July 9, 1935. H. A. AFFEL 2,007,416

VOLUME CONTROL CIRCUIT

Filed May 5, 1934

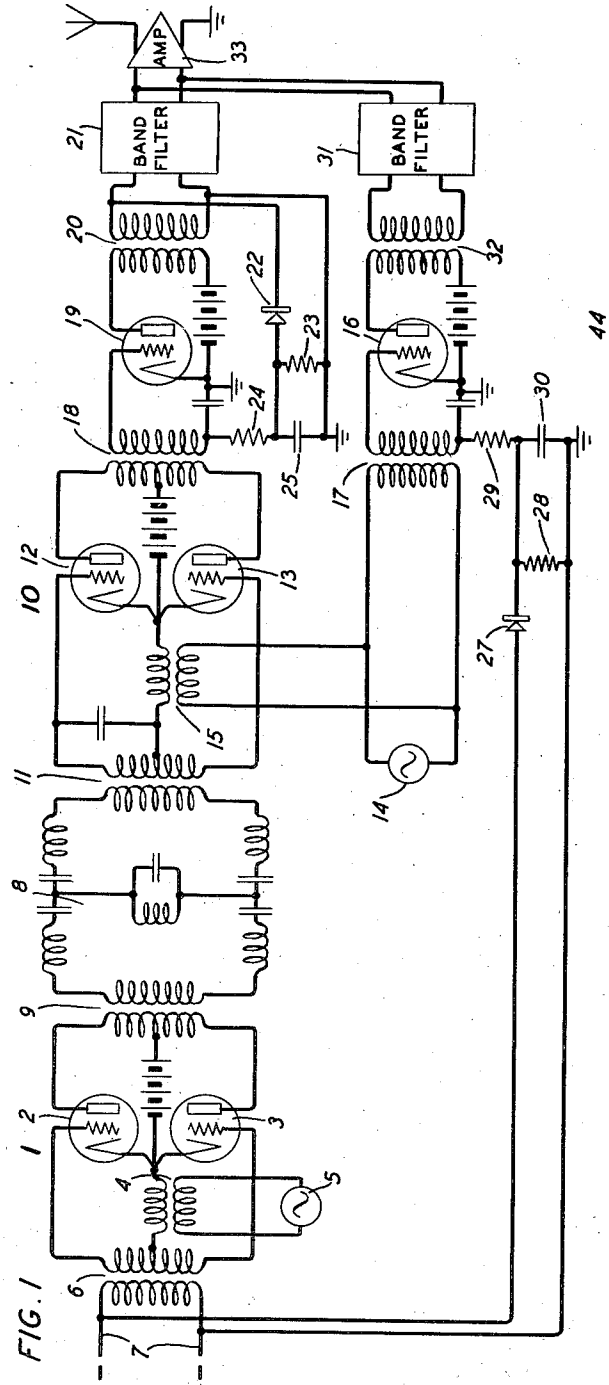


FIG. 1

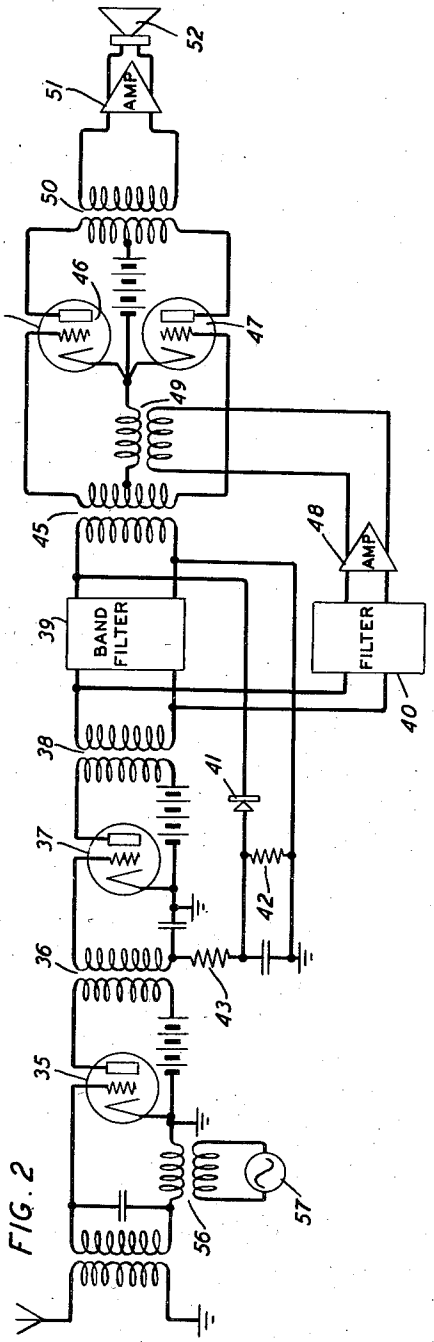


FIG. 2

INVENTOR
H. A. AFFEL

BY

ATTORNEY

Patented July 9, 1935 2,007,416

UNITED STATES PATENT OFFICE

2,007,416

VOLUME CONTROL CIRCUIT

Herman Andrew Affel, Ridgewood, N. J., assignor to American Telephone and Telegraph Company, a corporation of New York

Application May 5, 1934, Serial No. 724,167

10 Claims. (Cl. 250—6)

This invention relates to carrier wave transmission systems and particularly to volume control of carrier wave transmission systems.

One object of the invention is to provide a carrier wave transmission system that shall vary the volume of a carrier wave transmitted to a receiving station and that shall employ the variable-volume carrier wave to control the volume of the demodulated signals at a receiving station.

Another object of the invention is to provide a transmission system that shall transmit to a receiving station a constant volume side band and a carrier wave varying in volume according to signal waves and that shall demodulate the side-band under control of the variable-volume carrier wave to obtain signals varying in volume according to the variable volume of the carrier wave.

A further object of the invention is to provide a transmission system for transmitting signals to a receiving station that shall control the volume range of the transmitted signals by varying the volume of the carrier wave and that shall effect automatic volume control at the receiving station under control of a side band.

In the transmission of a modulated carrier wave by radio or over wires it is common to provide automatic volume control to take care of the so-called fading. The automatic volume control at the receiving station is generally governed by the carrier wave. Moreover, a volume range compression-expansion has in effect sometimes been provided by use of a variable carrier so that the receiver will be less subject to noise during the intervals when the programs are of a low volume. The employing of a variable carrier for preventing disturbance in a receiver when the signal volume is low makes it impossible to obtain automatic volume control by means of the carrier wave.

In accordance with the present invention it is proposed to provide for volume control and volume compression and expansion without employing any additional control channel. The carrier wave is controlled to obtain the volume range compression-expansion feature and one of the side bands is held at substantially constant volume from the transmitting station to obtain automatic volume control.

The transmitting circuit in the present invention is essentially a constant side band variable carrier transmitter. Because of the difficulty in separating the carrier wave and the side bands at the high frequencies of radio transmission, a double modulation system is disclosed. It is to be understood that the invention is not limited to such a type of system.

In a transmitting station constructed in accordance with the invention a suitable modulator is provided for modulating a carrier wave with the received signal waves which are to be transmitted to a distant receiving station. One side band from the modulator output is selected and supplied to a second modulator. A second carrier wave is modulated with the selected side band in a second modulator and the output supplied to a control amplifier. The control amplifier is so governed as to maintain the output thereof at substantially constant volume. One side band from the second modulation operation is selected from the output of the control amplifier for transmission to the distant receiving station. The signal waves which are supplied to the first modulator are also supplied to a control amplifier for varying the volume of the second carrier wave according to the volume variations of the signal waves. The second carrier wave with its volume varied according to the signal waves is transmitted with the selected side band to a distant receiving station either over wires or by radio. In the accompanying drawing the invention is illustrated by means of a radio system.

At the receiving station the combined currents are first stepped down by the heterodyne method to a suitable lower frequency for which the selecting circuits and amplifiers are more effective. The combined side band and carrier wave are supplied to a gain control amplifier which is controlled by the selected side band. In the output circuit of the gain control amplifier is a band selector for selecting the side band and a filter for selecting the carrier wave of variable volume. A rectifier which is connected to the output side of the band filter is connected to the gain control amplifier for controlling such amplifier to maintain the side band at substantially constant volume. The gain control amplifier corrects for the fading encountered during transmission. The output from the band filter and the output from the carrier filter after amplification are supplied to a demodulator. The demodulator is of a type which follows the square law so that the amplitude of the signals in the output of the demodulator follows the product of the carrier wave and the side band. Inasmuch as the side band is maintained at substantially constant volume, the signals in the demodulator output circuit must follow the volume

variations of the carrier wave. The signals in the output circuit of the demodulator are amplified and supplied to a suitable receiving device such as a loud speaker.

In the accompanying drawing,

Fig. 1 is a diagrammatic view of a transmitting station constructed in accordance with the invention; and

Fig. 2 is a diagrammatic view of a receiving station constructed in accordance with the invention.

Referring to Fig. 1 of the drawing a push-pull modulator 1 comprising space discharge devices 2 and 3 has the input circuit thereof connected by a transformer 4 to an oscillator 5. The input circuit of the modulator 1 is also connected by a transformer 6 to a circuit 7 which supplies signals from a microphone or from a telephone circuit. A band filter 8 is connected to the output circuit by a transformer 9. The band filter 8 which selects one side band from the modulator output circuit is connected to a second modulator 10 by means of a transformer 11. The second modulator 10 is preferably of the push-pull type and comprises space discharge devices 12 and 13. The modulators 1 and 10 are preferably of the push-pull type in order to eliminate the carrier wave. An oscillator 14 which supplies the second carrier wave is connected to the input circuit of the modulator 10 by means of a transformer 15. The oscillator 14 is also connected to the input circuit of a control amplifier 16 by means of a transformer 17. The output circuit of the modulator 10 containing the side band is connected by a transformer 18 to a control amplifier 19. The amplifier 19 is so controlled as to maintain the side bands in the output circuit thereof at substantially constant volume. A transformer 20 connects the output circuit of the control amplifier 19 to a band filter 21 which selects one of the side bands for transmission to a distant receiving station. The transformer 20 also connects the output circuit of the control amplifier 19 to a rectifier 22. Current from the rectifier 22 is impressed on a potentiometer 23 which supplies grid bias through a resistance 24 for controlling the amplifier 19. A condenser 25 is connected across the potentiometer 23 for smoothing out the rectified current. The output from the rectifier 22 so controls the bias on the grid of the control amplifier 19 as to maintain the side band output from the amplifier at substantially constant volume.

The amplifier 16 which is connected to the oscillator 14 by means of a transformer 17 is controlled in accordance with the volume variations of the signals supplied to the first modulator 1. A rectifier 27 which is connected to the signal circuit 7 supplies rectifier current to a potentiometer 28. The potentiometer 28 supplies grid biasing potential through a resistance element 29 to the control amplifier 16. A condenser 30 is connected across the potentiometer 28 for smoothing out the rectified current. The control amplifier 16 which effects variations in the volume of the carrier wave from the oscillator 14 according to the variations in volume of the signals supplied to the modulator 1 is connected to a filter 31 by means of a transformer 32. The carrier wave of variable volume in the output circuit of the filter 31 is supplied to the output circuit of the band filter 21. The selected side band and the carrier wave of variable volume are amplified by the amplifier 33 and transmitted by radio to a distant receiving station.

Referring to Fig. 2 of the drawing a heterodyne modulating stage is shown comprising a space discharge device 35 having the input circuit thereof connected by a transformer 56 to an oscillator 57 and by suitable coupling to an antenna. The waves received from the transmitting station shown in Fig. 1 are reduced to a suitable lower frequency by the heterodyne modulator. The output circuit of the heterodyne modulator 35 is connected by a transformer 36 to a gain control amplifier 37. The gain control amplifier 37 is controlled by the received side band to correct for fading effected during transmission. The output circuit of the gain control amplifier 37 is connected by a transformer 38 to a band filter 39 which selects the transmitted side band and to a filter 40 which selects the variable-volume carrier wave. A rectifier 41 which is connected to the output circuit of the band filter 39 impresses potential across a potentiometer 42. The potentiometer 42 supplies grid bias through a resistance element 43 to the gain control amplifier 37. By means of the rectifier 41 and the circuit controlled thereby the gain control amplifier 37 is so governed as to maintain the side band in the output circuit thereof at substantially constant volume.

The output circuit of the band filter 39 is connected to the input circuit of a demodulator 44 by means of a transformer 45. The demodulator 44 is preferably of the push-pull type and comprises space discharge devices 46 and 47. The filter 40 which selects the variable-volume carrier wave is connected to an amplifier 48 which, in turn, is connected by a transformer 49 to the input circuit of the demodulator 44. The space discharge devices 46 and 47 in the demodulator 44 follow the square law so that the signals in the output circuit are proportional to the product of the side band and the carrier wave. The side band has been maintained at substantially constant volume so that the output signals have volume variations according to the variations in volume of the carrier wave. The output from the demodulator 44 is connected by a transformer 50 to an amplifier 51. The amplifier 51 is connected to a suitable loud speaker 52.

In the above described system it will be noted that the advantages of a volume control system are obtained by the control effected through the selected side band and that the advantages of a compression expansion system are effected by controlling the volume of the transmitted carrier. Moreover, no additional channel is required to effect the volume control as well as the volume compression and expansion features.

Modifications in the system and in the arrangements and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. The method of transmitting signals which consists in modulating a constant volume carrier wave with signal waves, in deriving a constant volume side band from said modulation operation, in controlling the carrier wave according to the volume of said signals, in transmitting the constant volume side band and the variable-volume carrier wave to a receiving station, in correcting the received side band for fading effected during transmission and in demodulating the received side band to obtain signals varying in volume according to the received carrier wave.

2. The method of transmitting signals which consists in modulating a constant-volume carrier

wave with variable volume signal waves, in deriving a constant-volume side band from the modulated output, in varying the volume of the carrier wave according to the volume of the signal waves, in transmitting the constant-volume side band and the variable volume carrier wave, in correcting the volume of the received side band and carrier wave for fading during transmission, and in demodulating the received side band to obtain signals varying in volume according to the received carrier wave.

3. The method of transmitting signals which consists in deriving a constant-volume side band from a constant-volume carrier wave and signal waves, in varying the volume of the carrier wave according to the volume of the signal waves in transmitting the constant volume side band and the variable-volume carrier wave to a receiving station, in correcting the volume of the side band and the carrier wave for fading during transmission, and in demodulating the received side band to obtain signals varying in volume according to the variable volume carrier wave.

4. In a signal system, means for modulating a constant volume carrier wave with signals of variable volume, means for controlling the output of the modulation operation to render the volume thereof constant and for selecting one side band, means for varying the volume of the carrier wave according to the volume of the signals, means for transmitting the constant volume side band of said modulation operation and said variable carrier wave to a receiving station, means for correcting the received side band for fading, and means at the receiving station controlled by the variable-volume carrier wave for demodulating the constant volume side band to obtain signals varying in volume according to the variable-volume of the carrier wave.

5. In a signal system, means comprising space discharge devices in push-pull relation for modulating a constant-volume carrier wave with variable-volume signal waves, gain control means for obtaining a constant-volume output from the modulation operation, means comprising a band filter for selecting one side band from the modulation output, means for varying the volume of said carrier wave according to the volume of the signals and for transmitting the selected side band and the variable-volume carrier wave to a receiving station, means for selecting the received side band, gain control means governed by the received selected side band for correcting the received side band and carrier wave for fading during transmission, and means at the receiving station controlled by the variable-volume carrier wave for demodulating the received side band to obtain signals varying in volume according to the variable volume of the carrier wave.

6. In a signal system, means for generating a constant-volume carrier wave and for modulating the carrier wave with variable-volume signal waves, means for controlling the output of the modulation operation to render the volume thereof constant, means for selecting a side-band from the modulation output, means for varying the volume of said carrier wave according to the volume of said signal waves and for transmitting said constant volume side band and the variable-volume carrier wave to a receiving station, gain control means at the receiving station for correcting the received side band and carrier wave for fading during transmission, and means at the receiving station controlled by the variable volume carrier wave for demodulating the side band to obtain signals varying in volume according to variable volume of the carrier wave.

7. In a signal system, means for generating a constant volume carrier wave and for modulating the carrier wave with signal waves, means for controlling the output of the modulation operation to render the volume thereof constant and for selecting one side band, means for controlling the volume of the carrier wave according to the volume of the signal waves and for transmitting the constant-volume side band and the variable-volume carrier wave to a receiving station, gain control means at the receiving station for correcting the received side band and carrier wave for fading during transmission, and means for demodulating the side band under control of the variable carrier to obtain signals varying in volume according to the volume of the carrier wave.

8. In a signal system, the combination with a transmitting station comprising means for modulating a carrier wave with signal waves, means for maintaining the volume of modulation output constant, means for selecting a constant volume side band, means for controlling the volume of the carrier wave according to the volume of the signals and means for transmitting the selected side band and the variable-volume carrier wave, of a receiving station comprising means for maintaining the volume of the received side band constant, and for demodulating the received side band to obtain demodulated signals which vary in volume according to the variable volume carrier wave.

9. In a signal wave, means for modulating a constant volume carrier-wave with variable-volume signal waves, means for varying the volume of said constant volume carrier wave according to the volume variations of the signals, means for deriving a constant-volume side band from said modulation operation and for transmitting the constant volume side band and the variable-volume carrier wave to a receiving station, means at the receiving station for maintaining the volume of the received side band constant, and means controlled by the variable volume carrier wave for demodulating the side band to obtain signals varying in volume according to the variable volume carrier wave.

10. In a signal system, means at a transmitting station comprising space discharge devices in push-pull relation for modulating a constant volume carrier wave with variable volume signal waves, means for obtaining a constant volume output from the modulation operation, a band filter for selecting a side band from the constant volume ouput, means for varying the volume of the carrier wave according to the volume variations of the variable volume signals and for transmitting the constant volume side band and the variable volume carrier wave to a receiving station, gain control means at the receiving station for correcting the received side band and the carrier wave for fading during transmission, and means for demodulating the side band under the control of the variable volume carrier to obtain signals varying in volume according to the volume of the carrier wave.

HERMAN A. AFFEL.