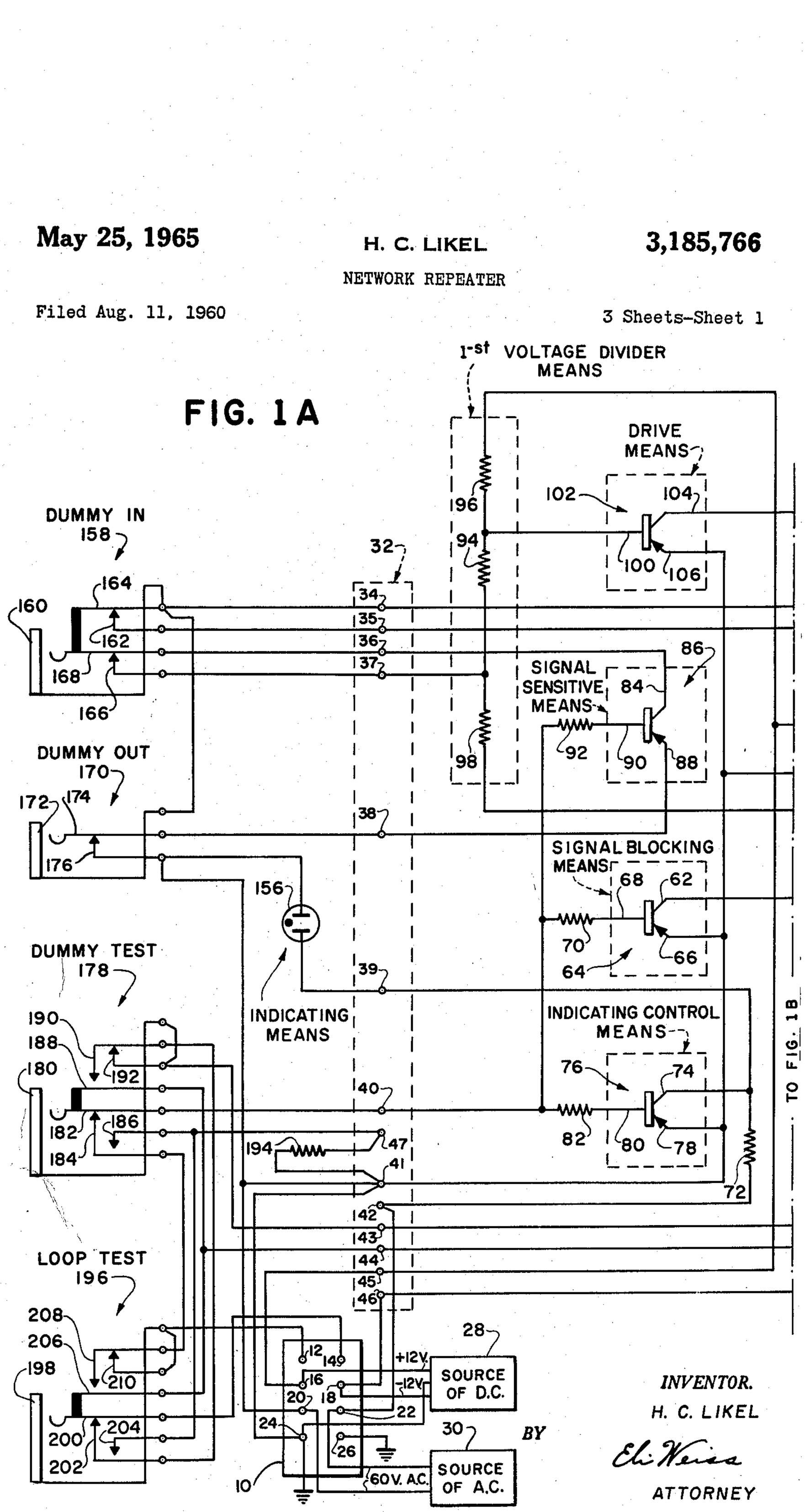
May 25, 1965 H. C. LIKEL 3,185,766

NETWORK REPEATER

Filed Aug. 11, 1960 3 Sheets-Sheet 1

FIG. 1A



INVENTOR.
H. C. LIKEL
BY
Eli Weiss
ATTORNEY

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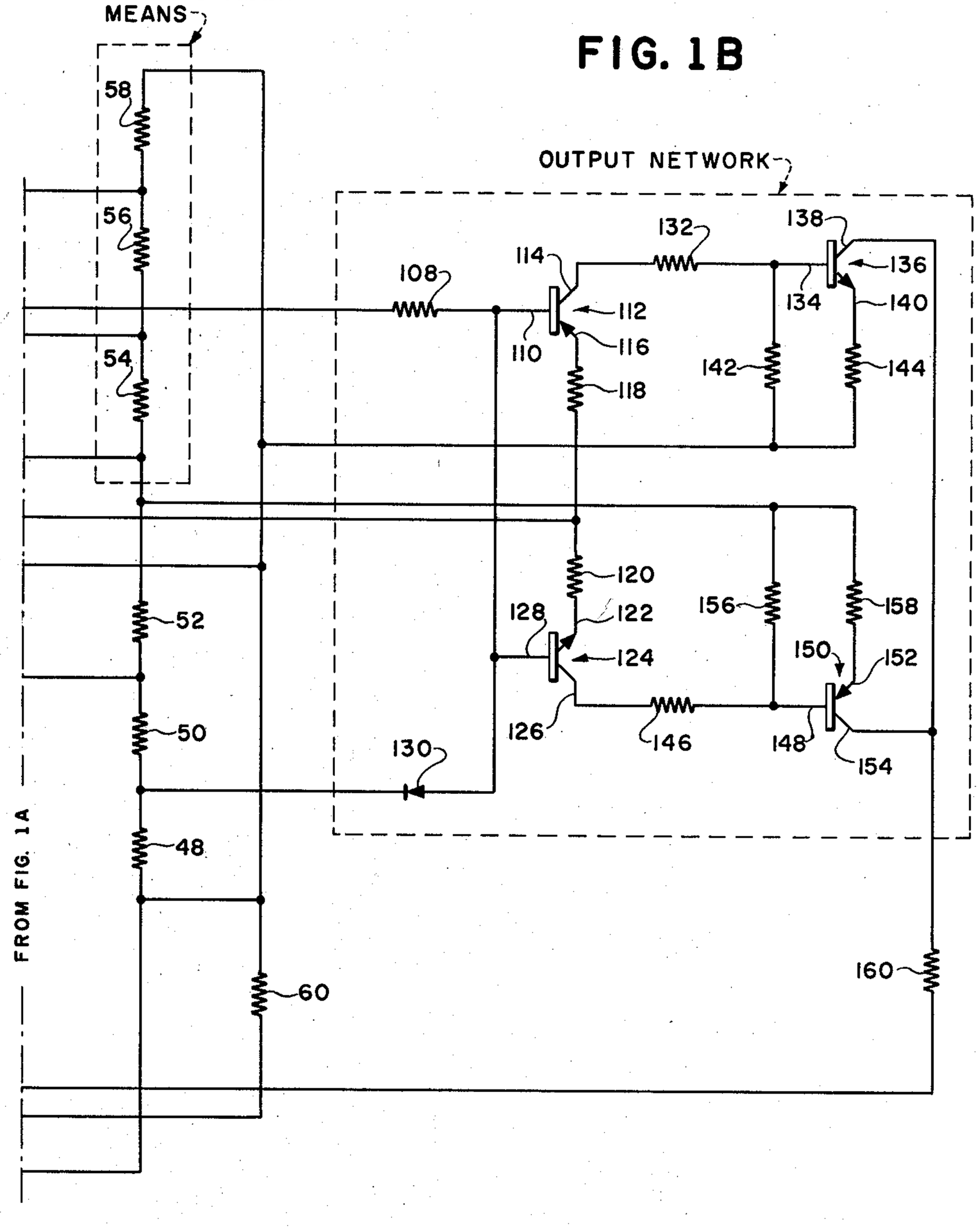
FIG. 1B



INVENTOR.
H. C. LIKEL

BY

Eli Weiss

ATTORNEY

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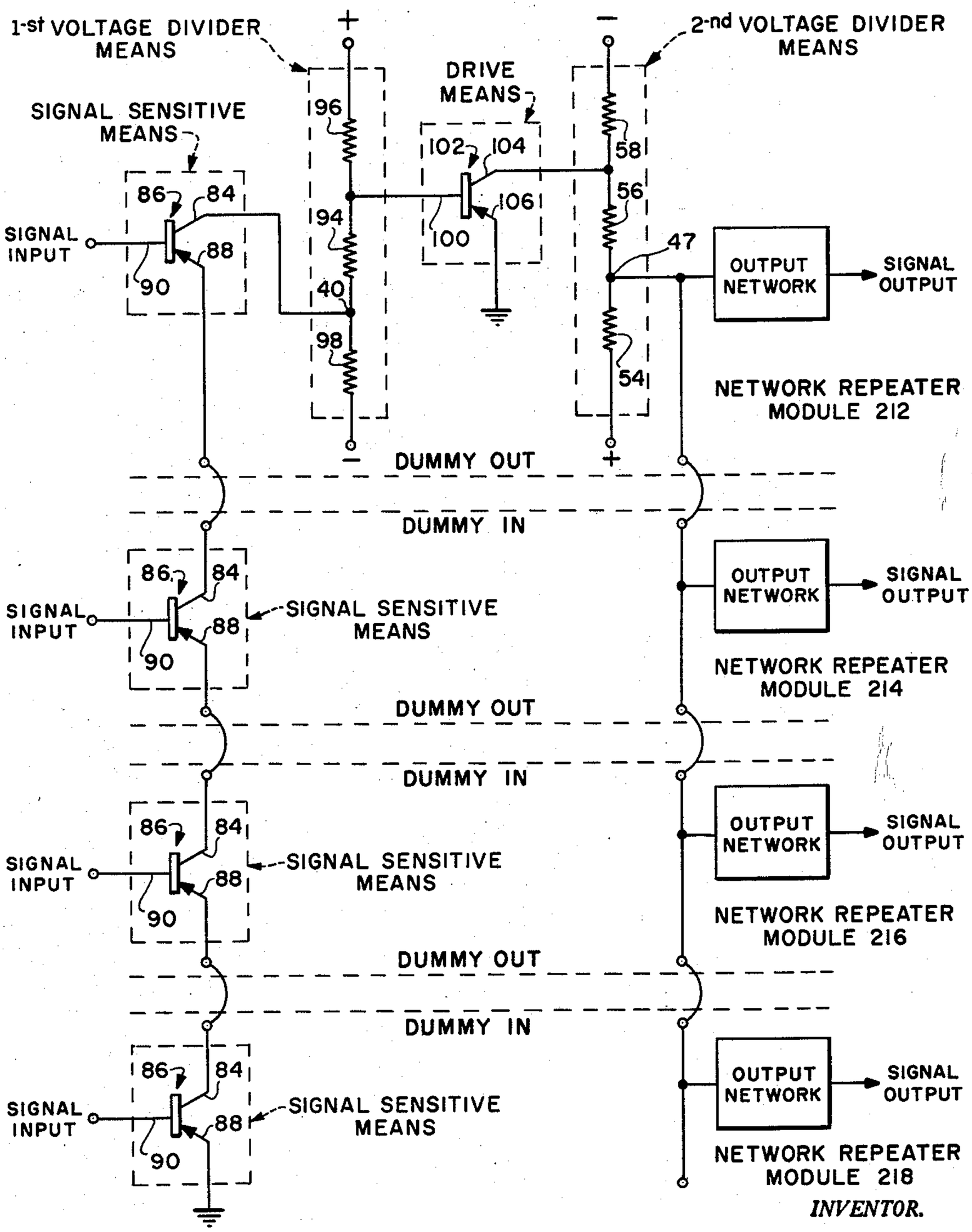
FIG. 2



INVENTOR.
H. C. LIKEL

BY

Eli Weiss

ATTORNEY

United States Patent Office

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NETWORK REPEATER

Harry C. Likel, Brooklyn, N.Y., assignor to The Western Union Telegraph Company, New York, N.Y., a corporation of New York

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13 Claims. (Cl. 178—70)

This invention relates generally to a network repeater and more particularly to a transistorized network repeater module having an improved mode of operation.

It is an object of this invention to provide a network repeater which is small in size, light in weight, reliable in operation, and economical to build.

It is another object of this invention to provide a network repeater which can be either inserted in or removed from a circuit containing many network repeaters without requiring circuit adjustments to maintain network stability.

It is still another object of this invention to provide a network repeater which will not require loop balancing procedures.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the apparatus becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIGS. 1A and 1B illustrate the structure of a module of a network repeater in accordance with the principles of this invention; and

FIG. 2 illustrates in block form an installation utilizing four network repeater modules.

Similar reference charaoters refer to similar parts throughout the several views of the drawings.

With reference to FIGS. 1A and 1B a connector **10** supports eight terminals **12, 14, 16, 18, 20, 22, 24, 26**. The signal fed to the network repeater module appears at terminal **14**, and the signal fed from the network repeater module appears at terminal **12**. A source of energy **28** which supplies a D.C. potential of twelve volts is coupled to feed a positive potential to terminal **16** and a negative potential to terminal **18**; terminal **24** provides the neutral (ground) connection. A source of energy **30** which supplies an A.C. potential of sixty volts is coupled to feed the terminals **20, 22**. Terminal **26** is connected to the chassis ground.

A terminal board **32** which supports the terminals **34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46**, and **47** is provided to facilitate the electrical wiring of this invention.

Terminal **46** is coupled through resistors **48, 50, 52, 54, 56, 58**, and **60**, each connected in series with each other to terminal **44**. Terminal **46** is also connected to the junction of the resistor **58** with resistor **60**. The junction of the resistor **50** with resistor **52** is connected to the collector terminal **62** of a transistor **64** which supports an emitter terminal **66** and a base terminal **68**. The emitter terminal **66** is connected to the terminal **41**; and the base terminal **68** is coupled through a resistor **70** to the terminal **40**. Terminal **39** is coupled through a resistor **72** to terminal **42**, and also to the collector terminal **74** of a transistor **76** which supports an emitter terminal **78** and a base terminal **80**. Emitter terminal **78** is coupled to terminal **41**, and base terminal **80** is coupled through a resistor **82** to terminal **40**.

Terminal **36** is connected to the collector **84** of a transistor **86** which supports an emitter terminal **88** and a base terminal **90**. The emitter terminal **88** is connected

to the terminal **38**, and the base terminal **90** is coupled through a resistor **92** to terminal **40**.

Terminal **37** is coupled through resistors **94** and **96**, connected in series with each other, to terminal **45**; and is also coupled through resistor **98** to the junction common to resistors **58** and **60**. The junction of resistor **94** with resistor **96** is connected to the base terminal **100** of a transistor **102** which supports a collector terminal **104** and an emitter terminal **106**. The emitter terminal **106** is connected to terminal **41**, and the collector terminal **104** is connected to the junction of the resistor **56** with the resistor **58**. Resistors **98, 94**, and **96** function as a first voltage divider means; resistors **54, 56**, and **58** function as a second voltage divider means.

Terminal **34** is coupled through a resistor **108** to the base terminal **110** of a transitsor **112** which supports a collector terminal **114** and an emitter terminal **116**. The emitter terminal **116** is coupled through a resistor **118** to terminal **41**, and through a second resistor **120** to the emitter terminal **122** of transistor **124** which supports a collector terminal **126** and a base terminal **128**. The base terminal **128** is connected directly to base terminal **110**, and coupled through a diode **130** to the junction of the resistor **48** with the resistor **50**. The collector **114** is coupled through a resistor **132** to the base terminal **134** of a transistor **136** which supports a collector terminal **138** and an emitter terminal **140**. The junction of the resistor **60** with the resistor **58** is coupled to the base terminal **134** through the resistor **142**, and to the emitter terminal **140** through the resistor **144**.

The collector terminal **126** of transistor **124** is coupled through a resistor **146** to the base terminal **148** of a transistor **150** which supports an emitter terminal **152** and a collector terminal **154**.

The junction point of the resistor **52** with the resistor **54** is connected to terminal **45**, and also to base terminal **148** of transistor **150** through a resistor **156**, and to the emitter terminal **152** through a resistor **158**.

Terminal **43** is coupled through a resistor **160** to collector terminal **154** of transistor **150** and to collector terminal **138** of transistor **136**.

The transistor **102** functions as a drive means; transistor **64** functions as a signal blocking means; and the transistors **112, 124, 136**, and **150** in combination with the input resistor **108** and the other associated resistors functions as an output network.

A glow discharge lamp **156** such as a neon lamp or the like is coupled between the terminals **39** and **41**.

The glow discharge lamp **156** functions as an indicating means; and the transistor **76** functions as an indicating control means.

A jack **158** designated as a "dummy in" jack supports a sleeve contact **160**, a stationary contact **162** which assumes a normally closed condition with a movable contact **164**, and a stationary contact **166** which assumes a normally closed condition with a movable contact **168**. The sleeve contact **160** is connected to the movable contact **164** and to the terminal **34**. Stationary contact **162** is connected to terminal **35**; movable contact **168** is connected to terminal **36**, and stationary contact **166** is connected to terminal **37**.

A second jack **170** designated as a "dummy out" jack supports a sleeve contact **172** and a movable contact **174** which assumes a normally closed condition with a stationary contact **176**. The sleeve contact is connected to the terminal **34**; the movable contact is connected to

the terminal 38 and the stationary contact is connected to the terminal 41.

A third jack 178 designated as a "dummy test" jack supports a sleeve contact 180, a movable contact 182 which assumes a normally closed condition with an intermediate contact 184 which assumes a normally open condition with a stationary contact 186. Jack 178 also supports a movable contact 188 which assumes a normally open condition with an intermediate contact 190 which assumes a normally closed condition with a stationary contact 192. The sleeve contact 180 is connected to the stationary contact 192 and to the terminal 43. The movable contact 188 is connected to the terminal 44; movable contact 182 is connected to terminal 40; and stationary contact 186 is connected through a resistor 194 to terminal 41.

A fourth jack 196 designated as a "loop test" jack supports a sleeve contact 198, a movable contact 200 which assumes a normally closed condition with an intermediate contact 202 which assumes a normally open condition with a stationary contact 204. Jack 196 also supports a movable contact 206 which assumes a normally open condition with an intermediate contact 208 which assumes a normally closed condition with a stationary contact 210.

In operation, a plurality of network repeater modules are coupled together by means of plugs and cords. With reference to FIG. 2, the "dummy out" jack in the first appearing network repeater module 212 is coupled to the "dummy in" jack of the next appearing network repeater module 214; the "dummy out" jack of repeater module 214 is connected to the "dummy in" jack of repeater module 216; and the "dummy out" jack of repeater module 216 is connected to the "dummy in" jack of repeater module 218. The "dummy in" jack of the first or "head end" network repeater module 212 does not contain a plug; and the "dummy out" jack of the last network repeater module 218 does not contain a plug.

When a plurality of network repeater modules are being utilized, and are interconnected as just described (and illustrated in FIG. 2) the emitter terminal 88 of transistor 86 in the "head end" network repeater module 212 is connected through the "dummy out" jack of repeater module 212, and the "dummy in" jack of repeater module 214 to the collector terminal 84 of transistor 86 in the network repeater module 214. In a like manner, the emitter terminal 84 of transistor 86 in the network repeater module 214 is coupled to the collector terminal of transistor 86 in repeater module 216; and the emitter terminal 84 of transistor 86 in the network repeater 216 is coupled to the collector terminal of transistor 86 located in network repeater 218. The emitter terminal 88 of the transistor 86 located in the last positioned network repeater 218 is coupled to a ground terminal. However, in the "head end" or first network repeater 212 the collector terminal 84 of transistor 86 is coupled through the movable contact 168 and stationary contact 166 of jack 158 to terminal 37. Thus, in the four network repeater modules 212, 214, 216, 218 there is provided between terminal 37 and a ground terminal a series arrangement of transistors connected emitter to collector; emitter to collector; emitter to collector.

Now, when all patron's lines are on marking—a negative potential signal—then each base terminal of each transistor 86 in each of the repeater network modules 212, 214, 216, 218 is conductive, and a completed electrical path is established between terminal 37 and ground terminal (through the transistor 86). However, if a positive potential signal is fed to the base terminal 90 of transistor 86 associated with any one of the repeater network modules 212, 214, 216, 218 from the terminal 12 through the loop test jack and dummy test jack—then that transistor will become nonconductive, the electrical path between terminal 37 and ground will become discontinuous, and a negative potential will appear at terminal

37 and at junction 47—the extension of terminal 35 located physically at the junction of resistors 54 and 56.

Continuing (with respect to a single network repeater module 212 only), when a signal having a negative potential is fed to the base terminal 90 of transistor 86, that transistor will become conductive, the collector terminal 84 will assume a potential close to ground potential and, therefore, terminal 37 will assume a potential close to ground potential. Two resistors 94, 96, are interposed between terminal 37 and terminal 16 which is maintained at a positive potential by a source of D.C. 28. Now, since terminal 37 is essentially at ground level—the base terminal 100 of transistor 102 will be at a positive potential, and the transistor 102 will not be conductive. Two resistors 56, 58 interposed between terminal 47 and the negative potential terminal of the source of D.C., and one resistor 54 interposed between terminal 47 and the positive potential terminal of the source of D.C. comprises a voltage divider. Terminal 47 exhibits a negative potential when transistor 102 is in a nonconductive state.

The application of a positive potential signal to the base terminal 90 urges transistor 86 to assume a nonconducting state, and terminal 37 is no longer at ground potential—but assumes a negative potential. Resistors 96, 94 are positioned between the negative potential which appears on terminal 37 and a positive potential with resistor 96 on the positive side and resistors 94, 98 on the negative side to urge the base terminal 100 of transistor 102 to a negative condition which conditions transistor 102 to become conductive. The collector terminal 104 of transistor 102 now assumes a potential that is at or very close to ground potential, and terminal 47 exhibits a positive potential.

Thus, the polarity of the signal that appears at terminal 47 is the same as the polarity of the signal fed from any of the sending stations. The effect of the plug and cord connections to couple the network repeater modules 212, 214, 216, and 218 together is to connect the terminal 47 in the first or "head end" network repeater module to terminal 34 in each of the other network repeater modules.

Repeating—the "dummy" plug cords and jacks create a series path via the plug tips from ground terminal through the emittter terminal and collector terminal of each transistor 86 located in the network repeater modules 212, 214, 216, 218 to the voltage divider network composed of the resistors 96, 94, 98 located in the first network repeater module 212 only. Similarly, the "dummy" plug cords and jacks create a parallel path through the sleeve of each jack whereby each output network is connected through the input resistor 108 to the terminal 47 positioned in the first network repeater module 212. Now, in actual use, when all patron's lines are on marking (negative signal), all of the PNP transistors 86 are in a conductive state and ground is applied to terminal 37 (the junction of resistors 94, 98) in the "head end" repeater. A ground potential at terminal 37 raises the potential at the junction of the resistors 96, 94 to a positive value to urge transistor 102 to assume a nonconductive state.

Resistors 58, 56, and 54 form a voltage divider which maintains a negative potential signal at the terminal 47. This signal is fed to the resistor 108 of each network repeater module 212, 214, 216, 218.

A negative potential fed to resistor 108 urges the PNP transistor 112 to a conductive state, and the NPN transistor 124 to a nonconductive state. Now, transistor 136 is urged to a conductive state and, acting through its collector, emitter, emitter resistor and negative battery, feeds a negative potential signal through the jacks 178 and 196 to the terminal 14. When a spacing signal is received from a patron, the positive potential signal fed to the base terminal 90 of the transistor 86 in the associated network repeater is urged to a nonconductive state, and the series

circuit from ground terminal to the voltage divider coupled to the base terminal **100** of transistor **102** becomes discontinuous. Removal of the ground terminal from the junction of resistors **94**, **98** (terminal **37**) urges the base terminal **100** to a negative state and transistor **102** becomes conductive and couples ground to the junction of resistors **56**, **58** to raise the potential at the junction of resistors **56**, **54** (terminal **47**) to a positive value to reverse the polarity of the signal fed to the resistor **108**, and the transistor **150** in each network repeater is urged to a conductive state and feeds a spacing signal through its collector, emitter, emitter resistor, and positive battery to the terminal **14**.

Transistor **64** prevents a sending patron's network repeater from retransmitting a spacing signal back to the patron. Signals sent by a patron are fed simultaneously to the base terminals of transistors **86**, **64**, and **76** located within the patron's network repeater. Thus, a spacing signal fed to the base terminal **68** of transistor **64** will urge it to a conductive state to couple ground terminal **24** to the junction of resistors **50**, **52** through its collector-emitter circuit. Now, voltage divider action lowers the potential at the junction of resistors **48**, **50** to a negative value and the crystal diode **130** is biased to a conductive state, and a negative potential is maintained on the base terminals of the output transistors **112**, **124** regardless of the signal fed through resistor **108**.

Thus, transistor **64** conditions the output network in the network repeater module of the patron transmitting to prevent retransmission of the information. The limiting effect of resistor **108** limits this overriding effect to the user's network repeater module only.

Transistor **76** controls the operation of gas discharge lamp **156** to provide a visual indication that transmitted information is being received by the network repeater. Application of a normal marking signal to the base terminal **80** of transistor **76** urges transistor **76** to a conductive state to shunt the "line" 60 v. A.C. gas discharge lamp lead to ground terminal through resistor **72**. However, since the other lead of the lamp is grounded permanently, the lamp will remain inoperative until a spacing signal urges transistor **72** to a nonconductive state to remove the ground shunt from the "live" A.C. lead. Thus, the lamp lights during the time that a spacing signal is transmitted by a patron.

The dummy test jack is utilized when it is desired to check the operation of the network repeater, and the loop test jack is utilized when it is desired to check the operation of the loop.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A module of a network repeater comprising a signal sensitive means sensitive to positive and negative polarity signals, a drive means driven selectively to an active or an inactive state by said signal sensitive means, an output network coupled to said drive means to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, and signal blocking means coupled to said signal sensitive means and said output network to inhibit selectively said output network from passing a positive signal.

2. A module of a network repeater comprising a first transistor sensitive to positive and negative polarity signals, a second transistor driven selectively to an active or an inactive state by said signal sensitive means, an output network coupled to said second transistor to pass a signal having a first polarity when said second transistor is in an active state and a second polarity when said second transistor is in an inactive state, and a third transistor coupled to said first transistor and said output network to inhibit selectively said output network from passing a positive signal.

3. A module of a network repeater comprising a first transistor sensitive to positive and negative polarity signals, a second transistor driven selectively to an active or an inactive state by said first transistor, an output network coupled to said second transistor to pass a signal having a first polarity when said second transistor is in an active state and a second polarity when said second transistor is in an inactive state, a gas discharge lamp, and a third transistor coupled to energize said gas discharge lamp when said first transistor senses a signal having a predetermined polarity to provide a visual indication that transmission is being received.

4. A module of a network repeater comprising a signal sensitive means sensitive to positive and negative polarity signals, a drive means driven selectively to an active or an inactive state by said signal sensitive means, an output network coupled to said drive means to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, signal blocking means interposed between sail signal sensitive means and said output network to inhibit selectively said drive means from passing a positive signal, indicating means, and indicating control means coupled to said signal sensitive means to energize said indicating means when said signal sensitive means senses a signal having positive polarity to provide a visual indication that transmission is being received.

5. A module of a network repeater comprising a signal sensitive means coupled to indicate the presence of a positive or negative signal by assuming an inactive or active state, a drive means, a first voltage divider means conditioned by said signal sensitive means to urge said drive means to an active or an inactive state, an output network, a second voltage divider means conditioned by said drive means to urge said output network to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, and signal blocking means, coupled to said signal sensitive means and said output network to inhibit selectively said output network from passing a positive signal.

6. A module of a network repeater comprising a signal sensitive means coupled to indicate the presence of a positive or negative signal by assuming an inactive or active state, a drive means, a first voltage divider means conditioned by said signal sensitve means to urge said drive means to an active or an inactive state, an output network, a second voltage divider means conditioned by said drive means to urge said output network to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, signal blocking means coupled to said signal sensitive means and said output network to inhibit selectively said output network from passing a positive signal, indicating means, and indicating control means coupled to said signal sensitive means to energize said indicating means when said signal sensitive means senses a signal having a positive polarity to provide a visual indication that transmission is being received.

7. A module of a network repeater comprising a first transistor coupled to indicate the presence of a positive or negative signal by assuming an inactive or active state, a second transistor, a first resistor network conditioned by said first transistor to urge said second transistor to an active or an inactive state, an output network, a second resistor network conditioned by said second transistor to urge said output network to pass a signal having a first polarity when said second transistor is in an active state and a second polarity when said second transistor is in an inactive state, a third transistor coupled to said first transistor and said output network to inhibit selectively said output network from passing a positive signal, a glow discharge lamp, and a fourth transistor coupled to said

first transistor to energize said glow discharge lamp when said first transistor senses a signal having a positive polarity to provide a visual indication that transmission is being received.

8. A first and second module of a network repeater comprising a first signal sensitive means sensitive to positive or negative signals, a second signal sensitive means sensitive to positive or negative signals coupled in series with said first signal sensitive means, a drive means driven selectively to an active or an inactive state by said first or second signal sensitive means, a first output network coupled to said drive means to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, a second output network coupled to said drive means to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, a first signal blocking means interposed between said first signal sensitive means and said first output network to inhibit said first output network from passing a positive signal when a positive signal is fed to said first signal sensitive means, and a second signal blocking means interposed between said second signal sensitive means and said second output network to inhibit said second output network from passing a positive signal when a positive signal is fed to said second signal sensitive means.

9. A first and second module of a network repeater comprising a first signal sensitive means sensitive to positive or negative signals, a second signal sensitive means sensitive to positive or negative signals coupled in series with said first signal sensitive means, a drive means driven selectively to an active or an inactive state by said first or second signal sensitive means, a first output network coupled to said drive means to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, a second output network coupled to said drive means to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, a first signal blocking means interposed between said first signal sensitive means and said first output network to inhibit said first output network from passing a positive signal when a positive signal is fed to said first signal sensitive means, a second signal blocking means interposed between said second signal sensitive means and said second output network to inhibit said second output network from passing a positive signal when a positive signal is fed to said second signal sensitive means, first indicating means, first indicating control means coupled to said first signal sensitive means to energize said first indicating means when said first signal sensitive means senses a signal having a positive polarity to provide a visual indication that transmission is being received, second indicating means, and second indicating control means coupled to said second signal sensitive means to energize said second indicating means when said second signal sensitive means senses a signal having a positive polarity to provide a visual indication that transmission is being received.

10. A first and second module of a network repeater comprising a first signal sensitive means sensitive to positive or negative signals, a second signal sensitive means sensitive to positive or negative signals coupled in series with said first signal sensitive means, a drive means, a first voltage divider means conditioned by said first or second signal sensitive means to urge said drive means to an active or an inactive state, a first output network, a second output network, and a second voltage divider means conditioned by said drive means to urge said first and second output networks to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state.

11. A first and second module of a network repeater comprising a first signal sensitive means sensitive to positive or negative signals, a second signal sensitive means sensitive to positive or negative signals coupled in series with said first signal sensitive means, a drive means, a first voltage divider means conditioned by said first or second signal sensitive means to urge said drive means to an active or an inactive state, a first output network, a second output network, a second voltage divider means conditioned by said drive means to urge said first and second output networks to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, first signal blocking means coupled to said first signal sensitive means and said first output network to inhibit said first output network from passing a positive signal when a positive signal is fed to said first signal sensitive means, and second signal blocking means interposed between said second signal sensitive means and said second output network to inhibit said second output network from passing a positive signal when a positive signal is fed to said second signal sensitive means.

12. A first and second module of a network repeater comprising a first signal sensitive means sensitive to positive or negative signals, a second signal sensitive means sensitive to positive or negative signals coupled in series with said first signal sensitive means, a drive means, a first voltage divider means conditioned by said first or second signal sensitive means to urge said drive means to an active or an inactive state, a first output network, a second output network, a second voltage divider means conditioned by said drive means to urge said first and second output networks to pass a signal having a first polarity when said drive means is in an active state and a second polarity when said drive means is in an inactive state, first signal blocking means coupled to said first signal sensitive means and said first output network to inhibit said first output network from passing a positive signal when a positive signal is fed to said first signal sensitive means, second signal blocking means interposed between said second signal sensitive means and said second output network to inhibit said second output network from passing a positive signal when a positive signal is fed to said second signal sensitive means, first indicating means, first indicating control means coupled to said first signal sensitive means to energize said first indicating means when said first signal sensitive means senses a signal having a positive polarity to provide a visual indication that transmission is being received, second indicating means, and second indicating control means coupled to said second signal sensitive means to energize said second indicating means when said second sensitive means senses a signal having a positive polarity to provide a visual indication that transmission is being received.

13. A first and second module of a network repeater comprising a first transistor sensitive to positive or negative signals, a second transistor sensitive to positive or negative signals coupled in series with said first transistor, a third transistor, a first resistor network conditioned by said first or second transistors to urge said third transistor to an active or an inactive state, a first output network, a second output network, a second resistor network conditioned by said third transistor to urge said first and second output networks to pass a signal having a first polarity when said third transistor is in an active state and a second polarity when said third transistor is in an inactive state, a fourth transistor coupled to said first transistor and said first output network to inhibit said first output network from passing a positive signal when a positive signal is fed to said first transistor, a fifth transistor interposed between said second transistor and said second output network to inhibit said second output network from passing a positive signal when a positive signal is fed to said second transistor, a first glow discharge lamp, a sixth transistor coupled to said first transistor to energize said first glow discharge lamp when said first transistor senses

a signal having a positive polarity to provide a visual indication that transmission is being received, second glow discharge lamp, and seventh transistor coupled to said second transistor to energize said second glow discharge lamp when said second transistor senses a signal having a positive polarity to provide a visual indication that transmission is being received.

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