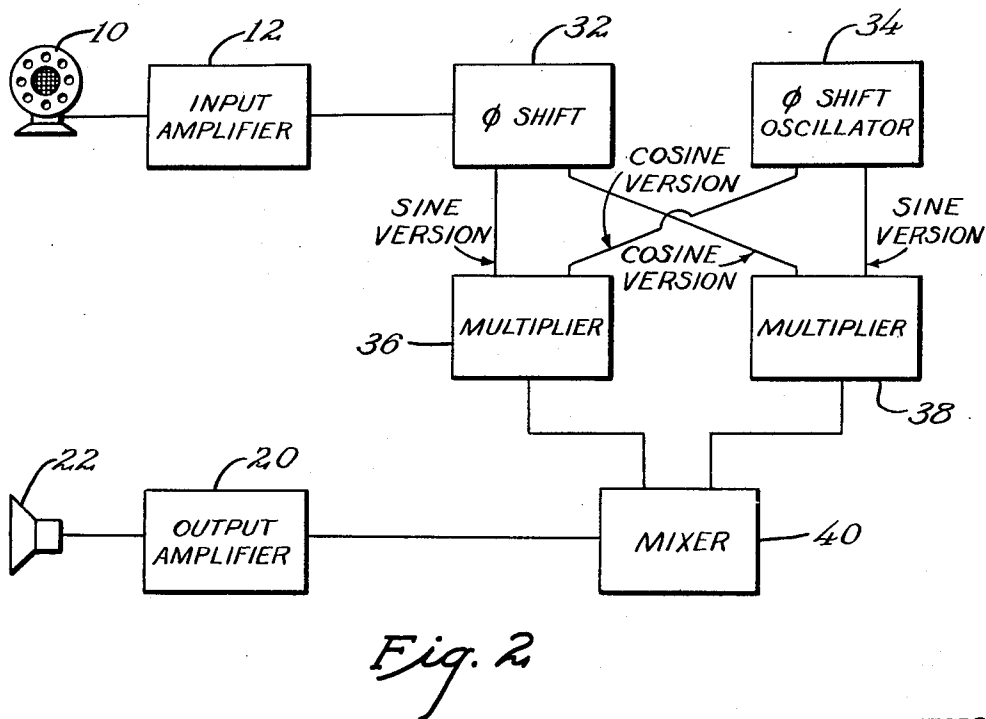
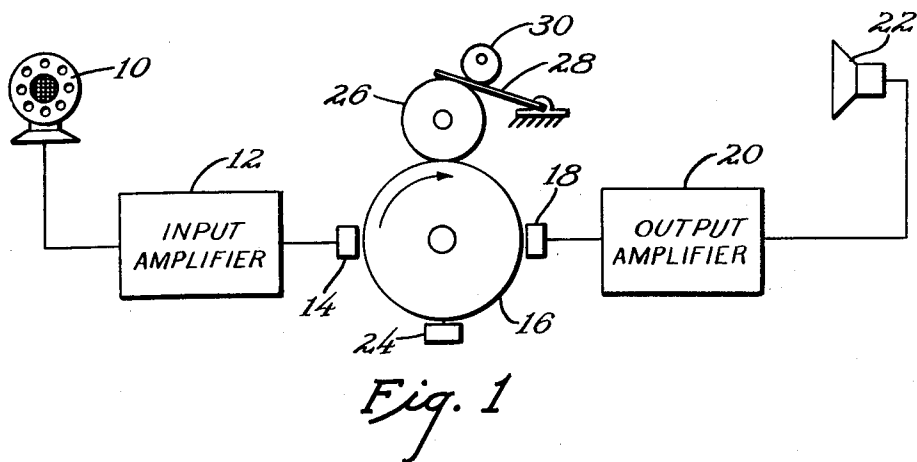


Nov. 8, 1955

J. D. GOODELL ET AL
METHODS AND APPARATUS FOR MINIMIZING
REGENERATIVE FEEDBACK
Filed April 9, 1951

2,723,316



INVENTORS
John D. Goodell
Tenny Lode
BY Robert M. Dunning
ATTORNEY

1

2,723,316

METHODS AND APPARATUS FOR MINIMIZING REGENERATIVE FEEDBACK

John D. Goodell and Tenny Lode, St. Paul, Minn., assignors to The Minnesota Electronics Corporation, St. Paul, Minn., a corporation of Minnesota

Application April 9, 1951, Serial No. 220,064

3 Claims. (Cl. 179—100.2)

This invention relates to electro-acoustic systems, and pertains more particularly to methods and apparatus for minimizing the effects of regenerative feed-back therein.

In sound reinforcement systems consisting of microphones, electrical amplifiers and loud speakers, a limiting problem has been the feed-back of a signal through a closed input-output-input loop. The most commonly experienced example of this occurs in simple public address systems wherein the output of the loud speaker feeds back into the system via the microphone, and in extreme cases causes sustained oscillation. However, in order to sustain any oscillation in a system of this character, it is necessary that the signal be fed back from the loud speaker to the microphone in suitable phase and magnitude. Under these conditions the signal will be continuously re-amplified and regeneration will be built up in the system to the maximum power output. Also, in all practical systems the frequency response of the enclosed loop will contain peaks, and as the operating level of the system is raised, the gain of one or more of these peaks will become unity or greater, resulting in sustained oscillation.

Accordingly, the principal object of the invention is to practically eliminate feed back in systems of the type referred to.

Another object is to provide apparatus that will overcome the aforementioned feed back difficulties which apparatus will be inexpensive to produce and which will require little attention in the operation thereof.

One feature of the instant invention resides in the provision of apparatus designed to shift the output frequency a certain number of cycles from the input frequency, such shift introducing negligible distortion of the signal, yet being highly effective in frustrating regeneration within the system.

The above objects, and other objects of the invention will be made more apparent hereinafter, are obtained by apparatus subsequently to be described and shown in the accompanying drawing, wherein:

Figure 1 is a schematic representation of the invention, this embodiment being primarily mechanical in nature, and

Figure 2 is a block diagram of another arrangement envisaged by the invention, this embodiment being primarily electrical.

Referring first to Figure 1 of the drawing, the system there depicted includes a microphone 10 and an input amplifier 12, the output of which is fed to a recording head 14. The head 14 is operatively associated with a continuous magnetic tape loop 16 which has an assumed rotation in the direction indicated.

Circumferentially displaced from the recording head 14 is a play-back head 18 which head is conventionally connected through an output amplifier 20 to a loud speaker 22, thus introducing a time delay of negligible duration. A suitable erasing head 24 is interposed between the recording and play back heads for erasing the recorded sound after it has passed beneath the play back head 18,

2

thereby always presenting a demagnetized section of tape to the recording head 14 for repetitive use.

The rotative speed of the tape loop 16 is not constant, but is deliberately made oscillatory at either a periodic or random rate to cause a frequency shift of all signals passing through the system. Consequently no signal is ever fed back repetitively at the same frequency.

It will of course be appreciated that the precise frequency shift should be left for empirical determination.

One convenient way of mechanically varying the rotative speed of the loop 16 is to employ a tape drive wheel 26 having a variable brake member 28 in friction engagement with the wheel's periphery. A periodic and variable drag is imposed on the brake member 28 by an eccentric cam 30 that may be rotated by the same motor driving the wheel 26 or by a separate device. Obviously there exists a wide choice of driving mechanisms when using the tape loop 16, and it should also be understood that it is within the purview of the invention to employ other types of storage mediums than the depicted magnetic tape loop 16.

Another approach to the solution of the problem of minimizing the feed back is illustrated in Figure 2. In principle this arrangement is somewhat similar to the arrangement shown in Figure 1, but may be preferable from the standpoint of simplicity in that a fixed increment of frequency is added or subtracted to each form appearing in the signal. By adding a fixed increment or term of frequency to each frequency term appearing in the signal passing through the system it will be observed that the frequency will be rapidly shifted in any regeneration process. Thus if a signal starts to regenerate within a peak in the response curve it is increased in frequency each time it passes through the system and quickly reaches a frequency that is outside the region where the gain is adequate to produce oscillation. If a fixed term is subtracted from each component in a complex signal passing through a system, the result will be essentially the same.

While it is true that a signal appearing close to the frequency of which the system tends to oscillate may pass through the peak, it will not remain in the oscillatory band for any appreciable period. Even in a system where the gain at all frequencies is sufficient to cause oscillation this method is designed to eliminate or at least greatly minimize serious feed back. It will of course be understood that the additive process raises all signals to a frequency above the transmission band of the system, and that the subtractive process lowers the signals to a level below the band. As a practical matter it may be desirable to divide the spectrum and use a subtractive process on low frequencies and an additive process on high frequencies. Under many conditions the peaks will appear only at the extremes of the spectrum and the method may not be needed in the middle range. It is also true that at the high end of the spectrum the shift in observed pitch will be less for a given added constant term than at the low end. Thus a relatively large term might be added to the upper frequencies and a relatively small term subtracted at the lower frequencies. Obviously, rapid attenuation beyond the frequency limits necessary for satisfactory intelligibility will facilitate the processes described.

In the particular embodiment depicted in Figure 2, the signal originating in the microphone 10 and amplified in the input amplifier 12 is passed through a phase shifting network 32, the output of which consists of the sine and cosine versions of the signal. The fixed frequency to be added as a constant is generated by a suitable phase shift oscillator 34, the result being the obtaining of sine and cosine versions of the frequency increment to be added. The sine version of the main signal and the cosine version of the incremental frequency are impressed on a multiplier 36, such as a balanced modulator, while the cosine

3

version of the signal and the sine version of the incremental frequency are similarly impressed on a second multiplier 38. The outputs from the two multipliers 36 and 38 are added together in a suitable mixing circuit 40. The sum signal is amplified by the power amplifier 20 and then fed to the loud speaker 22.

It can readily be shown that the output of the mixer circuit 40 will contain the components of the input signal with the constant term of the fixed frequency added to each component. Other terms will cancel out and with suitable linear networks no inter-modulation components will be introduced.

Similar methods may be used for subtraction. However, it should be noted in either case that the harmonic relationships will be somewhat disrupted by this process and this is likely to be the limiting factor with respect to the dimensions of the constant term to be added or subtracted. As in the embodiment of Figure 1, the exact frequency to be added or subtracted may be readily ascertained by simple experimentation. Within reasonable limits the incremental frequency selected should have no significant effect upon intelligibility.

In accordance with the patent statutes, the principles of the methods and apparatus for minimizing the effects of regenerative feed back have been described, and while it has been endeavored to set forth the best embodiments therein, it is desired to have it understood that obvious changes may be made within the scope of the following claims without departing from the spirit of the present invention.

We claim:

1. A system for minimizing regenerative feedback comprising means for accepting an input signal, phase shift

4

means for producing sine and cosine versions of said input signal, means for producing sine and cosine versions of an incremental frequency, and mixing means for combining the various sine and cosine versions to produce a output signal having a frequency differing slightly from that of said input signal.

2. A system for minimizing regenerative feedback comprising a microphone, means for accepting an input signal into the system via the microphone, means for recording said signal at a constantly varying rate, a speaker, the microphone being in sound wave receiving relation with said speaker, and means for playing back the recorded signal via said speaker to produce an output signal having a frequency varying from that of the input signal.

3. A system for minimizing regenerative feedback comprising a microphone, means for accepting an input signal into the system via the microphone, a continuous loop of magnetic tape, means for rotating the tape loop at a constantly varying rate, means for recording said input signal on the tape, a speaker, the microphone being in sound wave receiving relation with said speaker, means for playing back the recorded signal to obtain an output signal via the speaker, and means for thereafter erasing said recorded signal.

References Cited in the file of this patent

UNITED STATES PATENTS

2,177,769	Erickson	Oct. 31, 1939
2,286,072	Dudley	June 9, 1942
2,373,560	Hanert	Apr. 10, 1945
2,397,579	Veritch	Apr. 2, 1946
2,424,633	Rieber	July 29, 1947
2,593,113	Cutler	Apr. 15, 1952