled through a capacitor 29 to the output side of an audio signal source. The grid 28 is biased through resistor 30 leading to a tap 20 on potentiometer 24, this potentiometer being connected between ground and the negative terminal of the power supply 7. The anode in the tube 27 is connected to source 7 through a resistor 31. The screen grid is similarly connected through a resistor 32.

Tube 27 preferably has its cathode connected to ground through a cathode resistor 33, this resistor being shunted by a capacitor 34. The screen grid is coupled to ground through capacitor 35. The suppressor grid is connected to the cathode in the usual way. Utilization of the output from the tube 27 is obtained by means of an output circuit through capacitor 37.

The circuit comprising potentiometer 15 and capacitor C₅ is first adjusted with the carrier off to a point where the gaseous tube 9 is biased substantially to the firing point. The voltage drop across potentiometers 6 and 15 generally is lower than the available voltage between the negative and the grounded terminals of the source 7. The voltage drop through resistor 41 makes up the difference. The voltage regulator 21 serves to maintain a constant voltage drop through potentiometers 15 and 6. When potentiometer 15 is adjusted as outlined above potentiometer 6 then provides a control voltage in series with the output of the diode tube 3, so that the voltage across resistor 8 contributed by the rectified carrier wave can be cancelled and made zero at any predetermined modulation percentage. When the pre-set modulation percentage is reached the difference in potential between the grid and cathode of the gaseous tube 9 will be equal to the voltage required to render this tube conductive. Hence the compressor action will ensue.

As an illustration of how the circuit operates, consider that the voltages E₁ and E₂ are equal to the required firing potential of the gaseous tube 9 during the modulation within the capabilities of the transmitter. The output of the diode rectifier 3 will produce additional negative bias across resistor 8 and the gaseous tube 9 will then be inoperative. However, during a modulation peak which approaches one hundred percent in the negative direction the voltage across resistor 8 contributed by the diode tube 3 will be zero and tube 9 will become conductive and compression will ensue. The same effect will result from failure of the carrier wave itself. Upon resump-

tion of the transmitter operation the recovery of the gain in the amplifier will be comparatively slow until the normal modulation level or percentage is again reached. The operation of my invention in this manner is found to be quite advantageous in comparison with the action of volume compressors of the prior art.

In the operation of a transmitter it occasionally happens that the carrier wave source itself may fail. Means are usually provided for restoring the circuit connections automatically after the conventional circuit breaker has been tripped. One difficulty that has arisen in the past has been to restore the service without causing repeated tripping of the circuit breaker due to the presence of high amplitude of the modulation energy. Obviously the carrier wave is overmodulated under these conditions. The action of my volume compressor is one, however, in which the recovery of the gain is made relatively slow. Under such conditions, therefore, the repeated tripping of the circuit breaker is avoided.

By the adjustment of potentiometer 6 compression can be made to occur at any predetermined modulation percentage. The voltmeter 18 will show the difference in voltage between E_1 and E_2 and will act as a tuning indicator for the diode rectifier 3 and may be calibrated to indicate the percentage of modulation at which compression will occur. When the charging time of the condenser C1 and the associated resistor 12 is of shorter duration than the discharge period of capacitor 25 in combination with the resistors interconnecting its electrodes the unit will be capable of repeated compressor action as required.

The transformer T is by no means essential in the circuit arrangement of Fig. 1, but optionally it may be eliminated by interconnecting points A and B as shown in Fig. 2.

In conjunction with a circuit, such as a discriminator as used in present frequency modulation systems, in which the voltage across a resistor or other circuit element would be substantially dependent upon the frequency deviation, a voltage so obtained could be introduced into the grid circuit of a gaseous tube as described herein and could be used to initiate the compressor action on frequency deviations representing greater volume range than desired, and so act to maintain frequency deviations representing volume changes within the desired limits.

It will be apparent to those skilled in the art that various modifications of the circuit arrangement other than shown may be made without departing from the spirit and scope of the invention.

I claim:

1. In a modulated carrier wave signaling system in combination with a variable gain amplifier, means including a circuit device coupled to a transmission line in said system and responsive to variations in the modulation level of signals transmitted through said line for controlling the gain in said amplifier, said device including apparatus for rectifying a component of the modulated carrier wave energy and a gaseous discharge tube having circuit parameters such that it becomes ignited by failure of said energy component to maintain a predetermined negative bias on its input circuit when such failure is accompanied by the impress of a critically high cathode-anode voltage on its output circuit, said apparatus also including two resistively interconnected capacitors of different capacitive ratings and a discharge circuit for the smaller of the two capacitors through the ionization path of said tube,

the smaller capacitor being chargeable from the larger capacitor up to a voltage sufficient to ignite said tube, a direct current source, an impedance circuit connected across the terminals of said source and including the larger capacitor for charging the same, and means for rectifying a derivative of the discharge current from the smaller capacitor and applying the same to vary the gain in said amplifier and to produce volume compression therein only when the modulation level exceeds a predetermined percentage.

2. A circuit device in accordance with claim 1 and including two potentiometers the extremities of which are connected in parallel between points of potential difference at the negative side of said direct current source, the more positive point being grounded, as is the cathode of said gaseous tube, an input circuit resistor connected between the control grid of said gaseous tube and an adjustable tap on one of said potentiometers, an adjustable tap on the other of said potentiometers connected to one side of said rectifying apparatus, and means interconnecting the taps on the two said potentiometers for measuring the potential difference therebetween in terms of modulation percentage.

3. In a carrier signaling system, a variable gain amplifier having its input circuit coupled to a source of audio-frequency signals, a gain control circuit connected between the cathode and a control grid in the discharge device of said amplifier, a direct current source for supplying operating potentials to the electrodes of said device, a pair of interconnected time constant circuits comprising capacitors and resistors the parameters of which are suitably chosen for producing repeated charges of the first capacitor by draining off a portion of the charge in the second capacitor, the latter being resistively connected to said source, a gaseous triode tube having in its output circuit a resistor and the first said capacitor, means for diverting and for rectifying a portion of the modulated carrier wave energy from a signal source with which said amplifier is connected, a control circuit operable during periods when the amplitude of said rectified energy falls below a predetermined level for igniting said gaseous tube, thereby to close a discharge circuit for the first said capacitor, means for diverting and for rectifying a component of the energy discharged through said gaseous tube, and a circuit connection from the output side of the last said means to said gain control circuit for reducing the gain in said amplifier during periods of unwanted overmodulation.

4. In a system for volume compression as applied to an amplifier having at least one electron discharge tube stage in which the gain is a function of the direct current grid bias potential applied thereto, means for diverting a portion of the modulated carrier wave signaling energy from a source with which said amplifier is connected, means for rectifying said energy portion, a gaseous discharge tube having an input circuit subject to triggering control by a composite effect of direct current threshold bias and a superimposed rectified signal energy component from said rectifying means, a cathode-anode circuit for said gaseous tube including a capacitor and a resistor, means including a direct current source for charging said capacitor, a time constant circuit connected across the terminals of said source for storing and releasing the charging potentials applied to said capacitor, means for diverting and rectifying an energy compo-

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ment which is derived from the discharge of said capacitor through said cathode-anode circuit upon ignition of the gaseous tube, and a circuit for superimposing said diverted energy component on said grid bias potential which is applied to said amplifier.

5. In a system for transmitting a modulated carrier wave, a circuit arrangement constructed and adapted to control the gain in a variable gain amplifier so as to produce volume compression therein only on the near approach of the modulation level to 100% modulation, said circuit arrangement including a gaseous discharge tube of the triode type having a control electrode, an input circuit connected to said control electrode, circuit means for subjecting said input circuit to joint control by a source of threshold bias potential and by a rectified derivative of the modulated carrier wave energy to fire said tube at a predetermined voltage on said control electrode, an output circuit for said tube and connected thereto characterized by the inclusion therein of time constant means for causing said tube and output circuit to self-oscillate during periods when the voltage on said electrode is of a value to fire said tube, means connected to said output circuit for integrating and rectifying a component of the energy released by the self-oscillation, and means for applying said rectified and integrated component to the input circuit of said amplifier for producing volume compression therein.

6. In a system according to claim 5 a voltmeter connected across points of potential difference in said circuit arrangement where said potential difference varies as a function of the modulation level of the modulated carrier wave.

7. In a system for transmitting a modulated carrier wave, a circuit arrangement constructed and adapted to control the gain in a variable gain amplifier so as to produce volume compression therein only on near approach to the modulation level to 100% modulation, said circuit arrangement comprising a self-oscillating circuit having a control element and oscillating only during application of predetermined voltages to said control element, a first voltage deviation circuit

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connected to apply to said control element a control voltage derived from a portion of the modulated carrier wave energy, a second voltage derivation circuit connected to said self-oscillating circuit to derive a gain control voltage from the self-oscillations of said oscillating circuit, and means to apply said gain control voltage to the variable gain amplifier to vary the gain thereof to produce volume compression therein.

8. In a system for transmitting a modulated carrier wave, a circuit arrangement constructed and adapted to control the gain in a variable gain amplifier so as to produce volume compression therein only on near approach to the modulation level to 100% modulation, said circuit arrangement comprising a self-oscillating circuit including an electronic tube having a control electrode and oscillating only during application of predetermined voltages to said control electrode, a voltage derivation circuit connected to apply control voltage to said control electrode, said voltage being derived by rectification of a portion of the modulated carrier wave energy, a rectifier circuit connected to said self-oscillating circuit to integrate and rectify a component of the energy released by the self-oscillation thereof, and means applying said rectified and integrated component to the variable gain amplifier to vary the gain thereof, to produce volume compression therein.

9. The circuit arrangement claimed in claim 8, said electronic tube being a gas tube, said control electrode controlling the firing of said gas tube.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,064,192	Brown	Dec. 15, 1936
2,079,446	Goldsmith	May 4, 1937
2,090,820	Wehrin et al.	Aug. 24, 1937
2,131,443	Kummerer et al.	Sept. 27, 1938
2,325,366	Brown	July 27, 1943
2,335,796	Schrader	Nov. 30, 1943