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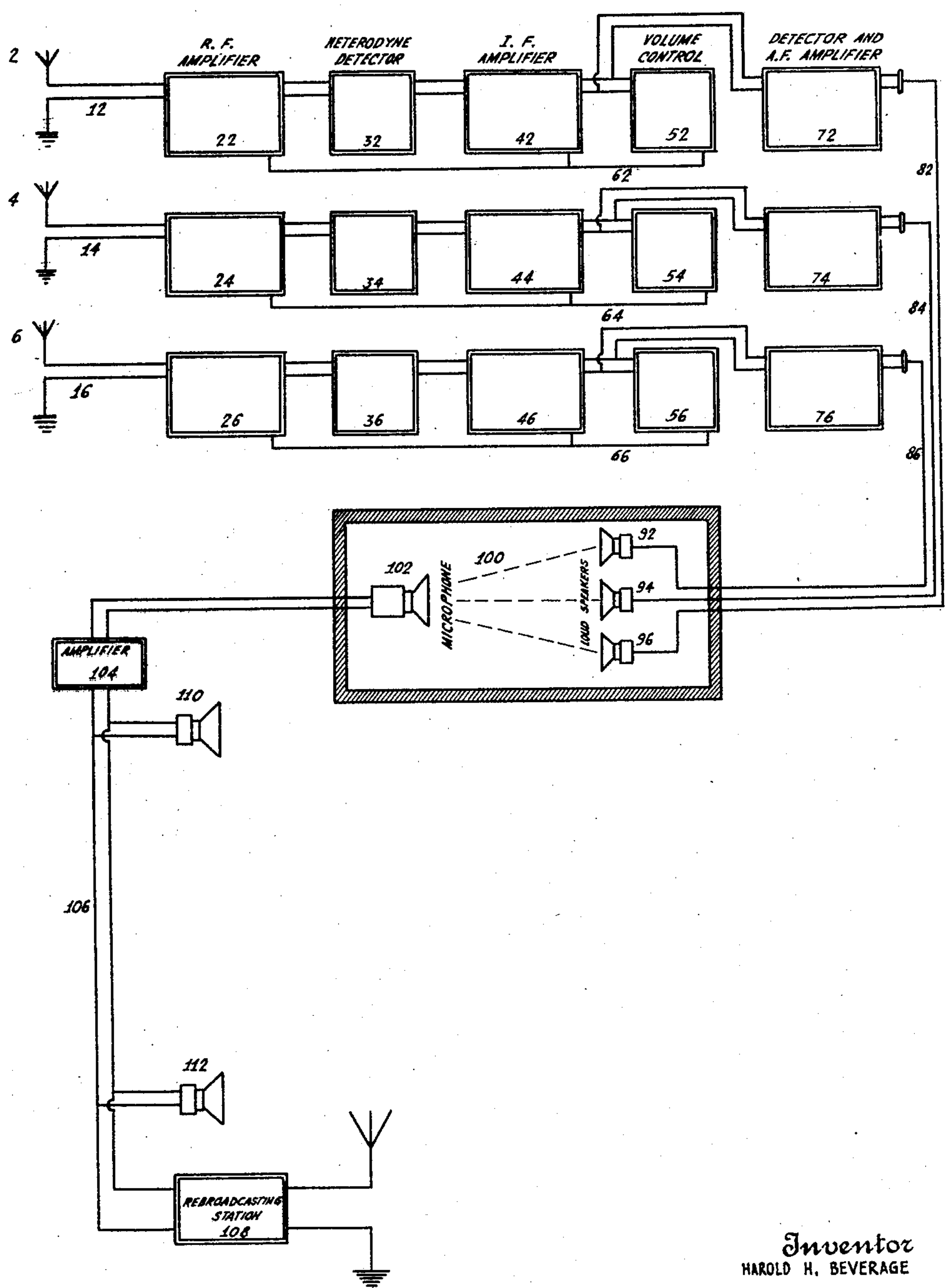
ACOUSTIC COMBINING SYSTEM

Filed Nov. 17, 1928



Inventor
HAROLD H. BEVERAGE

By his Attorney Ira J. Adams

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HAROLD H. BEVERAGE, OF RIVERHEAD, NEW YORK, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

ACOUSTIC COMBINING SYSTEM

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This invention relates to diversity reception and more particularly to a method and means for combining the energies collected by the several antennæ employed in diversity systems.

Short wave signals are subject to fading which varies both in frequency and degree in an unpredictable manner. Inasmuch as the fading at any instant may differ very widely at geographically spaced points, or in different planes of polarization, it has been suggested that a receiving station be equipped with a number of antennæ having different fading characteristics, the energies collected by which are fed to a single signal responsive means.

Experience has shown that high frequency energy fluctuates not only in intensity but also in phase, and that there may be considerable relative phase fluctuation at the several antennæ. This phenomenon makes it impossible to directly combine the radio frequency energies, for the energies may as often be in phase opposition as in like phase. To overcome this difficulty it has been suggested to equip each of the antennæ with a separate receiver, and to combine the energies after rectification, and this, in the case of code signals, has proven an apt solution.

However, I have found that in the case of speech telephony, or other speech-simulating signals, where the transmission energy is radiated in the form of a carrier and side bands, there may be a relative difference in the phase fluctuations of closely adjacent frequencies, such as side band and carrier frequencies, even at one antenna, just as there is between carriers of like frequency at different antennæ. This causes similar phase fluctuations in the beat of the carrier and side bands, for if of two beating waves one is kept constant in phase, while the other is shifted in phase, their beat is equally shifted in phase.

This may readily be understood by visualizing two beating radio frequency waves of slightly different frequency, which have an envelope which is a maximum where the waves are cophasal, and which gradually drops off to a minimum where the waves are in phase opposition. Now if the phase of one of these waves is kept constant while the phase of the other is shifted 180 degrees the waves will be in phase opposition where before they were cophasal, so that the envelope will be a minimum where before it was a maximum, and where the waves were in phase opposition they now will be cophasal, so that the envelope will be a maximum where before it was a minimum, and, therefore, in effect the envelope too has been shifted 180 degrees in phase.

Because of the foregoing considerations it follows that although the carrier and side band energies experience only radio frequency differences in phase, these differences are transferred to the detected or audio frequency energies, so that it is as impossible to combine the detected energies as it is to directly combine the originally collected radio frequency energies.

Another difficulty is that one variety of fading which often occurs is exceedingly rapid in frequency, at times almost approaching a low audio frequency. Neither volume control nor limiting can combat this type of fading, for they would then counteract the desired signal modulation.

The foregoing difficulties are especially important when it is desired to rebroadcast received signals, because for this purpose constant volume and good quality are essential, and to help obtain these characteristics is the object of my invention. For this purpose I combine the collected energies acoustically, rather than electrically. More in detail, my method includes simultaneously making a plurality of separate energy collections of relatively different fading characteristics, preferably by collecting the radiated energy at a plurality of spaced points, separately detecting the collected energies, separately translating the detected energies into sound energies, combining the sound energies, transforming the combined sound energy into electrical energy, modulating radio frequency energy by the electrical energy, and radiating the modulated energy. The combination of the sound energy is accomplished in an acoustically insulated chamber to considerably reflect and mix the sound energy therein, so that the resultant of the combination is more or less independent of changes in the audio frequency phase. The walls may be designed with a view to softening and improving the quality of the sound, though it should be kept in mind that this will affect the degree of reflection from the walls.

To take care of relatively slow fading I apply volume control to the amplifiers of the receiving circuits. Meanwhile the diversity reception inherently reduces and ordinarily eliminates the effect of rapid fading.

My invention is described more in detail in the following specification, which is accompanied by a drawing the single figure of which is a schematic wiring diagram for one form of my invention.

Referring to the drawing it will be seen that there are a plurality of antennæ 2, 4 and 6. Any desired number may be employed, and they are given relatively different fading characteristics in any suitable manner, such as by being geographically spaced, or by being positioned in different planes of polarization. The antennæ are coupled by transmission lines 12, 14 and 16 to radio frequency amplifiers 22, 24 and 26, the amplified outputs from which are fed to autodyne heterodyne detectors 32, 34 and 36, in which the received radio frequency energy is heterodyned to intermediate frequency energy, which in turn is amplified in the intermediate frequency amplifiers 42, 44 and 46. A portion of the output from the intermediate frequency amplifiers is fed to suitable volume control detector circuits 52, 54 and 56, of any conventional type, from which the bias leads 62, 64, and 66 run back to the control electrodes of the tubes of the amplifiers, in known manner.

The remainder of the intermediate frequency energy is led to detector and audio frequency amplifier stages 72, 74 and 76, the audio frequency outputs from which are separately conducted over lines 82, 84, and 86, to translating devices here exemplified by load speakers 92, 94, and 96 which, of course, have signal outputs of substantially the same frequency band width.

These speakers are located inside of a chamber 100, the walls of which are constructed so as to effectively sound insulate the chamber. The volume is such that the sound from the speakers strikes the walls and is echoed and reflected to a considerable extent, in consequence of which the sound energy from the various speakers is "well mixed", so to speak. This mixing is intended to so upset the phase relations of the sound energy that fluctuations in the relative phase of the audio frequency energies fed to the speakers will be lessened in significance, insofar as their effect upon the integrated or resultant sound within the chamber is concerned. Of course, for direct utilization the sound within the chamber may simply be listened to. However, for rebroadcasting a microphone 102, located within the chamber, responds to the resultant sound and transforms it into electrical energy, which may be amplified in an amplifier 104 to sufficient volume to be fed over a land line 106 to a broadcasting station 108, the electrical energy from the microphone serving as the modulating energy. Monitoring speakers 110 and 112 may be respectively located at the receiving station and at the broadcasting station.

It will be understood by those skilled in the art that many of the features described in the foregoing detailed arrangement are optional. For example, the number of antennæ used, and how they are given different fading characteristics, may vary. The receivers need not be superheterodyne receivers, and if they are, the first detectors need not be autodyne detectors, for separate local oscillators and detectors may be used. The volume controls may be arranged to control the gain in either the radio frequency or the intermediate frequency amplifiers alone, instead of in both, as has been indicated. The detectors used for obtaining the audio frequency energy for translation may be simultaneously used as the detectors for the volume control circuits, instead of employing separate detectors, as in the illustrated arrangement. Furthermore, in its simplest form my invention needs no volume control, for its paramount factors are merely a plurality of antennæ having different fading characteristics, a plurality of detectors to obtain the audio frequency energies, and means to acoustically, rather than electrically, combine the energies. While I have described this system in connection with the rebroadcasting of broadcast programs, it is of course applicable to private reception, either in the chamber 100, or from the speaker 110, when a high order of quality is desired.

I claim:

1. The method of diversity reception of audible signals transmitted on a single high frequency carrier which includes collecting the desired radiated signal energy at a plurality of spaced points, separately detecting the collected energies, separately translating the detected energies into sound energy, so directing and repeatedly reflecting the sound energies that they are thoroughly mixed, more or less independently of the initial audio frequency phase, transforming the resulting sound energy into electrical energy, and utilizing the electrical energy.

2. The method of diversity reception of audible signals transmitted on a single high frequency carrier which includes collecting the desired radiated signal energy at a plurality of spaced points, separately amplify-

ing the collected energies, separately controlling the gain in the step of amplification in response to the volume of the amplified energy to tend to keep the volume constant in order to obviate the effect of relatively slow fading, separately detecting the amplified energies, separately translating the detected energies into sound energy, combining the sound energies with sufficient reflection and mixing to tend to obviate the effect of audio frequency phase changes, transforming the resulting sound energy into electrical energy, and utilizing the electrical energy.

3. The method of rebroadcasting audible signals which includes simultaneously making a plurality of separate energy collections at the same frequencies of relatively different fading characteristics, separately detecting the collected energies, separately translating the detected energies into sound energy, combining the sound energy, translating the combined sound energy into electrical energy, modulating radio frequency energy by the electrical energy, and radiating the modulated energy.

4. The method of rebroadcasting audible signals transmitted on a single high frequency carrier which includes collecting the radiated energy at a plurality of spaced points, separately amplifying the collected energies, separately controlling the gain in the step of amplification in response to the volume of the amplified energy to tend to keep the volume constant in order to obviate the effect of relatively slow fading, separately detecting the amplified energies, separately translating the detected energies into sound energy, combining the sound energies with sufficient reflection and mixing to tend to obviate the effect of audio frequency phase changes, transforming the resulting sound energy into electrical energy, modulating radio frequency energy by the resulting electrical energy, and radiating the modulated energy.

5. A diversity receiving system comprising a plurality of antennæ adapted to receive a desired signal having different fading characteristics, means to separately detect the energies collected thereby, and means to acoustically combine the detected energies including an acoustically insulated chamber to reflect and mix the sound energy therein, and a plurality of reproducers within the chamber for separately translating each of the detected energies into sound energy of substantially like band width.

6. A diversity receiving system comprising a plurality of spaced antennæ collecting like signal energy, means to separately detect the energies collected thereby, and means to acoustically combine the detected energies including an acoustically insulated chamber to reflect and mix the sound energy therein, a plurality of reproducers within the chamber for separately translating each of the detected energies into sound energy of like band width, a microphone within the chamber responsive to the resultant sound energy, and means to utilize the electrical energy from the microphone.

7. A diversity receiving system comprising a plurality of spaced antennæ collecting signal energy of like frequencies, means to separately amplify the energies collected thereby, a volume control for controlling the amplification gain in the amplifiers to obviate the effect of relatively slow fading, means to separately detect the amplified energies, an acoustic combining system including an acoustically insulated chamber to reflect and mix the sound energy therein, a plurality of reproducers within the chamber for separately translating each of the detected energies into sound energy of like band width, a microphone responsive to the resultant sound energy, and means to utilize the electrical energy from the microphone.

8. A rebroadcasting system comprising a plurality of antennæ having different fading characteristics and collecting energy of like frequencies, means to separately detect the energies collected thereby, means to separately translate the detected energies into sound energy, means to combine the sound energy, a microphone responsive to the combined energy, and a broadcast transmitter the output from which is modulated by the electrical energy from the microphone.

9. A rebroadcasting system comprising a plurality of spaced antennæ collecting energy of like frequencies, means to separately amplify the collected energies, a volume control for controlling the amplification gain in the amplifiers to obviate the effect of relatively slow fading, means to separately detect the amplified energies, an acoustic combining system including an acoustically insulated chamber to reflect and mix the sound energy therein, a plurality of reproducers within the chamber for separately translating each of the detected energies into sound energy, a microphone responsive to the resultant sound energy, and a broadcast transmitter the output from which is modulated by the electrical energy from the microphone.

HAROLD H. BEVERAGE.