United States Patent

Dalke

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[45] **Dec. 5, 1972**

[54] DC VOLTAGE REGULATOR AND IMPEDANCE CONVERTER

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[73] Assignee: **MetroData Corpration**, Seattle, Wash.

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Related U.S. Application Data

[63] Continuation of Ser. No. 878,284, Nov. 20, 1969, abandoned.

[52] **U.S. Cl.** .....**323/22 T**, 179/174, 307/30

[51] **Int. Cl.** .....**G05f** , H04m 1/74, H02j

[58] **Field of Search**.....323/9, 22 T; 330/11 P, 204 P, 330/177, 180; 179/78–80, 172–174; 307/1, 3, 12, 30

[56] **References Cited**

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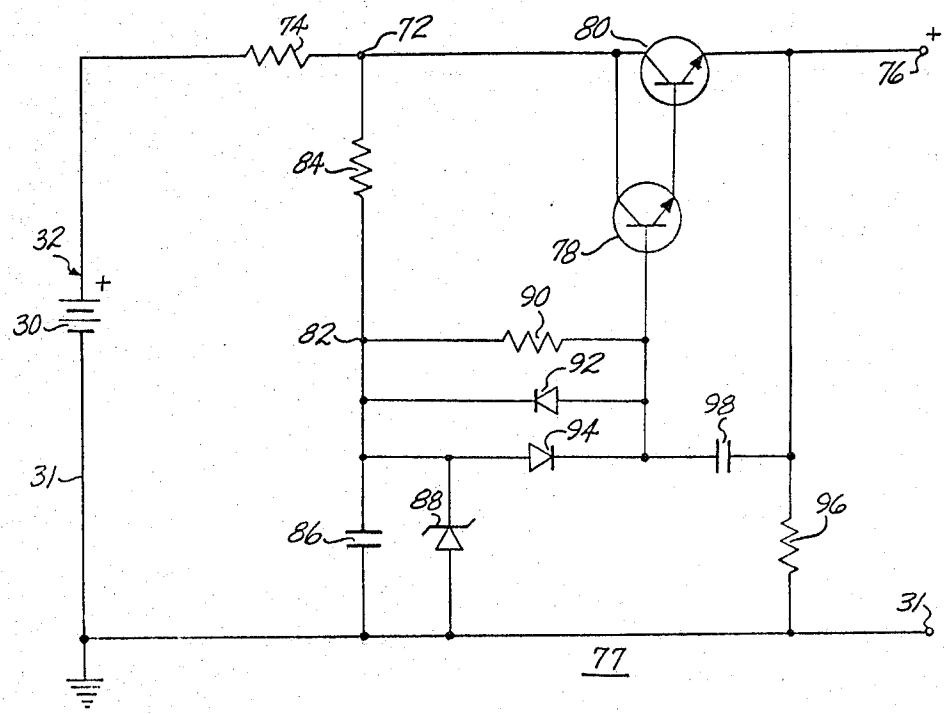
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Attorney—Christensen & Sanborn

[57] **ABSTRACT**

A voltage regulator and impedance converter is interposed in the connections between a DC power supply and an intercom system having common communication and power circuits. The regulator and converter comprises a series connection of a resistor and an amplifier, preferably two transistors connected in a Darlington configuration. The amplifier regulates the DC output voltage under control of a source reference diode which is coupled to the amplifier's control electrode through a pair of limiting diodes and a second resistor. The amplifier is connected as an emitter follower, and the output voltage is regulated at the reference voltage of the reference diode minus the base-emitter voltage drop of the amplifier's transistors. Output transient voltage swings are limited to the forward drops of the limiting diodes. A connection is also provided from the output to the amplifier's control electrode through a capacitor. The RC time constant of the second capacitor and the second resistor connected to the amplifier's control electrode provides an output impedance which is low at DC and relatively high at voice frequencies, allowing the use of many communication sets on the common communication and power circuits.

12 Claims, 4 Drawing Figures



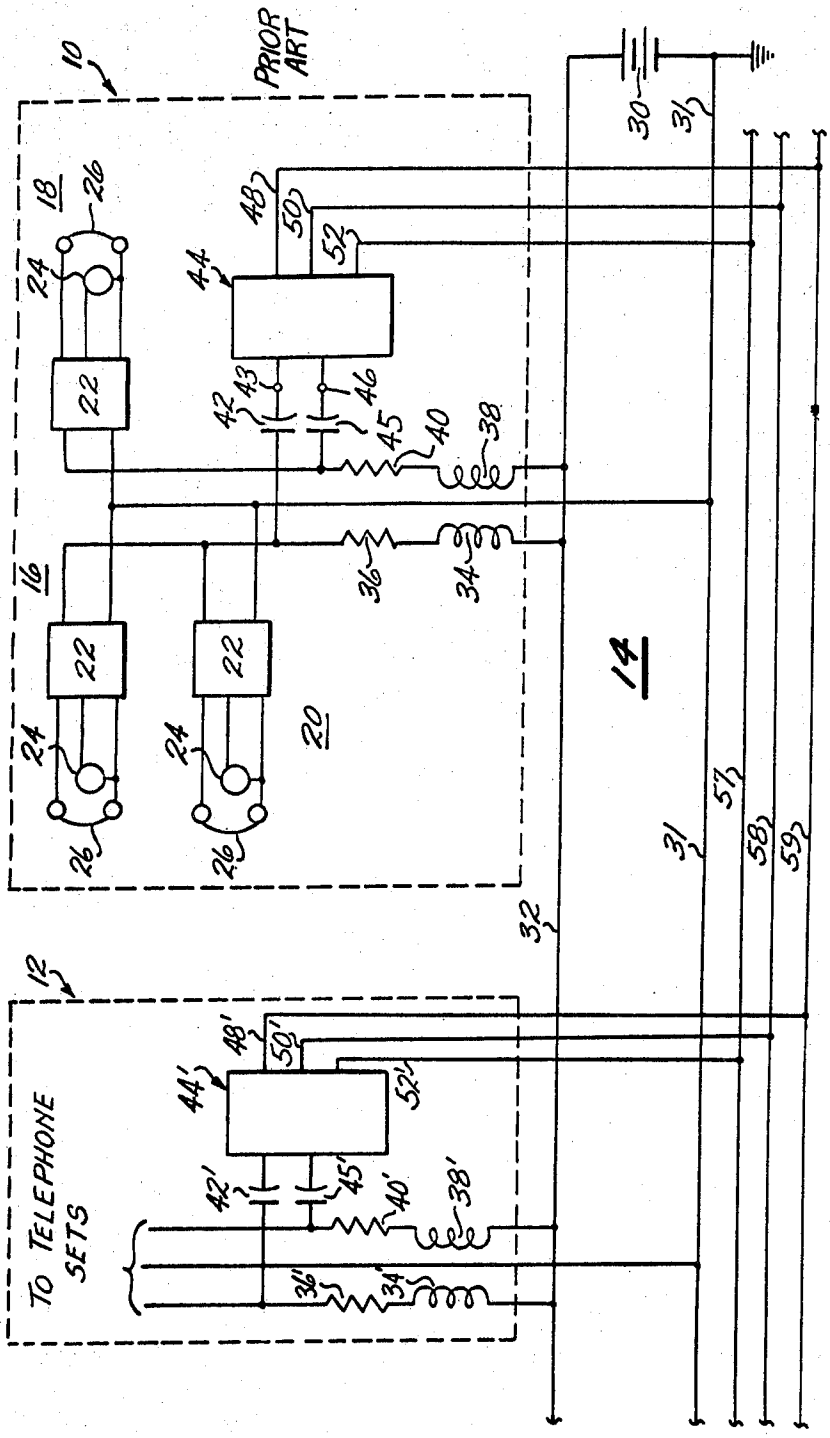

PRIOR ART
10
18
26
24
22
44
48
50
52
42
43
46
45
40
38
16
36
34
14
20
30
31
57
58
59
32
12
TO TELEPHONE SETS
44'
48'
50'
52'
42'
45'
40'
38'
36'
34'

FIG. 1

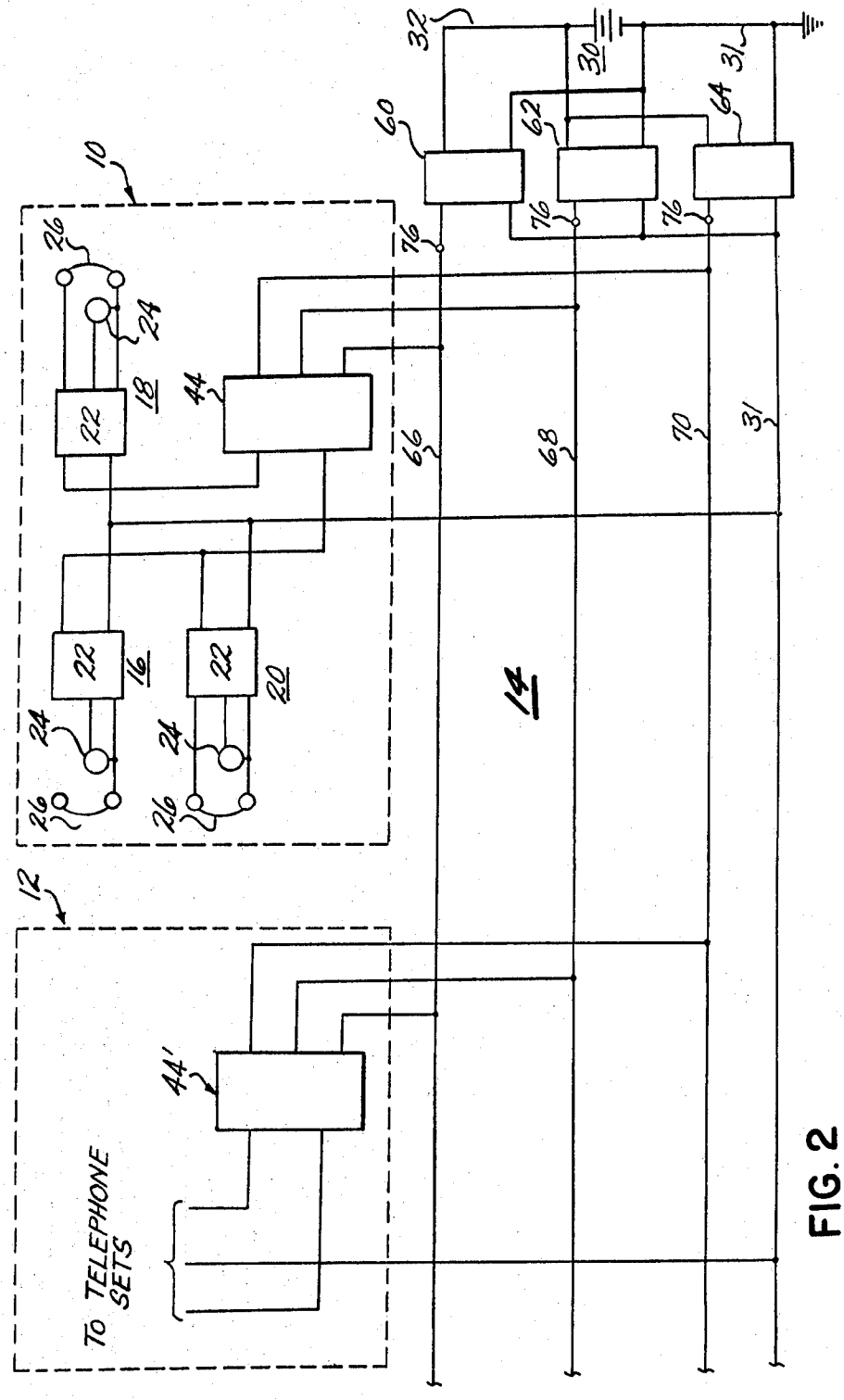

32
30
31
60
62
64
10
26
24
18
22
44
76
66
68
70
31
16
20
14
12
44'
TO TELEPHONE SETS

FIG. 2

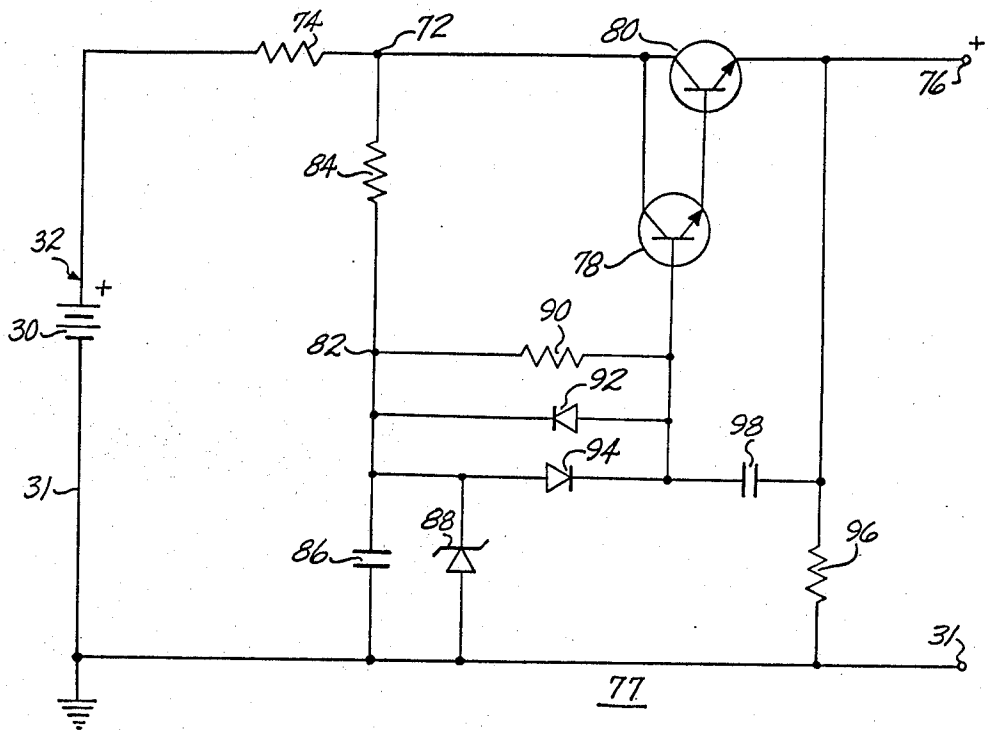

74
72
80
76
+
84
78
32
+
30
90
82
92
98
94
31
88
86
96
31
77

FIG. 3

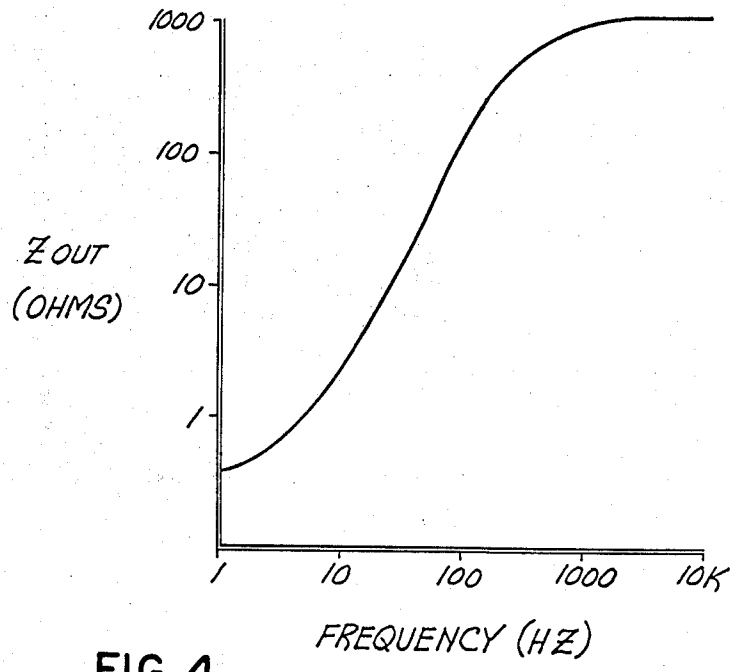

1000
100
10
1
Z OUT
(OHMS)
1
10
100
1000
10K
FREQUENCY (HZ)

FIG. 4

DC VOLTAGE REGULATOR AND IMPEDANCE CONVERTER

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. Ser. No. 878,284, filed Nov. 20, 1969, and now abandoned entitled DC VOLTAGE REGULATOR AND IMPEDANCE CONVERTER, inventor, JAMES A. DALKE.

BACKGROUND OF THE INVENTION

This invention generally relates to telephone-type intercommunication systems having common voice and power circuits and, more particularly, to a voltage regulation and impedance conversion circuit permitting operation of many telephone sets with a single power supply.

In telephone-type communications systems, it is common practice to supply DC to the transmitting elements of the telephone sets on the same line that is used to transmit and receive audio signals. The telephone sets are connected to a battery source through an inductor to prevent the audio signals from being attenuated by the power supply. The telephone sets may be connected together for intercommunication by direct connection. However, since each set presents a load to the power supply, the increased current demand caused by increasing the number of sets across the line results in a loss of power voltage as a result of the resistance in the inductor.

Designers of such systems avoid the problem of having to place an unwieldy inductor in series with the supply by providing each set with a relatively small inductor, often termed a retard coil, which is connected between the DC supply and the set. The voice intercommunications may be accomplished by tying the units together through a capacitor to a common bus.

It follows that a large number of retard coils and capacitors are then required to connect a system of any appreciable size.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a means for connecting a plurality of telephone sets together using a common voice communication and power supply circuit.

It is a further object of this invention to provide interconnection of these telephone sets with a single power supply eliminating the use of multiple retard coils, and additionally furnishing voltage transient limiting means maintaining a constant average current to each set regardless of the number of sets used.

These objects and others which will be realized from a consideration of the following specification are attained, briefly, by replacing all of the conventional retard coils with a single voltage regulator and impedance converter, which comprises an amplifier providing voltage regulation with transient limiting and having a relatively high AC and low DC output impedance.

DESCRIPTION OF THE DRAWINGS

The subject matter of the invention is distinctly pointed out and claimed in the concluding portion of the specification. For purposes of explanation, reference should be made to the following specification

taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagram of a prior art intercommunication system.

FIG. 2 is a diagram of an intercommunication system utilizing the voltage regulator and impedance converter.

FIG. 3 is a schematic diagram of the voltage regulator and impedance converter; and

FIG. 4 is a graph of the output impedance characteristic of the circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, illustrated therein is a communication system including, for purpose of explanation only, two communication stations **10** and **12** which are interconnected by a communication system generically designated **14**. It is to be understood that any number of additional communication stations may be used with the intercommunication system **14**. Each station includes at least one telephone set which is connected to the intercommunication system **14** by suitable means hereinafter to be described. If more than one set is provided in each station, provision also may be made for direct or switched communication between the sets of the communication station. In the embodiment illustrated in FIG. 1, communication station **10** includes three such telephone sets **16**, **18**, and **20**. Each set includes an amplifier **22**, a telephone transmitter **24** and a telephone receiver **26** which are conventional in configuration and interconnection. Power for the communication stations **10** and **12** is supplied via the intercommunication system **14** by means of a battery **30**, one of whose terminals is connected to ground or reference potential and which serves as a common bus **31** and the other of whose terminals provides a DC voltage for the communication stations and which serves as a bus **32**. Common bus **31** is connected to each of the telephone sets **16**, **18** and **20** of communication station **10**. Bus **32** is connected to sets **16** and **20** through a retard coil **34** and a voltage dropping resistor **36**.

By such an arrangement, the users of telephone sets **16** and **20** may constantly communicate in a point-to-point fashion and the retard coil **34** and voltage dropping resistor **36** provide isolation of the voice circuit from the DC supply **30** so as to reduce any loading effects thereof. If communication is desired, however, with telephone set **18**, the communication signals from either of the sets **16** or **20** must be connected together.

Set **18** is provided with DC potential from bus **32** by means of a retard coil **38** and a voltage dropping resistor **40**. In FIG. 1, the separation of telephone set **18** from set **16** and **20** allows those sets to be isolated and yet use a common power supply. However, the voice or communication signals must be transmitted by means of separate communication lines to effect complete voice isolation. To this end sets **16** and **20** are connected through a capacitor **42** to one input terminal **43** of a switching network **44** and set **18** is connected through a capacitor **45** to another input terminal **26**. Network **44** may comprise a simple switch arrangement with the requisite number of poles and movable contacts. Alternatively, switching network **44** may com-

prise any network having capability to interconnect any combination of communication lines. Connected to the output lines of switching network **44** are, for purposes of illustration only, three communications lines **48**, **50** and **52**. Line **48** is connected to bus **59** and uses that bus to transmit voice signals. Likewise, line **50** is connected to a communication line **58**, and line **52** to a communication line **57**.

Lines **31**, **32**, **57**, **58** and **59** form the basis of the intercommunication system **14** and are thus available for connection to communication station **12** and any additional stations desired. Communication station **12** may be a duplicate of station **10**, as illustrated in FIG. **1**, or it may have any configuration required. If station **12** is a duplicate of station **10**, it should be noted that required therein are two retard coils **34'** and **38'**.

In operation, the user of set **16**, for example, may directly communicate with the user of set **20** at station **10**. When communication is desired with set **18**, switching network **44** is set so that connection is made between the input terminals **43** and **46** thereof. Sets **16** and **18** may also be interconnected through the output lines **48**, **50** and **52**. When operating in this mode, communication may also be made between sets **16** and **18** and any of the telephone sets of station **12** connected to the chosen output line by the switching network **44** of station **12**.

In any intercommunication system wherein paths for DC voltage for the intercommunication units and the voice signals therebetween are provided along common lines, it is evident that certain characteristics are desired of a successful design. Because of these common circuits, there is a necessity that separation be made of the voice signals from the DC supply voltage. In FIG. **1** this is accomplished by feeding the voice signals through capacitors **42** and **45** to the switching network **44** which interconnects them and other voice signals in a suitable manner.

In using the interconnection scheme in the prior art just described, it is evident that for maximum flexibility in connecting the telephone sets together a separate DC supply bus **32** must be provided throughout the system. Another problem which exists in prior art is voltage transients which result when the telephone sets are switched from one interconnecting bus to another as a result of current changes through the inductors.

Therefore, systems such as illustrated in FIG. **1**, although approximating desired performance, require a great deal of additional components, such as retard coils, the voltage dropping resistors and the large isolation capacitors, to those nominally used. These components merely approximate the desired operating characteristics of an intercommunication system having a plurality of independently usable telephone sets.

For purposes of economy and performance, it would be desirable to provide or accomplish all these functions by means of a single circuit or a very few circuits. Such a circuit is the object of this invention and is illustrated by the diagrams in FIGS. **2** and **3**.

As noted by comparison of FIGS. **1** and **2**, retard coils such as **34** and **38**, voltage dropping resistors **36** and **40**, and capacitors **42** and **45** have been eliminated from box **10**, and replaced by circuits **60**, **62** and **64** which are interposed between the DC supply and the three communications lines **66**, **68** and **70**. Each unit **60**, **62**, and **64** comprises a voltage regulator and impedance converter which forms the subject matter of this invention. If simple point-to-point communication is desired between telephone sets **16**, **18**, and **20** of communication station **10** and those associated with communication station **12** and any other stations, only unit **60** and communication line **66** and common bus **31** would be required.

A complete understanding of how the units **60**, **62**, and **64** effectively replace the heretofore used retard coils can best be understood by reference to the schematic diagram of FIG. **3**. The DC voltage supply is illustrated as a battery **30** at the left hand side of the figure. Lead **32** in this embodiment connects the positive terminal of the battery **30** to a first common junction point **72** through a voltage dropping resistor **74**. Point **72** is connected to output point **76** by means of an amplifier **77** connected as an emitter follower. Amplifier **77** may comprise two transistors **78** and **80** in a standard Darlington connection wherein the emitter of transistor **80** serves as the output point **76** and the base of transistor **78** serves as the control electrode for the amplifier **77**. The DC input voltage present at point **72** is connected to a second common junction **82** by means of a resistor **84**. Connected between point **82** and the negative terminal **31** is a means for providing a constant reference voltage which includes the parallel connection of a capacitor **86** and a reference or zener diode **88**. The constant reference potential thus obtained at point **82** is coupled to the control electrode of the DC amplifier, or the base electrode of transistor **78**, by means of a parallel connection of a resistor **90** and two reverse-parallel diodes **92**, and **94** whose limiting function will be hereinafter described. The output voltage present at point **76** is likewise connected to the control electrode by means of a circuit including a resistor **96** connected across the output and a capacitor **98**.

In operation, the amplifier **77** including the Darlington transistors **78** and **80** operates at essentially a unity voltage gain. Control of the output voltage and current is accomplished by varying the bias point thereof under control of the voltage regulation means and what may be termed an impedance conversion section. The desired output voltage is set by choosing the reference or zener diode **88**. This reference voltage is maintained across the capacitor **86** and appears at point **82**. If for any reason the output voltage at point **76**, should vary from the reference voltage at point **82**, this voltage change will result in current being conducted through resistor **90** to the base or control electrode of amplifier **77** to vary the gain thereof in a manner such as to compensate for the output voltage variation. Operation of such a circuit is standard in the art and needs no further description. However, the use of a two transistors in Darlington for amplifier **77** merits special consideration, for it allows the use of a high value resistor **90** and hence allows amplifier **77** to have a characteristically high input impedance. This forms one portion of the impedance conversion section hereinafter to be described.

As noted above, diodes **92** and **94** perform a transient limiting function. Although in the embodiment of FIG. **2** the conventional retard coils have been eliminated, and thus the inductance presented to the

power supply has been reduced somewhat, still there is considerable inductance in the telephone sets. When one of these sets is added to or removed from the line, the current therethrough tends to stay constant and the voltage across the set changes rapidly and produces a spike which is transmitted along the line. Normally the current through resistor **90** is so small the voltage drop is somewhat less than the forward conduction voltage of diode **92** and **94**, and hence the diodes are not conducting. However, when the output voltage swings positive an amount greater than the forward conduction of diode **92**, diode **92** conducts to provide a current path through diode **88** to common bus **31** to clamp the base electrode of transistor **78** at the reference voltage plus the forward voltage drop of diode **92**. A similar operation occurs when the output voltage drops an amount below the reference voltage equal to the forward conduction voltage of diode **94**. At such time, diode **94** conducts to discharge capacitor **86** and thereafter clamp the base electrode **78** at the reference voltage minus the forward voltage drop of diode **94**.

Capacitor **98** blocks the DC output voltage but couples any AC voltage components directly to the control electrode of the amplifier. Capacitor **98** and the resistor **90** form an RC circuit whose time constant is such as to provide a desired rising impedance characteristic with frequency. The characteristic may be appropriately chosen so as to be approximately zero at DC and to sharply rise at frequencies in the audio or voice communication range. An experimentally obtained output impedance characteristic of one embodiment of this circuit is illustrated in FIG. **4**.

Referring back now to FIG. **2**, it is quite evident that considerable cost saving has been effected since only three circuits of the nature illustrated in FIG. **3** are required for three communication lines. Because of the output impedance characteristics of circuits **60**, **62** and **64**, each of the lines **66**, **68**, and **70** may supply a virtually unlimited number of communication stations such as stations **10** and **12**.

While this invention has been particularly described in terms of a single embodiment, as illustrated in FIG. **3**, it is to be clearly understood by those skilled in the art the invention is in no way limited thereto. For example, the pair of transistors **78**, **80** connected in Darlington may be replaced by any other stable, amplifier operating at a unity voltage gain. Likewise, voltage dropping resistor **74** may not be required in all cases. Accordingly, the scope of the invention is to be measured only by the limits of the appended claims.

What I claim is:

1. An improved intercommunications system comprising:

a. a plurality of voice communication and power circuits,

b. at least one intercommunication means coupled to each of said plurality of voice communication and power circuits, each of said intercommunication means including a transmitter and a receiver,

c. means providing selective interconnection paths between said voice communication and power circuits,

d. a source of DC supply voltage,

e. a plurality of voltage regulation and impedance conversion circuits, each of said circuits coupling said source of DC supply voltage to one of said voice communication and power circuits and including

1. an amplifier having input, output and control terminals,
2. means coupling the source of DC supply voltage to said input terminal,
3. means coupling the communication and power circuit to said output terminal,
4. means deriving from said source of DC supply voltage a reference voltage,
5. resistance means coupling said reference voltage to said control terminal, and
6. energy storage means connected between said output terminal and said control terminal, the values of said energy storage means and said resistance means being chosen so as to provide an impedance at said output terminal which is low in DC and which gradually increases to a relatively high value at AC frequencies in the voice range.

2. A system as recited in claim **1**, wherein each of said voltage regulation and impedance conversion circuits includes first and second diodes connected in reverse-parallel between said reference voltage source and said control terminal of said amplifier.

3. An improved intercommunications system as recited in claim **1**, wherein said amplifier comprises first and second transistors, the base of said first transistor being said control terminal, the emitter of said second transistor being said output terminal, the collectors of said first and second transistors being coupled together and being said input terminal, and the emitter of said first transistor being connected to the base of said second transistor.

4. An improved intercommunications system comprising:

a. a common voice communications and power circuit,

b. a plurality of intercommunications means coupled to said common voice communications and power circuit, each of said intercommunications means including a transmitter and a receiver,

c. a source of DC supply voltage,

d. a voltage regulation and impedance conversion circuit, said circuit coupling said source of DC supply voltage to said common voice communications and power circuit and including:

i. an amplifier having input, output and control terminals

ii. reference voltage means supplying a DC signal to said control terminal for controlling the voltage on said output terminal, and

iii. feedback means coupled between said output terminal for coupling to said control terminal only those portions of any AC signals appearing on the output terminal thereof which have frequencies within the voice range for controlling the impedance at said output terminal.

5. An improved intercommunications system as recited in claim **4**, wherein said amplifier comprises first and second transistors, the base of said first transistor being said control terminal, the emitter of said second transistor being said output terminal, the collectors of said first and second transistors being cou-

pled together and being said input terminal, and the emitter of said first transistor being connected to the base of said second transistor.

6. An improved intercommunications system as recited in claim 4, wherein said feedback means of said voltage regulation and impedance conversion circuit comprises a capacitor connected from the output terminal of said amplifier therein to said control terminal, and wherein said reference voltage means of said circuit comprises a zener diode coupled to the source of the DC supply voltage, and further comprising a resistance means coupling said zener diode to said control terminal, the values of said capacitor and said resistance means being chosen so as to provide an impedance at said output terminal which is low at DC and which gradually increases to a relatively high value at AC frequencies in the voice range.

7. An improved intercommunications system as recited in claim 6, wherein said voltage regulation and impedance conversion circuit includes first and second diodes connected in reverse-parallel between said zener diode and said control terminal of said amplifier.

8. In an intercommunications system comprising a common communications and power circuit and a source of DC supply voltage, a new use for a voltage regulation and impedance conversion circuit, said circuit comprising an amplifier having input, output and control terminals, reference voltage means for supply of a DC signal to said control terminal for controlling the voltage on said output terminal, and feedback means coupled between said output terminal for coupling to said control terminal only those portions of any AC signals appearing on the output terminal thereof which have frequencies within the voice range for controlling the impedance at said output terminal, said new use comprising the application of said circuit for isolating the source of DC supply voltage from the common communications and power circuit by applying the DC supply voltage to the amplifier's input terminal and by coupling signals present on said amplifier's output terminal to the common communications and power circuit.

9. A new use for an intercommunications system as recited in claim 8, wherein said feedback means of said circuit comprises a capacitor connected from the output terminal of said amplifier therein to said control terminal, and wherein said reference voltage means of said circuit comprises a zener diode coupled to the source of the DC supply voltage, and further comprising a resistance means coupling said zener diode to said control terminal, wherein said new use further comprises the step of choosing the values of said capacitor and said resistance means so as to provide an impedance at said output terminal which is low at DC and which gradually increases to a relatively high value at AC frequencies in the voice range.

10. A new use for an intercommunications system as recited in claim 8, wherein said circuit further includes first and second diodes connected in reverse-parallel between said zener diode in said control terminal of said amplifier.

11. A method for coupling a DC supply voltage from a source thereof through an amplifier having input, output and control terminals to a common communications and power circuit, while yet isolating any intercommunications means connected to said common communications and power circuit from said source of DC supply voltage, said method comprising the steps of:

a. supplying said DC supply voltage to said amplifier's input terminal,
b. coupling an output voltage appearing on said amplifier's output terminal to said common communications and power circuit,
c. regulating said output voltage by supplying a reference voltage to said control terminal of said amplifier, and
d. providing an impedance at said amplifier's output terminal which is low at DC and which gradually increases to a relatively higher value at AC frequencies within the voice range by coupling to said control terminal only those portions of any Ac signals appearing on the output terminal of said amplifier which have frequencies within the voice range.

12. A method as recited in claim 11, further including the step of limiting the output voltage on said amplifier's output terminal by applying said reference voltage directly to said amplifier's control terminal whenever said output voltage exceeds said reference voltage by a predetermined amount.

* * * * *