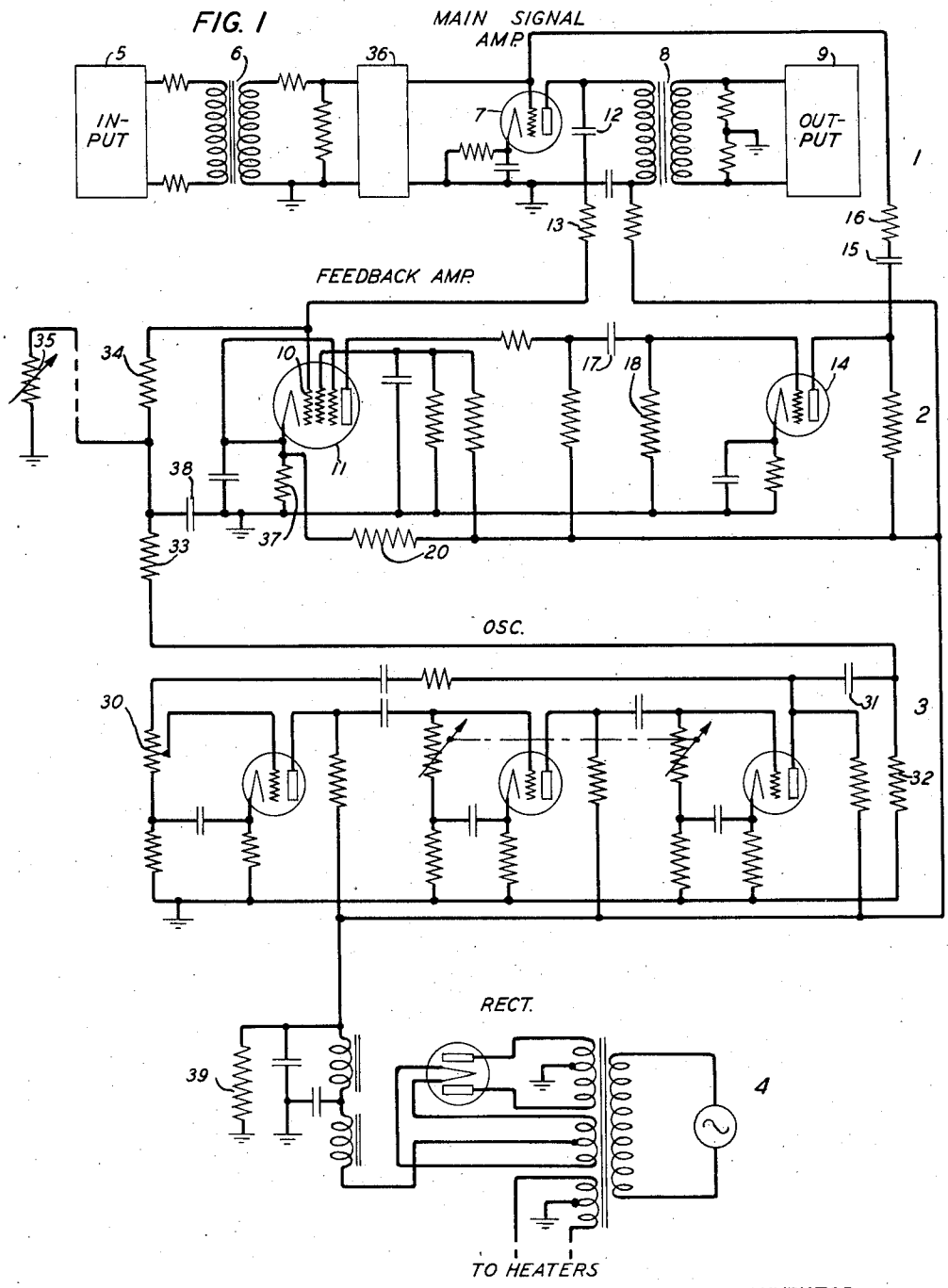
June 29, 1943. A. A. ROETKEN 2,322,884

AMPLIFYING SYSTEM

Filed April 26, 1941 2 Sheets-Sheet 1

FIG. 1



INVENTOR
A. A. ROETKEN

BY G. H. Heydt

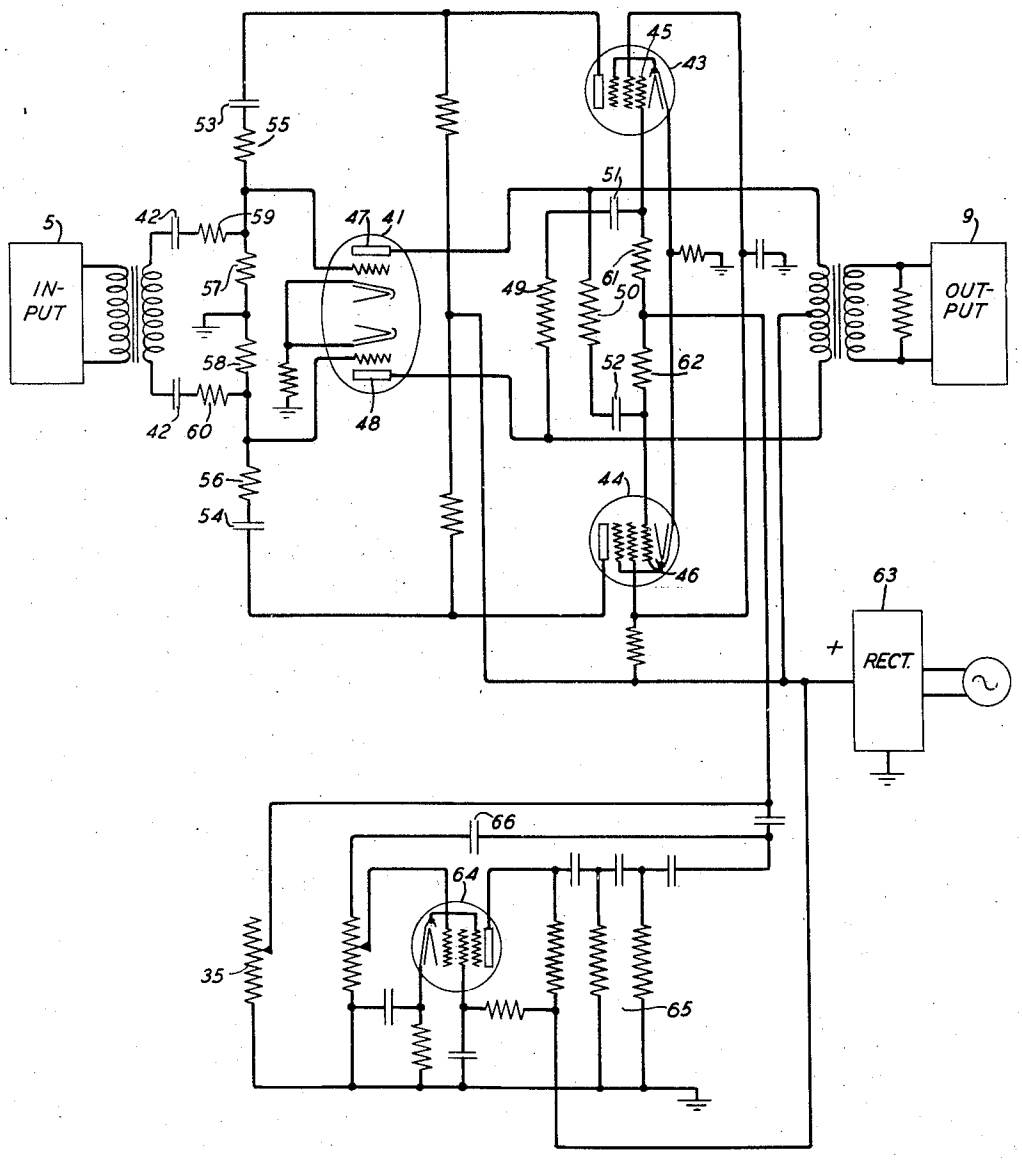
ATTORNEY

June 29, 1943. A. A. ROETKEN 2,322,884

AMPLIFYING SYSTEM

Filed April 26, 1941 2 Sheets-Sheet 2

FIG. 2



INVENTOR
A. A. ROETKEN

BY G. H. Heydt.

ATTORNEY

Patented June 29, 1943 2,322,884

UNITED STATES PATENT OFFICE

2,322,884

AMPLIFYING SYSTEM

Alfred A. Roetken, Madison, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 26, 1941, Serial No. 390,450

5 Claims. (Cl. 179—1)

This invention relates to amplifying systems and the object of the invention is an amplifying system in which the amplitude of the signal waves transmitted is automatically varied in a cyclic manner.

Amplitude modulated waves of this type are useful for various purposes and particularly for producing tremolo effects in connection with electronic organs or similar instruments. A number of tremolo mechanisms have been suggested heretofore but these have not been entirely satisfactory for various reasons. Some of these, for example, provide no means for producing a tremolo effect which varies with frequency and others involve the use of electrical contacts for this purpose and such contacts may introduce objectionable noise after a period of use.

According to this invention an amplifier is provided with a negative feedback path and the amount of feedback is varied cyclically at the amplitude and frequency required to produce the desired amplitude modulations in the output circuit. In the preferred embodiment an amplifier is used in the feedback path and the feedback is varied by means of an oscillator which varies the gain of the feedback amplifier.

In cases where the amplitude of the modulations should vary with the frequency of the signals being transmitted, the feedback path has a transmission characteristic which varies with frequency in the manner required to give the tremolo effect desired. If, as in the case of electronic organs, the tremolo is to increase in amplitude with frequency, the gain reduction due to feedback may be a maximum at the upper limiting frequency and, by means of networks in the feedback path, be tapered off to zero at some lower frequency below which no tremolo effect is desired. By giving the main signal amplifier when operating without feedback a transmission characteristic which varies with frequency in the same manner as the transmission through the network of the feedback path, the desired tremolo effect is obtained with uniform transmission over the whole band transmitted.

In the drawings

Fig. 1 is an amplifying system according to the invention; and

Fig. 2 is an alternate circuit using push-pull signal and feedback amplifiers.

The system shown in Fig. 1 comprises a main signal amplifier 1, a feedback amplifier 2, an oscillator 3 and a conventional power supply set 4. Signals from the source 5, which in the case of an electronic organ would be the common output circuit of the various tone frequency oscillators, pass through the input transformer 6 to the signal amplifying tube 7 and from the output of the tube through the output transformer 8 to the loud-speaker or some other receiving circuit 9. The output of this amplifier in the absence of feedback gradually increases with frequency. This rising characteristic may be obtained in various known ways such as by choosing the transformers or other circuit elements to give the desired response or by inserting a suitable network 36 in any convenient part of the circuit not in the feedback loop.

Negative feedback voltage from the output circuit of the tube 7 is applied to the grid 10 of the tube 11 in the feedback amplifier through a condenser 12 and a resistor 13 in the usual manner. The output of the tube 11 is connected to the input of the tube 14 and the output of the latter tube is applied through a condenser 15 and a resistor 16 as negative feedback to the grid of the tube 7 in the main amplifier. This feedback circuit also has a rising characteristic which is similar to that of the main signal amplifier and may be determined largely by the proper proportioning of the values of the condenser 17 and resistor 18 in accordance with well-known principles of design.

Two stages of amplification are shown in the feedback amplifier so as to phase the feedback properly for application to the grid of the single stage main amplifier. The use of two stages also simplifies the modulating problem and permits of greater discrimination against the low oscillator frequency in the interstage network thereby making it possible to use a greater depth of tremolo without noticeable variations at oscillator frequency in the main output circuit. The resistor 20 from the power supply to the cathode of the tube 11 is used to increase the current flowing in the biasing resistor 37 so that the bias on the tube is substantially constant and independent of the variations in plate current. The condenser 38 is used to avoid possible introduction of noise when operating the amplitude control 35 and the resistor 39 across the power supply loads the rectifier to improve its regulation.

With this type of system the tendency of the output level of the main amplifier to rise as the frequency increases will be nullified by the increase in the amount of feedback to the input of the tube 7 so that the response characteristic

for steady tones is uniform over the whole frequency range to be transmitted.

The tremolo action is essentially a variation in amplitude at a very low frequency such as 5 cycles per second and such a control wave may be obtained in various known ways such as by rotating a potentiometer or by using a heterodyne oscillator. The oscillator shown, however, consists of a three-stage resistance capacity coupled amplifier with an adjustable feedback circuit to form an oscillator of the general type described by Van der Mark and Van der Pol in Physica, vol. 1, No. 6, page 437. By proper choice of circuit constants and proper adjustment of the feedback by means of the potentiometer **30** this circuit may be made to oscillate at the desired frequency and this cyclically varying output voltage is applied through the condenser **31** to the resistor **32**. The voltage across the resistor is impressed on the input of the tube **11** of the feedback amplifier through the resistors **33** and **34**.

This cyclic variation in the grid potential of tube **11** will produce a corresponding variation in the output of the feedback amplifier which in turn produces a low frequency variation or tremolo effect in the output of the main amplifier. The amplitude or depth of the tremolo may be readily controlled from any point convenient to the operator by means of a variable resistor **35** connected across the resistors **32** and **33** to vary the tremolo voltage applied to the tube **11**.

In the circuit of Fig. 2 the main signal amplifier comprises a push-pull stage which may be a double triode **41** with conventional input and output circuits except that small condensers **42**, **42** or their equivalent, are connected in the circuit externally of the feedback loop to give the amplifier a rising characteristic with frequency as in the case of the amplifier of Fig. 1.

The large amount of negative feedback necessary may be obtained in a single stage by using high gain pentode tubes **43**, **44** but it is impractical to apply the high feedback voltage required to the cathodes of the signal amplifier tubes since this would involve an excessive reduction in the effective plate voltage. In order to make it possible to apply the feedback to the grids of the tube **41** the proper polarity is obtained, as disclosed in Patent 1,955,827 to Peterson, by cross-connecting the control grids **45** and **46** to the plates **48** and **47**, respectively, of the tube **41**, through the usual resistors **49**, **50** and blocking condensers **51** and **52**. The plates of the feedback tubes are connected to the grids of the tube **41** through condenser **53**, **54** and resistors **55**, **56** and these elements and resistors **57** to **60** are so proportioned as to give the required rising frequency characteristic as in the circuit of Fig. 1. The normal gain of the feedback circuit is fixed at its proper value primarily by the proportioning of resistors, **49**, **61** and **50**, **62**. The plate and screen circuits and the filaments (not shown) are all energized by means of any suitable rectifier **63**.

While the tremolo frequency may be applied by means of the oscillator shown in Fig. 1, it is possible further to simplify the circuit by using for the oscillator a single high transconductance pentode **64** connected to operate in the same general manner as the three-stage oscillator of Fig. 1. With a single tube circuit, it is necessary, however, to use a resistance capacity filter **65** of several sections between the plate and the feedback condenser **66**.

In the circuit of Fig. 1 the permissible amplitude of the tremolo is limited by the discrimination to the tremolo frequency introduced by the circuit of the feedback amplifier. In the circuit of Fig. 2, however, the oscillator frequency is impressed on the mid-branch circuit of the push-pull tubes **43**, **44** and is therefore substantially balanced out so that much greater tremolo action can be used before the oscillator frequency appears in the signal output circuit at sufficient level to be objectionable.

Other possible modifications will occur to those skilled in the art but the invention is intended to be limited only by the scope of the following claims.

What is claimed is:

1. In a sound reproducing system, a source of currents representing sounds to be reproduced, a receiver, an amplifier connecting the source to the receiver, a negative feedback path in the amplifier and means for cyclically varying the transconductance of the feedback path at a subaudio frequency for producing tremolo effects in the output of the receiver.

2. In a sound reproducing system, a source of currents representing sound to be reproduced, a receiver, an amplifier connecting the source to the receiver and having a transconductance which increases with frequency, a negative feedback path for the amplifier having a transmission characteristic which makes the output of the amplifier substantially linear with frequency, a feedback amplifier in the feedback path and means for cyclically varying the transconductance of the feedback amplifier to produce in the receiver a tremolo effect which increases with the frequency of the sounds being reproduced.

3. An amplifying system for producing an amplitude-modulated signal wave comprising a signal amplifier, a negative feedback path in the amplifier, a push-pull feedback amplifier in the path and means in the midbranch path of the push-pull amplifier for cyclically varying the gain of the feedback amplifier at a frequency which will produce frequency changes in the output of the signal amplifier.

4. A system according to claim 3 in which the signal amplifier without feedback and the feedback path each has a transmission characteristic which rises with frequency.

5. In an amplifying system, a signal amplifier comprising two vacuum tubes having grids and plates connected in push-pull, a feedback amplifier comprising two vacuum tubes having plates connected to the grids of the signal amplifier and grids cross-connected to the plates of the signal amplifier and an oscillator connected to both grids of the feedback amplifier tubes.

ALFRED A. ROETKEN.