Oct. 23, 1962 R. H. DUNCAN ET AL 3,060,265

CONFERENCE CALL CIRCUIT

Filed Jan. 26, 1960 2 Sheets-Sheet 1

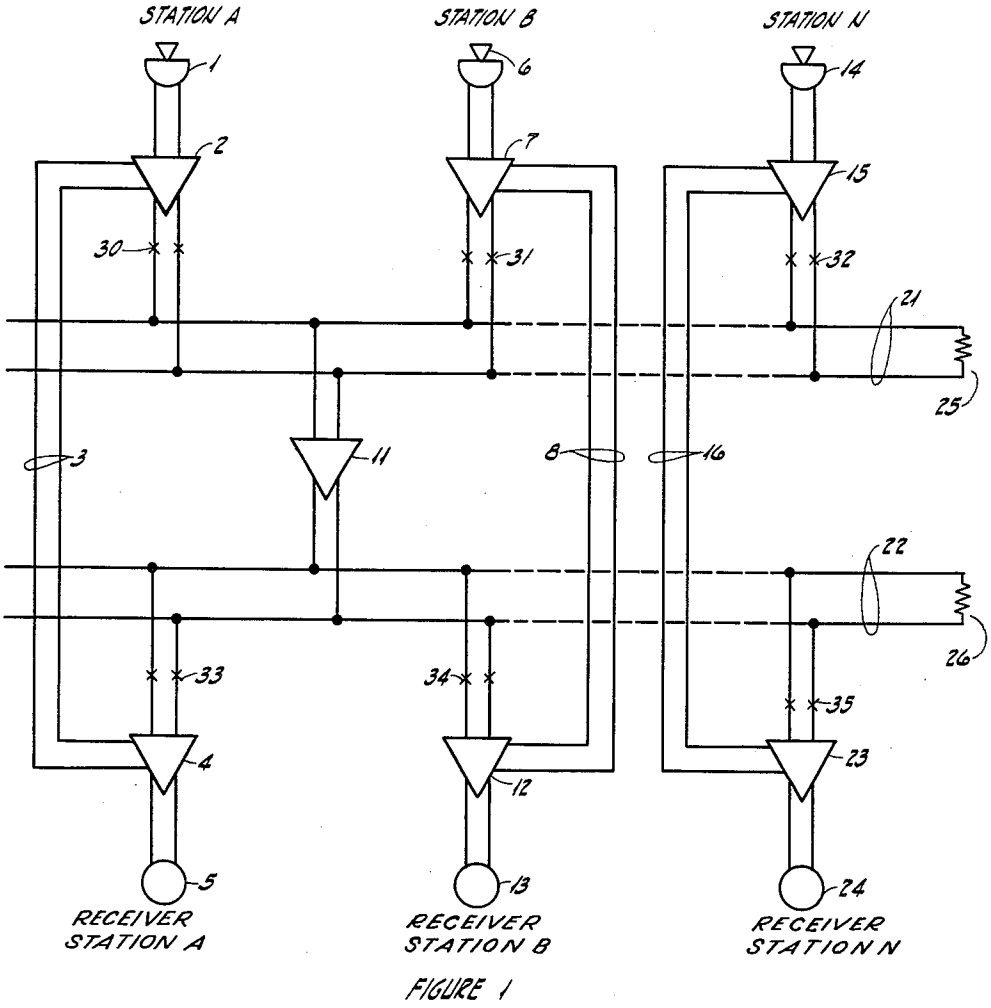

FIGURE 1

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CONFERENCE CALL CIRCUIT

Filed Jan. 26, 1960 2 Sheets-Sheet 2

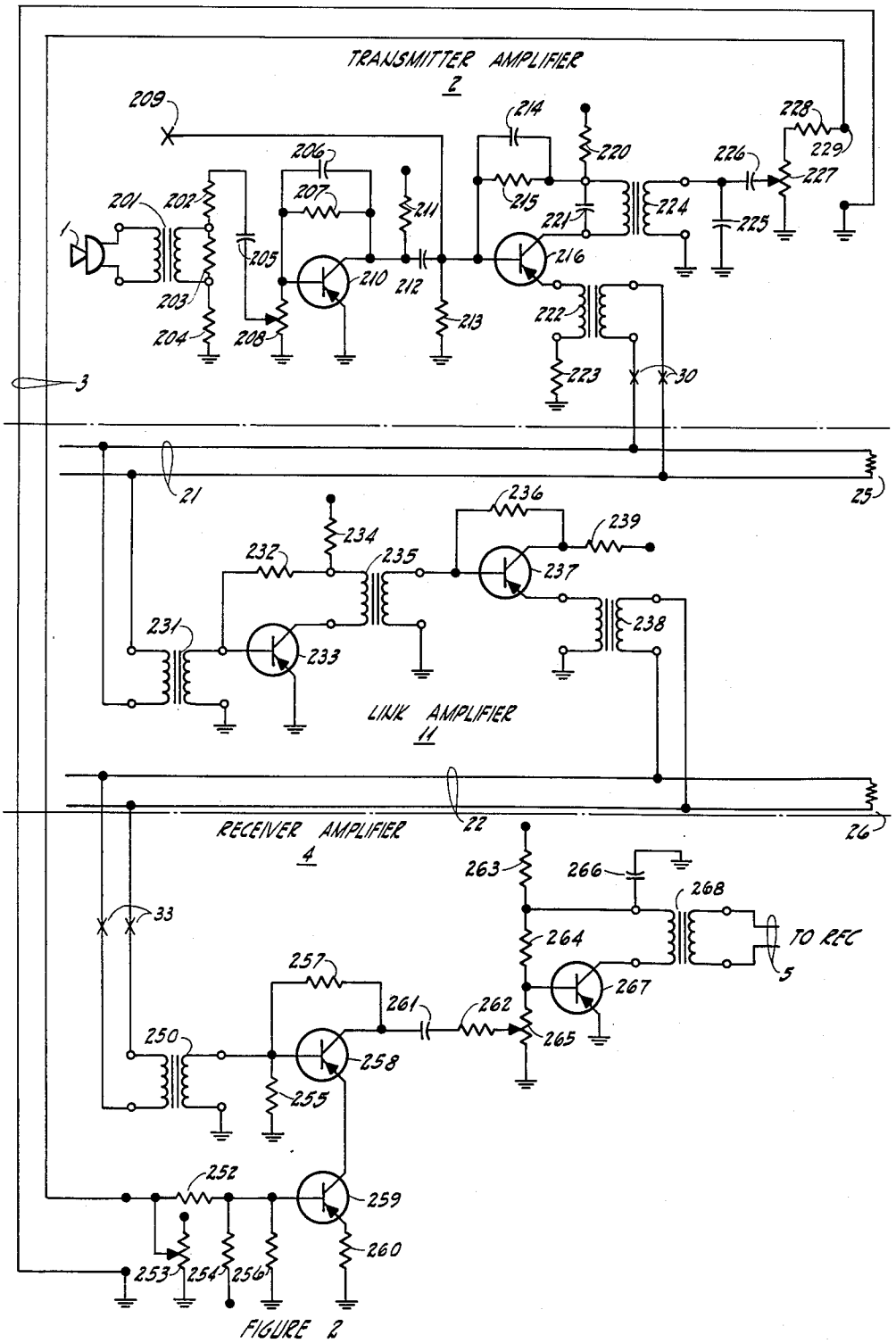

FIGURE 2

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CONFERENCE CALL CIRCUIT

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This invention relates to telephone systems and more particularly to conference call circuits for use in such systems.

Typical conference call circuits provide for matching the impedances of all interconnected circuits with provisions for equalizing the attenuation of signals by all stations and with provisions for negating signal attenuation caused by the introduction of an excess number of stations. However, conference call circuits have not met all of these requirements primarily because the characteristics of individual subscriber lines are not sufficiently uniform; and because the strength of the voice signal at a subscriber's receiver is a function of the number of stations connected to the conference call circuit, i.e., the characteristic impedance of the conference circuit is lowered as stations are connected thereto and raised as stations are removed therefrom. The result is that conference circuits which have been used in the past were unstable, and provided inefficient power transfer, improper sidetone and combinations thereof.

An object of this invention is to provide new and improved conference call circuits.

A further object of this invention is to provide conference call circuits which may simultaneously serve either a large number or a small number of stations, as required.

Another object of this invention is to provide conference call circuits wherein each receiver and transmitter is terminated by its own characteristic impedance.

Still another object of this invention is to provide telephone systems having controlled sidetone.

Yet another object of this invention is to provide conference call circuits that require no adjustment of signal amplitude as stations are added to or dropped from the conference.

Another object of this invention is to minimize instability in conference call circuits.

In accordance with this invention, a conference call circuit is provided with transmit and receive channels which are common to all conversing subscribers and which are interconnected by a high gain link amplifier that compensates for any attenuation. Each subscriber line which may be connected into the conference circuit is provided with individual transmit and receive channels each containing a device for individually isolating the transmitter and the receiver from the common channel, thereby preventing changes in the characteristic impedance of the common channel which might otherwise be caused when stations are added to or dropped from a conference call. The individual transmit channel and the individual receive channel of each subscriber line are interconnected so that signals originating in such individual transmit channel are inverted and fed back into

The above mentioned and other objects of this invention together with the manner of obtaining them will become more apparent and the invention itself will be best understood by making reference to the following description of a preferred embodiment of the invention taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram which shows a portion of a conference call circuit; and

FIG. 2 shows the details of the circuit which may be used to complete the hollow blocks of FIG. 1.

Where possible, simple terms are used and specific items are described hereinafter to facilitate an understanding of the invention; however, it should be understood that the use of such terms and references to such items are not to act in any manner as a disclaimer of the full range of equivalents which is normally given by established rules of patent law. To illustrate, the attached drawings show transistorized amplifiers; however, any suitable amplifying and isolating means such as vacuum tubes may be used. Still further the amplifiers are shown as two-stage amplifiers; whereas, any combination of stages that results in a proper signal phase shift may be utilized. Although only three subscriber lines are shown, any suitable number may be interconnected via the conference circuit. Quite obviously other examples could be selected to illustrate the manner in which specific terms that have been used and items have been described are entitled to a wide range of equivalents.

Brief Description

Turning now to FIG. 1, a conference call circuit is shown in block diagram form. Each of the three subscriber stations A, B and N has an individual transmit and receive channel. For example, subscriber station A has a transmitter **1**, an isolation transmitter amplifier **2**, a receiver **5**, and an isolation receiver amplifier **4**. A first output of the transmitter amplifier **2** is connected to a first input of the receiver amplifier **4** by way of an individual circuit branch such as sidetone control circuit **3**, so that a sample of all signals originating in transmitter **1** may be inverted and fed back into receiver amplifier **4** to control the sidetone. Another output terminal on transmitter amplifier **2** is connected by any suitable means such as plugs and jacks or automatic switches at point **30** to a common channel or transmission line such as transmit bus **21** which is terminated by a characteristic impedance **25**. Another input terminal on receiver amplifier **4** is similarly connected to a common channel or transmission line such as receive bus **22** which is also terminated by a characteristic impedance **26**. The common transmit and receive channels are, in turn, interconnected by a link amplifier **11** which provides a uniform amplification of all voice signals originating in the conference call system.

It should be noted that the invention provides a telephone system wherein all subscriber lines terminate in the uniform impedance of an individually and permanently associated amplifier which is adjusted to compensate for loss on the associated line. While the attached drawings and this description speak only of conference call circuits, it should be understood that the principles

Detailed Description

For a more complete understanding of the invention, reference is made to the detailed circuit individually associated with subscriber station A together with the common link equipment as shown in FIG. 2.

More particularly, FIG. 2 relates to FIG. 1 in the following manner. Transmitter **1** of subscriber station A is shown near the upper left-hand corner of FIG. 2, receiver **5** of subscriber station A is shown near the lower left-hand corner, isolation transmitter amplifier **2** is shown in the upper third, isolation receiver amplifier **4** is shown in the lower third, and sidetone control feedback circuit **3** is shown near the left-hand edge. The remainder of FIG. 2 is the common channel which serves all subscriber lines that participate in a conference call. It should be understood that the circuits which complete hollow boxes **7, 12, 15** and **23** are identical to those shown in FIG. 2 in connection with amplifiers **2** and **4**.

Next, it is assumed that a party at station A is talking after a conference call has been set up.

Transmitter amplifier.—Means are provided for obtaining two output signals from transmitter amplifier **2**, a first of such signals being used to provide the principal voice signal and a second of such signals being used to provide controlled sidetone. More particularly, transmitter **1** is connected to transmitter amplifier **2** through transformer **201** and a network comprising capacitor **205**, resistors **202, 203** and **204**, the purpose of which is to match the characteristic impedance of the transmitter. Signals from transmitter **1** are applied through transformer **201** and coupling capacitor **205** into variable resistor **208** and then to the base of transistor **210** where the signals are amplified. Capacitor **206** and resistor **207** along with resistor **211** make up the bias and by-pass circuits for transistor **210**. The amplified signal from transistor **210** is applied via capacitor **212** to the base of transistor **216** which provides the two output signals.

The principal voice signal is obtained from the emitter of transistor **216** while the sidetone control signal is obtained from the collector thereof. The voice signal is extended to the common link of the conference circuit over a path that can be traced from the emitter of transistor **216** through the primary winding of transformer **222** and resistor **223** to ground. The output side of transformer **222** is connected via terminals **30** to the common transmit bus **21** which is terminated by a characteristic impedance **25**. A high impedance is presented to bus **21** by amplifier **2** to allow a great number of transmitting stations to be interconnected without substantially altering the characteristic impedance of bus **21**. The sidetone control signal travels over an individual circuit branch than can be traced from the collector of transistor **216** through transformer **224** (which is tuned by capacitors **221** and **225**), coupling capacitor **226**, potentiometer **227**, and resistor **228** to sidetone control circuit **3** and a first input circuit of receiver amplifier **4**. Potentiometer **227** is adjusted to cause the amplitude and phase of the sidetone control signal to be approximately 180° out of phase with the principal voice signal taken from the emitter of transistor **216**.

It should be noted that the impedance of transmit bus **21** remains uniform regardless of the number of stations that are connected into the conference call circuit. More particularly, transmitter **1** always sees only its own characteristic impedance looking into transformer **201** while transmit bus **21** sees only an extremely high impedance which has little or no effect on its characteristic impedance when looking back into transmitter amplifier **2**. Therefore, the number of transmit channels that are connected in the conference call circuit, does not effect the impedance of bus **21**.

Link amplifiers.—Means are provided for uniformly amplifying all voice signals originating in the conference

applied to link amplifier **11** through transformer **231** and then applied to transistor **233** which is a grounded emitter type amplifier. Transistor **233** is properly biased from the power supply through resistor **234**, resistor **232** and also through one side of transformer **235**. Transformer **231** is used to match the impedance of link amplifier **11** to the characteristic impedance of transmit bus **21** whereby maximum power transfer is achieved.

After amplification in transistor **233**, the voice signal is applied through transformer **235** to the base of transistor **237** where there is further amplification. Transistor **237** is properly biased from the power supply through resistors **239** and **236**. The emitter of transistor **237** is connected to ground through a winding of transformer **238** which is used to match the impedance of link amplifier **11** to the characteristic impedance of receive bus **22** whereby maximum power transfer is achieved. Thus, it is seen that all voice signals are amplified by link amplifier **11** which is a high gain, two stage, transistorized amplifier that utilizes inductive coupling exclusively rather than capacitive coupling.

Receiver amplifier.—Means are provided in the form of receiver amplifier **4** for isolating the receive channels of individual subscriber stations and for providing controlled sidetone under the influence of signals received over conductors **3**. In greater detail, the amplified voice signals appearing on receive bus **22** are applied through transformer **250** to the base of transistor **258** which is also biased to ground through resistor **255**. Transformer **250** presents a high impedance to receive bus **22**; therefore, the impedance of the bus is not materially affected by the addition or removal of stations to the conference circuit.

To control sidetone in receiver amplifier **4**, the base of transistor **259** is directly coupled to transmitter amplifier **2** through resistor **252**. The amplitude of the sidetone control signal appearing on conductors **3** can be adjusted by potentiometer **253**. Resistors **254** and **256** form a voltage divider for applying a proper bias to the base of transistor **259**. The emitter of transistor **259** is connected to ground through resistor **260**. Both the voice signal applied through transformer **250** from receive bus **22**, and the sidetone control signal received over conductors **3** are vectorially summed in the connection between the collector of transistor **259** and the emitter of transistor **258**. As explained above, the signal appearing on conductors **3** is approximately 180° out of phase with that applied from receive bus **22** via transformer **250**; therefore, the voice and sidetone control signals in combining buck and the talking subscriber at station A hears only a controlled amount of sidetone. Although, the potentiometers **227** and **253** could be adjusted to completely cancel all signals originating at transmitter **1**, they are preferably adjusted to provide the sidetone which occurs during normal or non-conference calls.

To energize receiver **5**, the vectorially summed signal appearing at the collector of transistor **258** is applied through coupling capacitor **261**, resistor **262** and amplitude adjusting potentiometer **265** to the base of transistor **267**. The base of transistor **267** is properly biased through a voltage divider including potentiometer **265** and resistors **264** and **263**. The collector of transistor **267** is also biased from the B supply through resistor **263** and one winding of transformer **268**. Capacitor **266** acts as a filter from the collector of transistor **267** to ground. The output signal from the collector of transistor **267** is applied through transformer **268** to receiver **5**. Thus, it is seen that the receiver looking back into transformer **268** sees an impedance that matches its own impedance regardless of how many subscriber stations are conferenced in the circuit.

When a subscriber at a station other than station A is talking, no signal is received at receiver amplifier **4** over conductors **3** from individually associated transmitter amplifier **2**; therefore, the only signal appearing at

transformer 250, transistor 258, transistor 267 and transformer 268. Since no sidetone control signal is received over conductors 3, there is no signal combining with the signal through transistor 259. Therefore, the signal driving receiver 5 when a subscriber at station B or N is talking is made up solely of the signal from receiving bus 22. The high impedance that receive bus 22 sees when looking into receiver amplifier 4 through transformer 250 results in no material alteration of the characteristic impedance of bus 22. Therefore, any reasonable number of receive channels can be interconnected in the conference circuit without creating instability.

The power transfer loss resulting from the lack of impedance matching between transmit bus 21 and transmitter amplifiers 2, 7 and 15; and between receive bus 22 and receiver amplifiers 4, 12 and 23 is compensated for by link amplifier 11. The power loss problem is not as serious as the instability problems that would result if there were no isolation amplifiers and the impedance of transmit bus 21 and of receive bus 22 were allowed to vary as a function of the number of stations that are connected thereto.

While the principles of the invention have been shown and described in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What is claimed is:

1. A four wire conference call system comprising a plurality of subscriber stations, each having a transmitter and receiver associated therewith, first means associated with each of said stations for isolating the transmitter associated therewith, second means associated wtih each of said stations for isolating the receiver associated therewith, common amplifier means, means for selectively connecting said first and second means of any calling station through said common amplifier, means for selectively connecting said first and said second means of any desired called stations to said common amplifier for interconnecting each of said transmitters to all of said receivers, individual means for linking the isolating means associated with the same subscriber stations, and means including said last named means for automatically controlling sidetone responsive to actuations of said transmitter.

2. In a four wire conference call system, a plurality of subscriber stations, each comprising transmit means and related receive means, first isolating means individually associated with each of said transmit means, second isolating means individually associated with each of said receive means, separate means for interconnecting the transmit and related receive isolating means associated with the same subscriber station, first common bus means linking each of said transmit isolating means, second common bus means linking said receive isolating means, means including associated isolating means and common link means for selectively connecting any calling subscriber station with a desired number of called stations, and means associated with each of said isolating means responsive to signals imparted over said interconnecting means for controlling the amplitude of at least some of said signals in said related receive means.

3. The communication system of claim 2 wherein said isolating means associated with each of said transmit means comprises an amplifier, means within said amplifier for splitting signals appearing in said associated transmit means, and means for inverting a portion of said split signal.

4. In the communication system of claim 3 an impedance matching means for interconnecting each of said transmit means and the amplifier individually associated therewith whereby maximum power is transferred from all of said isolating means that are associated with said receive means, and means for applying another portion of said split signal to the particular receive isolating means that is associated with the station at which said split signal originates.

5. The communication system of claim 2 wherein said isolating means associated with each of said transmit means comprises means for splitting said signals received from said associated transmit means, means for phase inverting a portion of said split signal, means for controlling the phase and amplitude of said inverted portion of said split signal, means for applying said controlled signal directly to the isolating means associated with the receive means of the station where said controlled signal originated, and means responsive to said last named means for controlling sidetone in said last named station.

6. In a communication system, a conference call circuit comprising a plurality of subscriber stations each having electrically isolated transmitter and receiver means associated therewith, means for interconnecting said isolated transmitters, means for interconnecting said isolated receivers, means for linking said interconnected transmitters and receivers thereby providing conferencing means, means individually associated with each of said stations for independently transferring signals from said isolated transmitter of said associated station to the isolated receiver of the same station, and means responsive to receipt of said independently transferred signals for controlling sidetone at said same station.

7. The conference call circuit of claim 6 wherein said linking means includes a multistage amplifier means, means for coupling said amplifier stages to provide a high gain and minimum distortion, and means also associated with said amplifier for matching impedances to maximize power transfer between said interconnected transmitters, said amplifier and said interconnected receivers.

8. A conference call circuit including a plurality of subscriber stations each having individually associated transmit and receive channels, a plurality of amplifiers, means for individually associating one of said amplifiers with each of said channels, each of said amplifiers associated with said transmit channels having one input and two outputs, each of said amplifiers associated with said receive channels having two inputs and one output, first means for connecting one of said outputs of each amplifier in said transmit channels to one of said inputs of the amplifier in an associated receive channel, second means including a common link for inter-coupling said other of said outputs of each amplifier in said transmit channels and the other of said inputs of each amplifier in said receive channels, and means for bucking signals supplied via said first and said second means for controlling sidetone at said subscriber stations.

9. The conference call circuit of claim 8 and means for controlling the gain of each of said channel amplifiers to compensate for losses in said individually associated channel, thereby providing substantial uniformity of signal strength regardless of the variations of loss in said channels.

10. The conference call circuit of claim 9, wherein said means for connecting one of said outputs of each of said amplifiers in said transmit channels to one of said inputs of each of said amplifiers in said receive channels comprises a common receive bus, a transmit bus, and means for coupling the transmit bus to said receive bus.

11. In the conference call circuit of claim 10, means including said amplifiers in said transmit channels for providing a constant terminating impedance to said transmit channel, and means including said amplifier in said receive channels for providing a constant driving impedance to said receive channel.

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