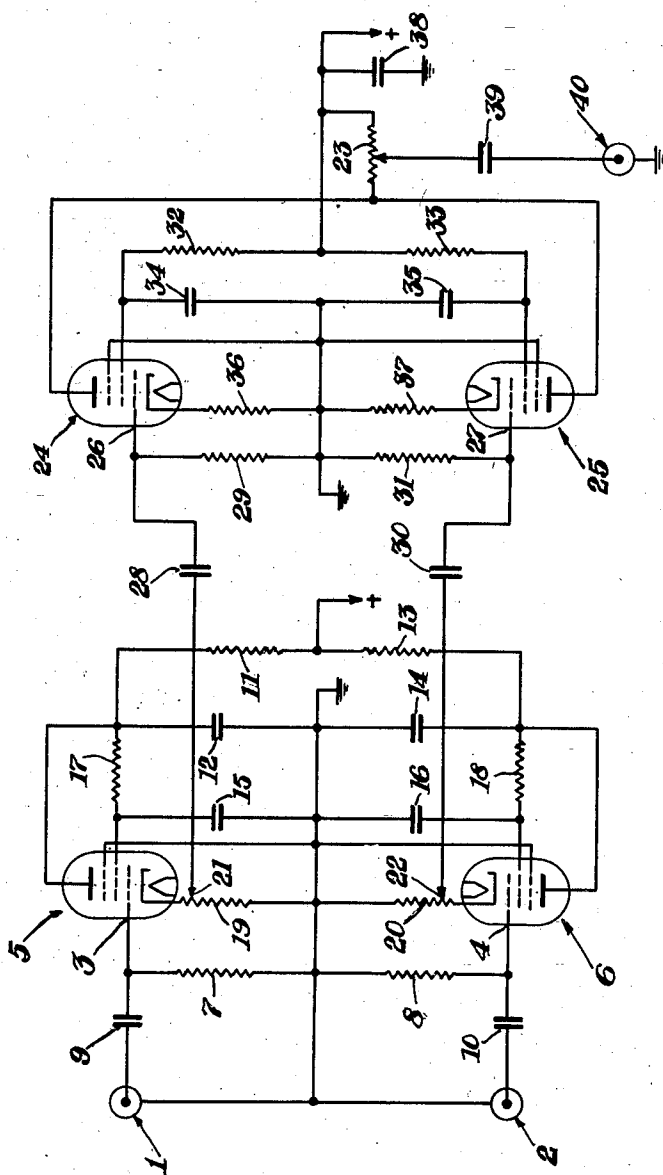


May 31, 1949.

R. B. READE ET AL
MIXER CIRCUIT USING CATHODE
FOLLOWER FEED-IN STAGES
Filed Dec. 8, 1945

2,471,449



INVENTORS
DONALD D. GRIEG
RALPH B. READE

BY

R. P. Morris
ATTORNEY

UNITED STATES PATENT OFFICE

2,471,449

MIXER CIRCUIT USING CATHODE FOLLOWER FEED-IN STAGES

Ralph B. Reade, Larchmont, and Donald D. Grieg,
Forest Hills, N. Y., assignors to Federal Tele-
phone and Radio Corporation, New York, N. Y.,
a corporation of Delaware

Application December 8, 1945, Serial No. 633,835

1 Claim. (Cl. 178-44)

1

This invention relates to a mixer circuit, and more specifically, to a circuit for producing wide band linear mixing of signals with a minimum of distortion.

Whenever the signals from a plurality of channels are to be combined to produce a resulting signal, it is very often desirable that this resulting signal be the algebraic sum of corresponding instantaneous values of the signals, or proportional thereto, that is, the adding or mixing is desired linear. In addition, independent control of the amplitudes of each of the signals to be mixed is usually required. One arrangement which approaches these results involves feeding the signal from each channel to the grid of a tube which has a plate load in common with other tubes having grids excited from other channels. In this arrangement the output of each of the tubes appears in the common plate load and the combined output may be taken from across this load; it therefore becomes possible to vary the grid input signal voltage to each tube, hence the amplitude of output due to this voltage, without influencing the amplitudes of output produced by other signals.

However, arrangements of this type have heretofore proven successful only a limited extent. One difficulty has involved intermodulation between channels, wherein fluctuations of plate voltage in one channel occur due to signal variations of another channel. Other difficulties are experienced due to minor dissimilarities between characteristics of the circuits and tubes in each channel of the mixing arrangement. Additionally, at ultra high frequencies, the ordinary mixer circuits are unsuitable because of distortions introduced by feedback from the output through inter-electrode capacitances of the mixer tubes.

Therefore it becomes one object of the present invention to provide a circuit for algebraically adding a plurality of signals from different channels and maintaining inter-modulation between channels at a minimum.

A second object is to provide a mixer circuit, the operation of which is substantially unaffected by slight variations in the characteristics of the tubes employed.

A further object of this invention is to provide a mixer circuit which has a constant gain versus frequency characteristic over a wide band of frequencies.

Another object is to provide a circuit for mixing ultra high frequency signals from a plurality

2

of channels while minimizing feedback and distortion.

In addition to the individual mixer stages which have a common plate load, as previously mentioned, this invention provides separate cathode follower feed-in stages coupled to the inputs of the mixer stages. This allows adequate decoupling of the channels from one another prior to introduction to the mixer stages to prevent the occurrence of non-linear mixing due to amplification of any signal more than a single time. Since these initial stages are cathode followers amplifiers, the amplification in these stages is linear even at high frequencies and the output impedances presented to the mixer stages are very low. The ability of the cathode follower amplifier to handle large input voltage without overload and its independence of small changes in tube factors or operating voltages are further advantages.

Each of the mixer stage amplifiers receives grid excitation from the voltage developed across the cathode resistance in the cathode follower amplifier which precedes it. The variations of voltages across the cathode resistance are not of very large amplitude and the gains of the amplifying stages in the mixer are kept low through negative feedback, hence the fluctuations of plate voltage in the mixer supply due to the signal in any one channel are small enough so that the inter-modulation effects produced with other channels are negligible. Negative feedback in the mixer stages as well as the cathode follower amplifier stages insures linear amplification of each signal by causing the gains to be substantially independent of phase and frequency distortion, slight differences in tube characteristics, or tube noises. In many mixer circuits distortion is introduced at high frequencies by feedback through inter-electrode capacities; however, in the present invention the impedances of the cathode input circuits of the mixer amplifiers are low compared with the capacitive impedances between the cathodes and grids and the occurrence of undesired feedback is minimized.

These features and objects may be better comprehended and other features and further objects may become apparent from a discussion of a particular embodiment of the wide band linear mixer patterned after this invention, with reference to the drawing wherein:

The single figure is a schematic diagram of a circuit for linearly mixing signals from two channels.

The A. F. or R. F. signals from two channels

may be introduced to the mixing circuit shown in the figure through coaxial input connectors 1 and 2, which are designed for use even at very high frequencies. It is preferred that coaxial cables be used for coupling to these connections in order to prevent alternation of high frequency components of the signals. Coupling of the signals from connectors 1 and 2 to control grids 3 and 4, respectively, of two pentode amplifier tubes 5 and 6, is accomplished by coupling circuits incorporating grid resistors 7 and 8 and coupling condensers 9 and 10. The plate circuit of one tube 5, includes a decoupling resistance 11 in series with the D. C. supply and a decoupling condenser 12 shunted across the series combination of supply and the resistor 11; similarly, the plate circuit of the other tube, 6, includes a decoupling resistance 13 and a decoupling condenser 14. These decoupling circuits aid in preventing distortion and inter-modulation which might occur due to plate voltage fluctuations with various signal amplitudes applied to the tube grids 3 and 4. By-pass condensers 15 and 16 and screen voltage dropping resistances 17 and 18 are connected to the tubes 5 and 6 respectively.

Cathode follower resistances 19 and 20 are variably tapped by taps 21 and 22 respectively, so that any desired percentages of the voltages appearing across the cathode resistances may be selected. Negative feedback is produced by cathode resistances 19 and 20 also, with the resulting advantages previously mentioned.

The actual mixing of signals occurs in the variably tapped plate load resistance 23, which is common to the plate circuits of the mixer stage pentodes 24 and 25. The control grids 26 and 27 of the mixer pentodes 24 and 25 respectively, are coupled to the cathode resistor taps 21 and 22 by the grid coupling circuits, one composed of coupling condenser 28 and grid resistance 29 and the other of coupling condenser 30 and grid resistance 31. As in the cathode follower stages, screen voltage dropping resistances 32 and 33, as well as screen by-pass condensers 34 and 35, are included. Negative feedback is provided in the mixer amplifiers for reasons already discussed and is produced by the voltage drop across the cathode resistances 36 and 37. A by-pass condenser 38 is shunted across the D. C. supply, and a condenser 39 couples the tapped desired percentage of output voltage, appearing between the tap and grounded side of the plate resistance 23 to the coaxial output connector 40.

It should be apparent that this two-channel mixer satisfies the objects previously set forth. Inter-modulation between channels is minimized by utilizing low gain cathode follower amplifiers in each channel and also negative feedback in each mixer tube circuit. These same features insure that slight variations in operating voltages or

small differences in tube characteristics will have no appreciable effect upon the linear amplification of each signal. Also, these features provide constant gain versus frequency characteristics over a wide band of frequencies as well as reduce distortion and undesired feedback.

Although the embodiment diagrammed and described incorporates stages to accommodate only two signals, it is possible to include other stages for mixing other signals simultaneously. Pentodes are shown in all stages, but other tubes, such as triodes may be substituted, with the same resulting advantages. Other minor changes in the circuits may well be instituted by those skilled in the art without departing in principle from the present invention whose scope is to be considered limited only by the foregoing objects and accompanying claim.

We claim:

20 An electrical circuit for producing an output voltage which is proportional to the algebraic sum of corresponding instantaneous values of a plurality of signals over a wide band of frequencies, comprising a plurality of low-gain linear cathode follower amplifiers incorporating negative feedback and having low impedance output circuits, means for applying said signal to said linear amplifiers, means coupled to each of said linear amplifiers for preventing intermodulation therebetween, said last-mentioned means comprising a plate decoupling resistance connected in series with the plate voltage supply of said linear amplifiers and a by-pass condenser shunted across the series between said supply and said resistance; a plurality of low-gain negative feedback amplifiers having a common plate load across which the output signal voltages may be developed, means coupling said negative feedback amplifiers to said low gain linear amplifiers, voltage tapping arrangements coupled to each of said low-gain amplifiers across the cathode follower resistances thereof for controlling the gain thereof, means coupled to said negative feedback amplifiers for preventing intermodulation therebetween, and output means coupled to said common plate load and conducting the linearly mixed output signals therefrom.

RALPH B. READE.
DONALD D. GRIEG.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,221,398	Geohegan	Nov. 12, 1940
2,252,613	Bingley	Aug. 12, 1941
2,365,575	Maxwell	Dec. 19, 1944