

June 3, 1930.

H. S. HAMILTON

1,760,984

TRANSOCEANIC RADIO TELEPHONE SYSTEM

Filed July 16, 1927

2 Sheets-Sheet 1

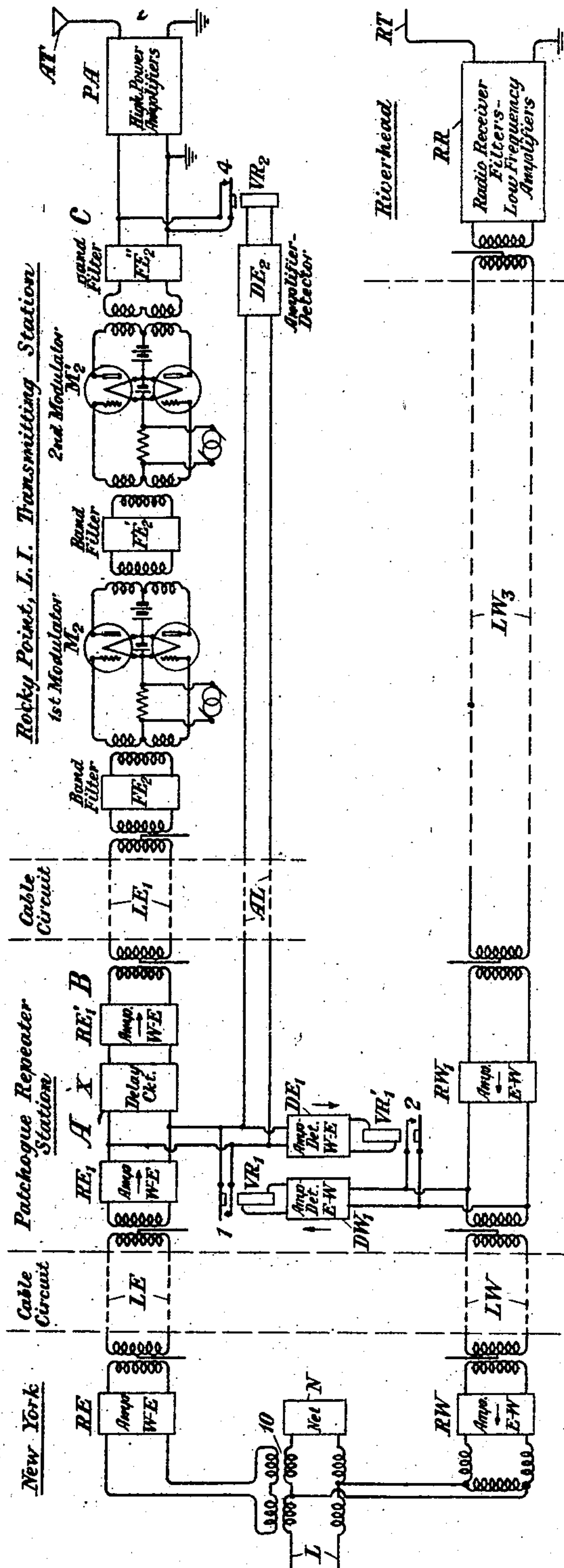


Fig. 1

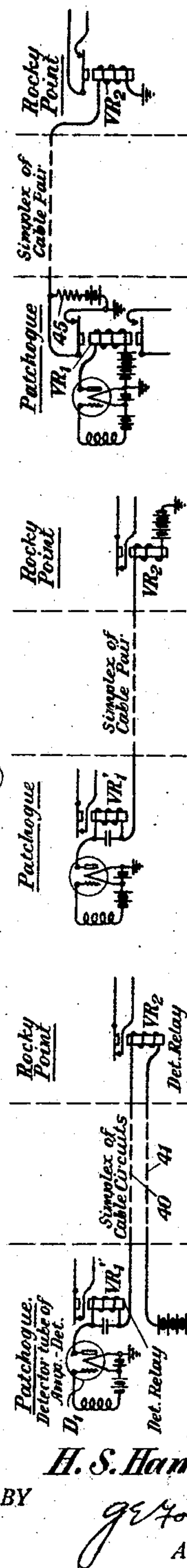


Fig. 2

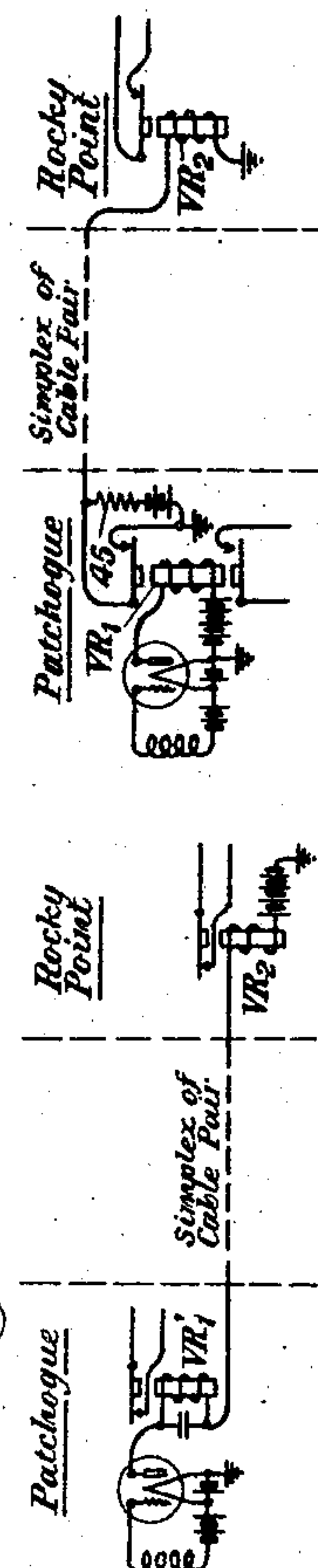


Fig. 3

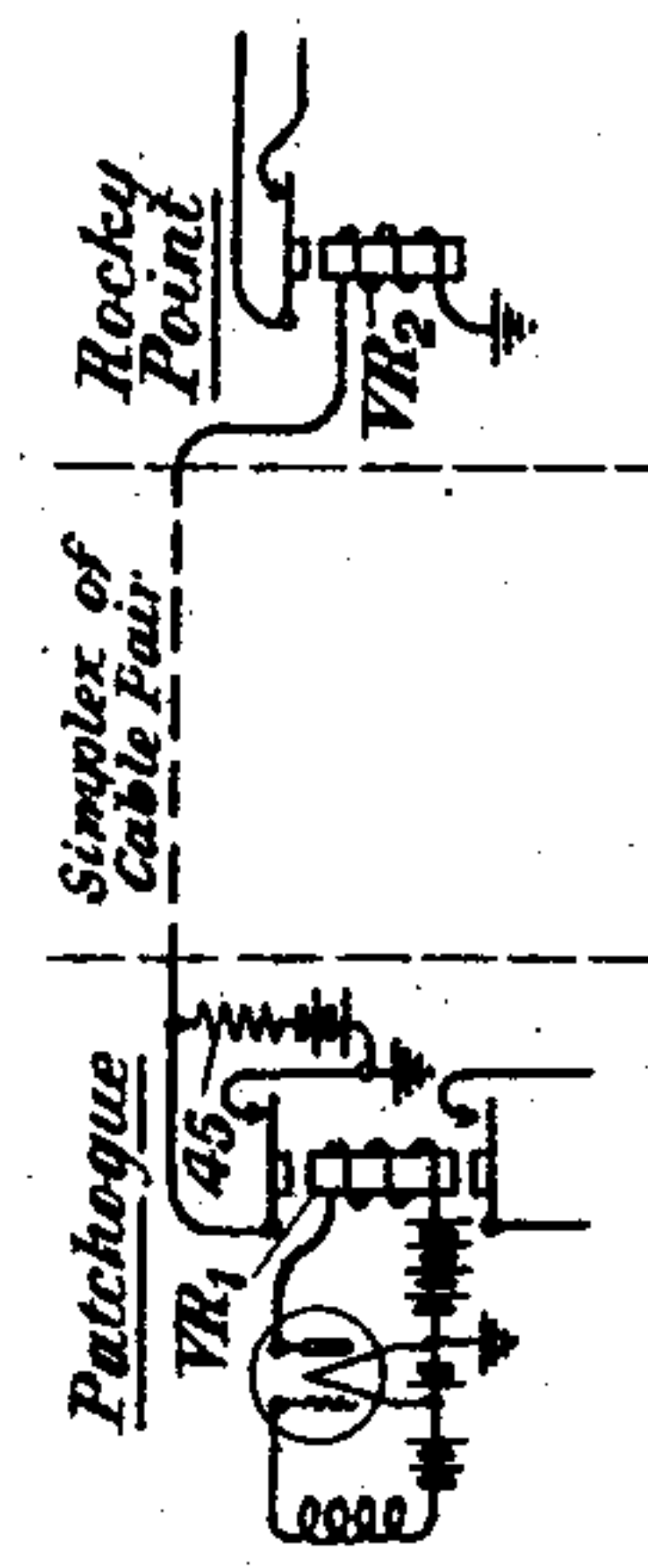


Fig. 4

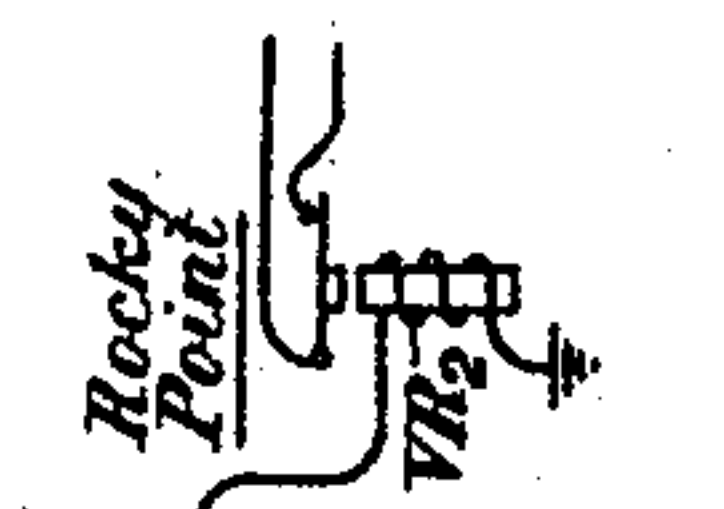


Fig. 5

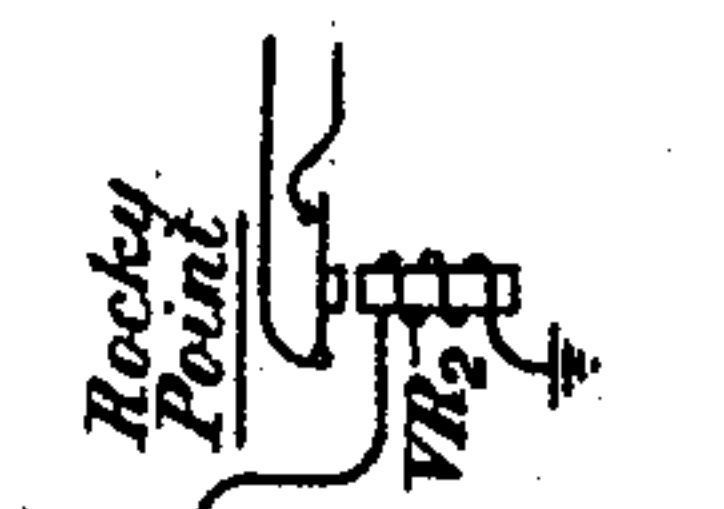


Fig. 6

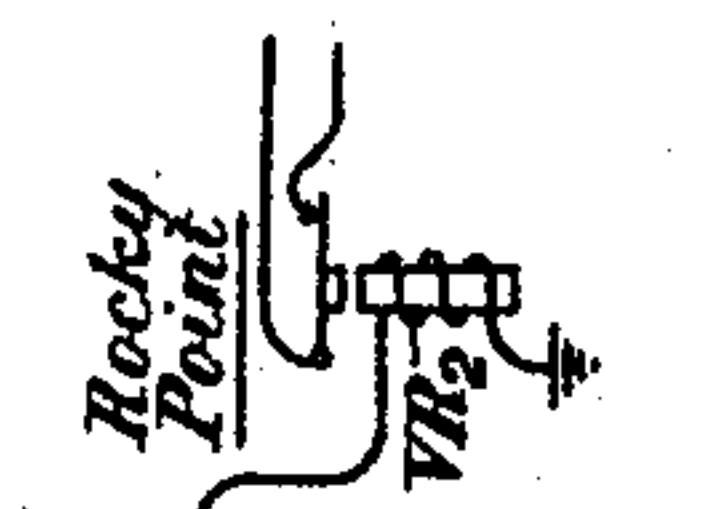


Fig. 7

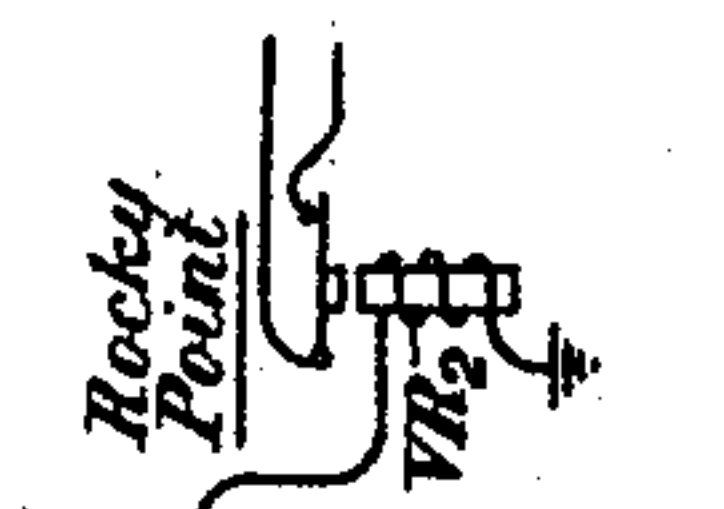


Fig. 8

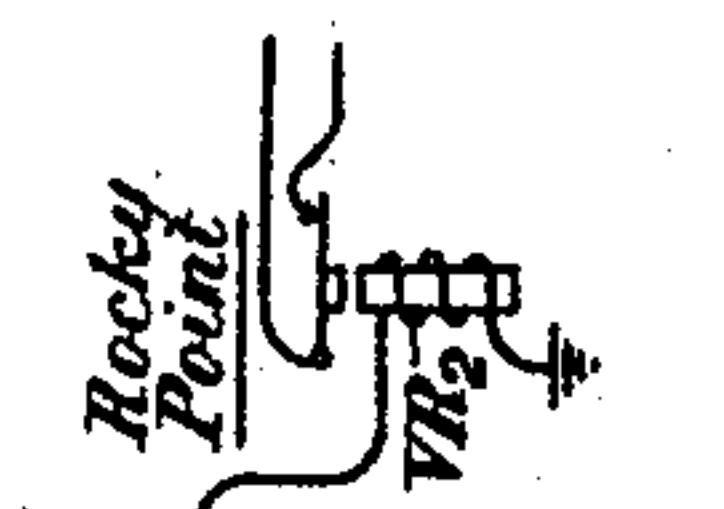


Fig. 9

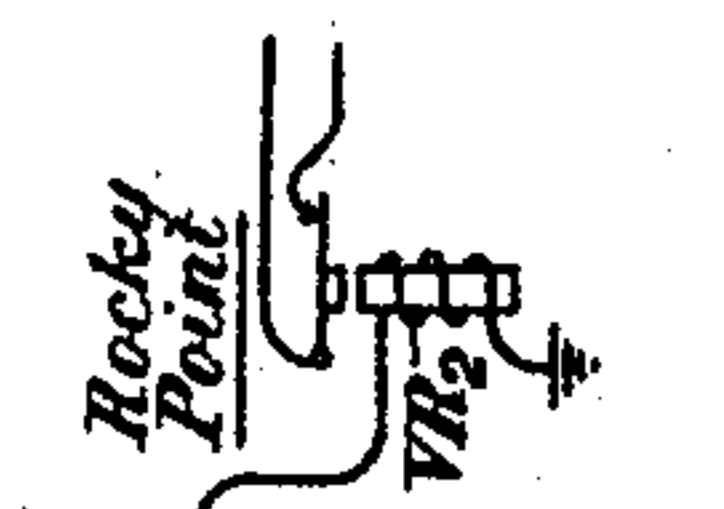


Fig. 10

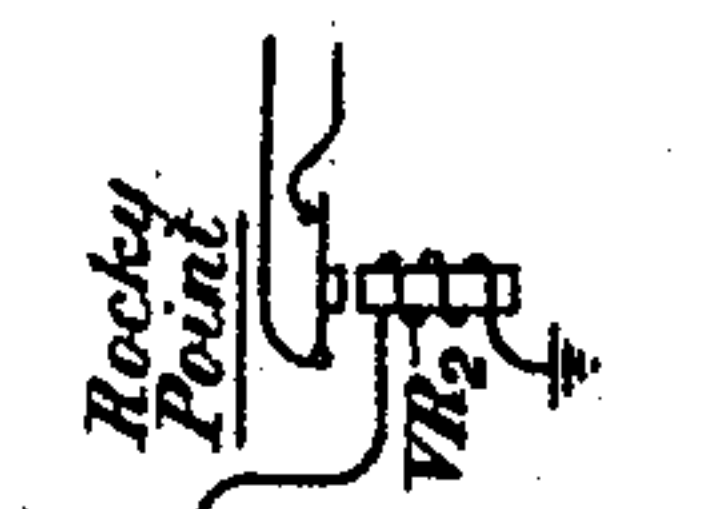


Fig. 11

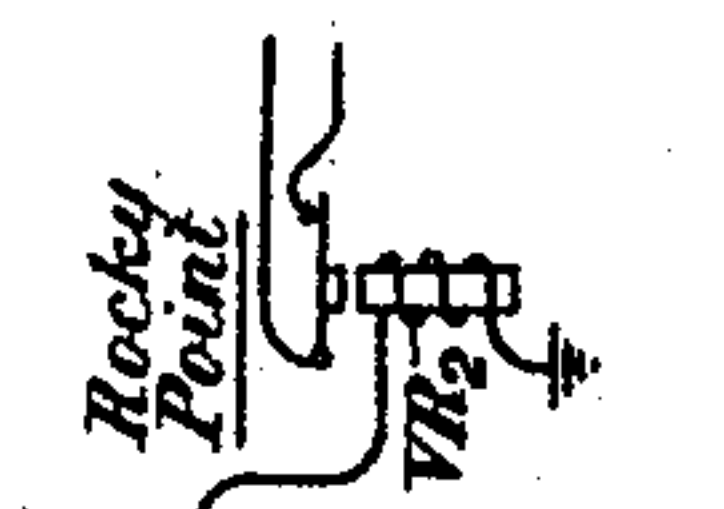


Fig. 12

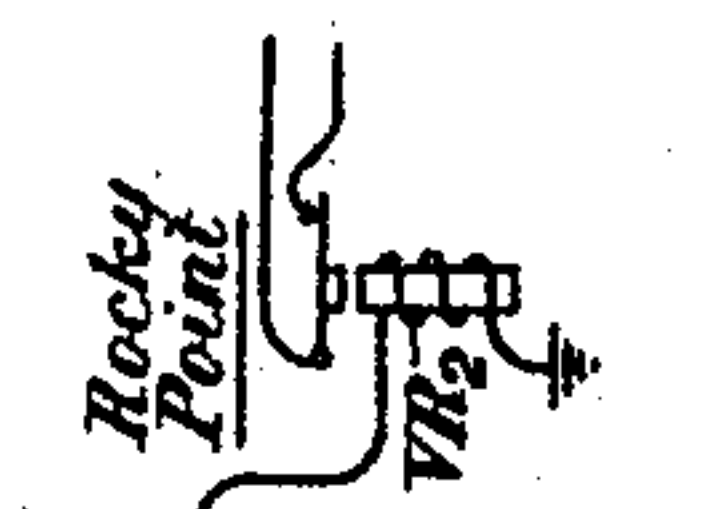


Fig. 13

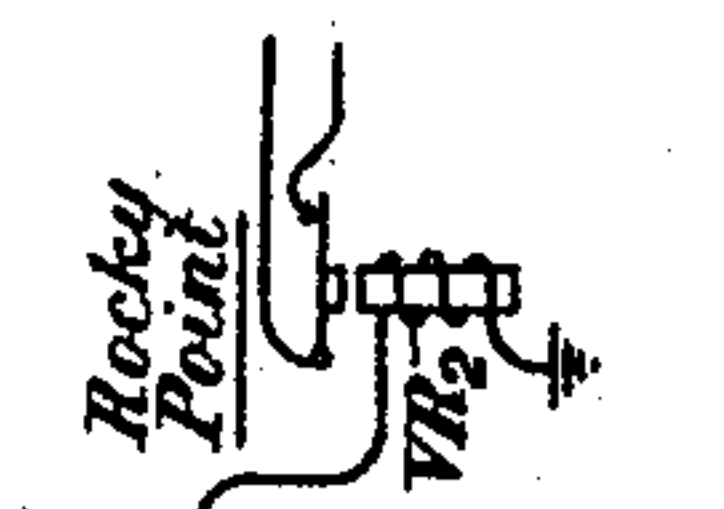


Fig. 14

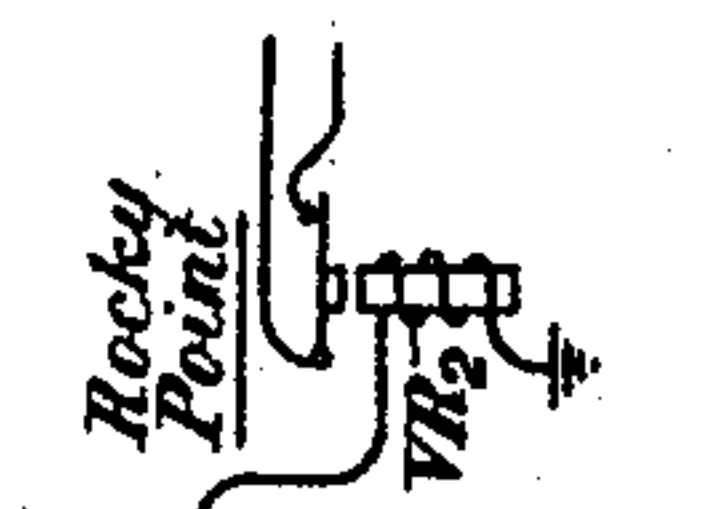


Fig. 15

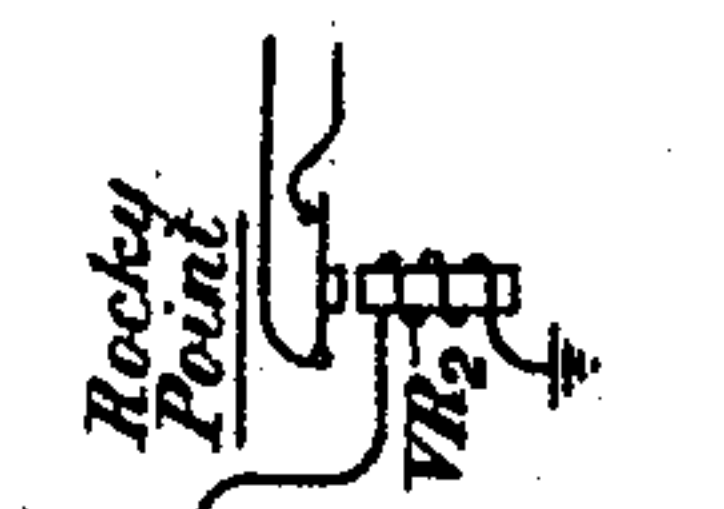


Fig. 16

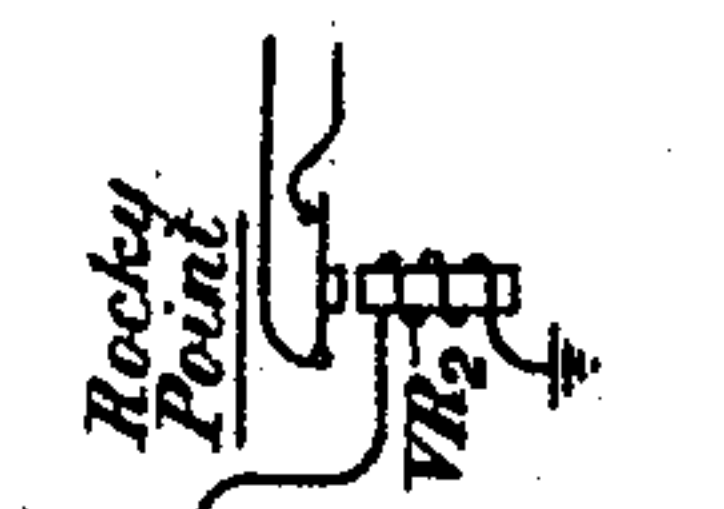


Fig. 17

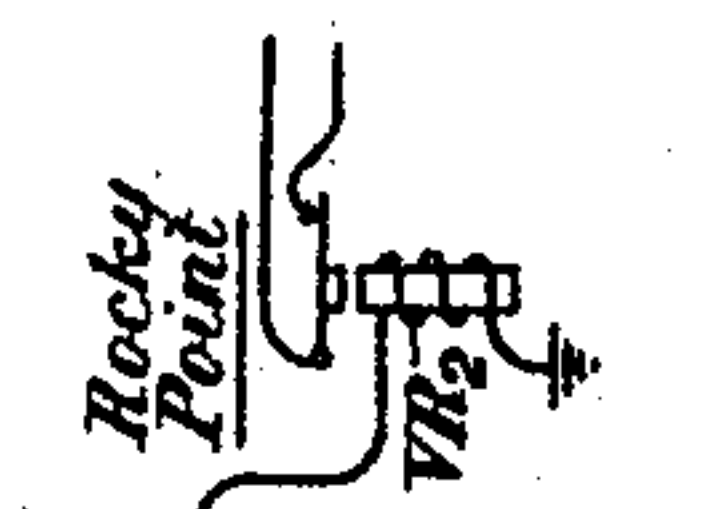


Fig. 18

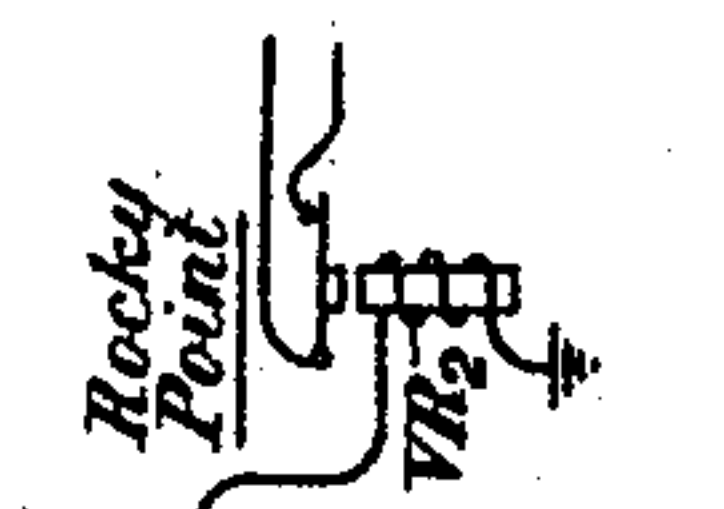


Fig. 19

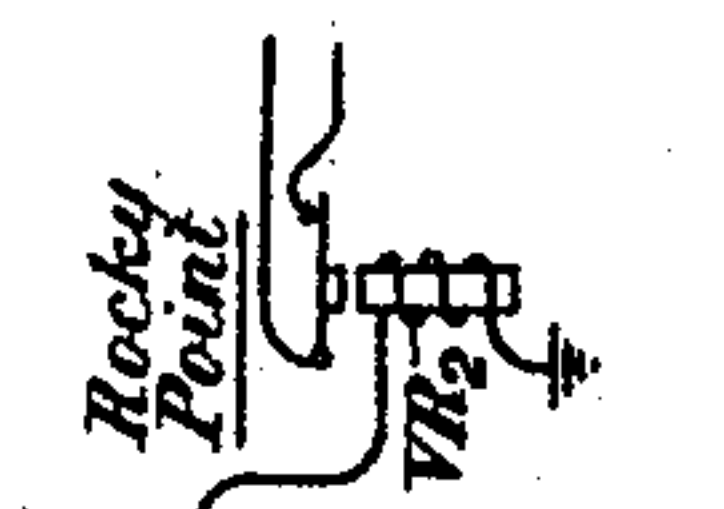


Fig. 20

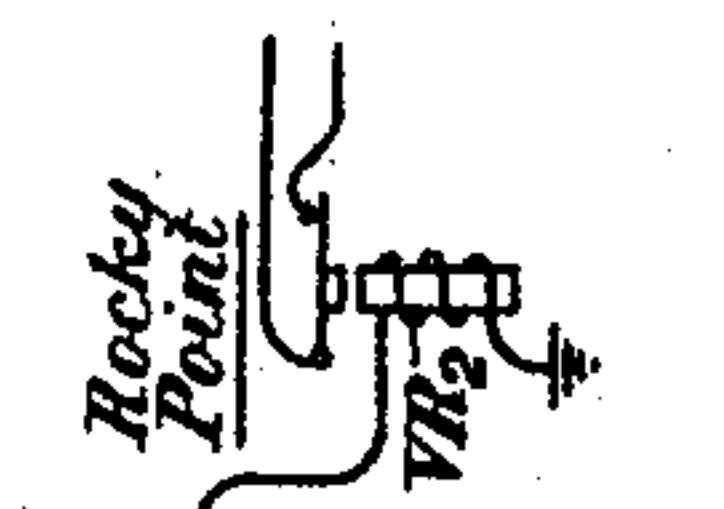


Fig. 21

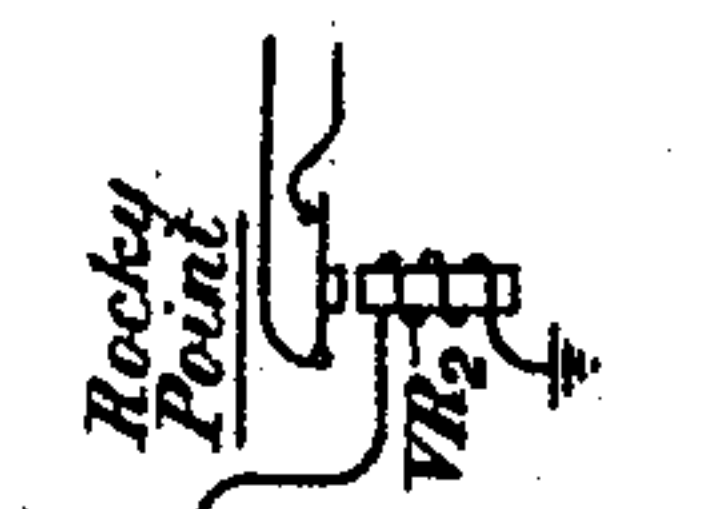


Fig. 22

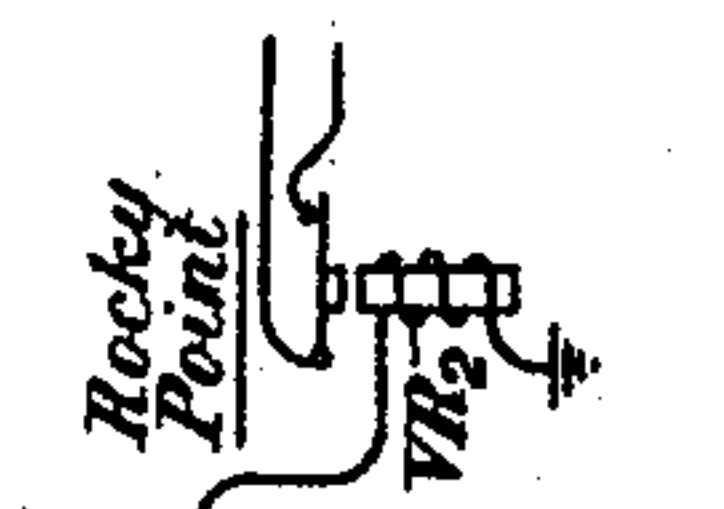
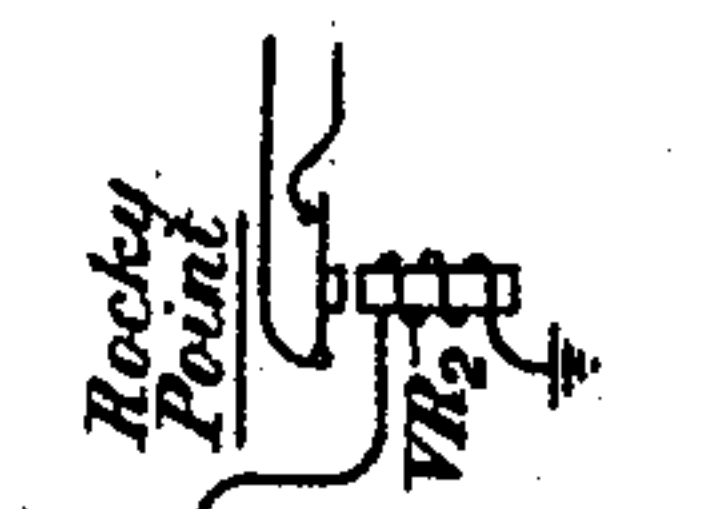


Fig. 23



June 3, 1930.

H. S. HAMILTON

1,760,984

TRANSOCEANIC RADIO TELEPHONE SYSTEM

Filed July 16, 1927

2 Sheets-Sheet 2

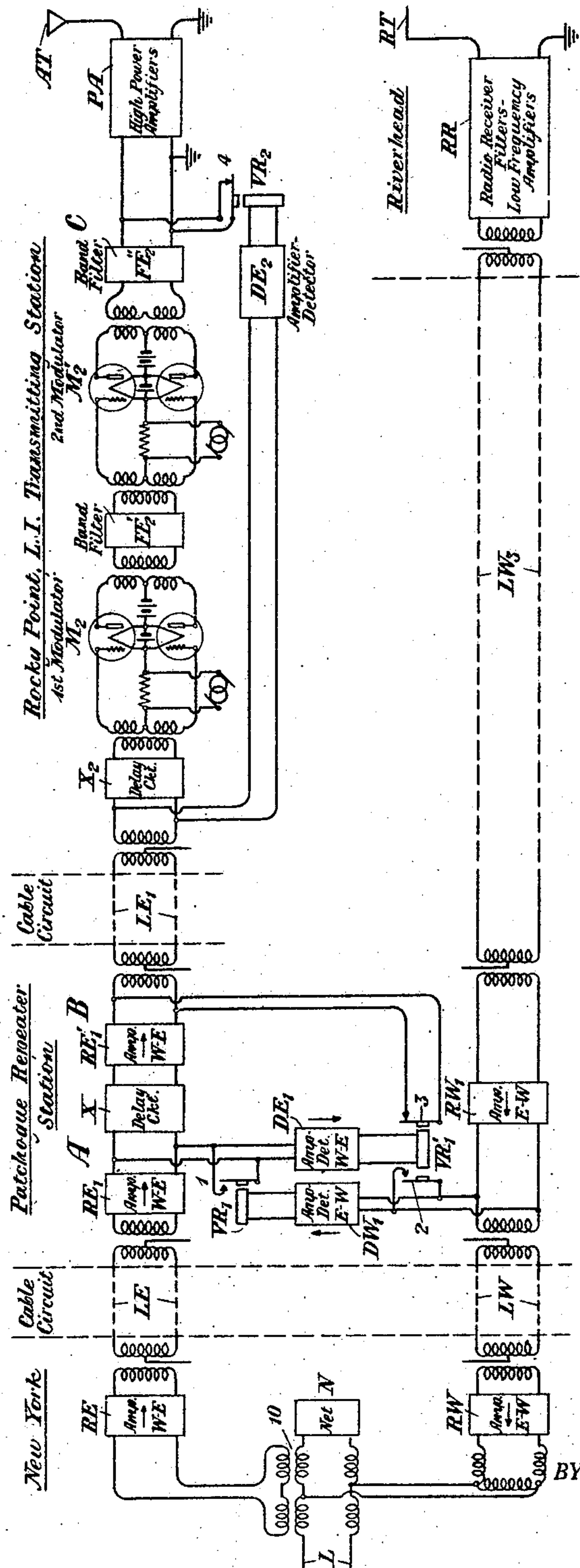


Fig. 5

INVENTOR.
H. S. Hamilton
BY
ATTORNEY

UNITED STATES PATENT OFFICE

HAROLD S. HAMILTON, OF PHOENIX, ARIZONA, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

TRANSOCEANIC RADIO TELEPHONE SYSTEM

Application filed July 16, 1927. Serial No. 206,342.

This invention relates to radio circuits, and more particularly to arrangements for effecting two-way telephone communication by means of radio apparatus.

5 In connecting a two-way telephone line to a radio circuit, it is customary to provide a radio transmitter and a radio receiver at points separated by a considerable distance, and to associate the wire line with these two
10 stations by a four-wire connection. In a system involving a long radio link, such, for example, as a transoceanic system, the amount of power generated by the transmitter on one side of the ocean is so large, as compared with
15 the amount of energy received by the receiver on the same side, that the transmitter and receiver must be separated by considerable distances. Even so, however, where a common wave length is used for transmission in both
20 directions, it is obvious that when transmission is being sent out from the transmitting station on one side of the ocean, some positive means must be provided for preventing the receiving station on the same side of the ocean
25 from picking up the transmitted signal.

Heretofore it has been proposed to accomplish this result by using echo suppressors at some point in the four-wire line connecting the two-way transmission line with the radio
30 transmitter and receiver. In order to prevent local singing over the four-wire circuit and from the radio transmitter to the local radio receiver, the transmitting branch of the four-wire system is normally disabled. An echo
35 suppressor unit is associated with that branch and is so arranged that when operated by voice currents, it will render the transmitting branch operative and will disable the receiving branch of the four-wire circuit. A
40 similar echo suppressor unit associated with the receiving branch is arranged to operate in response to voice currents received by radio from a distant transmitting station to disable the transmitting branch.

45 Owing to the fact that each echo suppressor

unit is arranged to disable the other when operated, it is convenient to locate both echo suppressor units at some point between the terminal of the wire line and the radio apparatus where both the transmitting and receiving branches of the four-wire circuit pass
50 through the same station. This means that the echo suppressor units would be arranged at some distance from the radio transmitter. The disabling means for the transmitting
55 branch of the four-wire circuit has been heretofore applied to such a branch at the point where the echo suppressor units are located.

Experience with transoceanic radio telephony has shown, however, that a disabling
60 arrangement controlled by an echo suppressor associated with the transmitting branch and arranged to perform its function at a point distant from the radio transmitter is unworkable where a considerable amount
65 of energy is picked up by the radio receiver from the radio transmitter during idle periods of the latter. This is for the reason that during idle periods of the transmitter, the transmitter is not actually quiet, but, on
70 the contrary, it transmits interfering waves due to the carrier leak in the modulating apparatus to noise picked up by the wire line between the point at which the echo suppressor is located and the radio transmitter,
75 and to noises in the transmitter itself. All of these noises are amplified by the high-power amplifier used at the transmitter, and, in some instances, the effect upon the radio receiver is so great as to operate and lock up
80 the echo suppressor associated with the receiving branch of the four-wire circuit even during the so-called idle periods of the radio transmitter.

Therefore, it is proposed, according to the
85 present invention, to apply a disabling means to the transmitting branch of the four-wire circuit at the radio transmitter, itself. This means is preferably applied at a point beyond the modulating apparatus, but ahead of the
90

power amplifier, and is arranged to be operated at a distance by means of the echo suppressor associated with the transmitting branch of the four-wire circuit. The disabling means, if applied beyond the modulating apparatus, will absolutely prevent the radiation of either line noises, carrier current, or noise generated within the circuits of the radio apparatus, itself. It is also located ahead of the power amplifier for the reason that the power amplifier does not generate any interference within itself, but has the effect of greatly amplifying the energy received by it, so that a switch applied beyond the amplifier would have to commutate a very much larger volume of energy than would a switch located ahead of the amplifier.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawing, Figure 1 of which is a diagram showing the invention as applied to a typical circuit arrangement used for transoceanic radio telephony; while Figs. 2, 3 and 4 thereof represent modified arrangements for operating the transmitter disabling means from a distance. Fig. 5 represents a modified circuit arrangement.

Referring to Fig. 1, a typical circuit arrangement is here shown for connecting the radio transmitter and receiver at one side of the ocean with a two-way telephone transmission line. L designates such a two-way transmission line entering the city of New York, for example. This line is to be connected to a radio transmitter shown on the right-hand side of the diagram located at Rocky Point, Long Island, for example. The corresponding radio receiver might be located, for example, at Riverhead, Long Island, a town some distance from Rocky Point, and also some distance from New York. This radio receiver would also be connected to the line L.

In order to effect these connections, a hybrid coil 10 is provided, and the line is balanced by a suitable network N. From one side of the hybrid coil, a connection extends through amplifier RE, and over a two-wire line LE to a repeater station between New York and the points at which the radio transmitter and receiver are located. In the present instance, the repeater position is assumed to be at Patchogue, Long Island. At this point, the line LE is connected through amplifiers RE₁ and RE'₁ to a two-wire line LE₁ extending from Patchogue to Rocky Point, where the radio transmitting station is located. The radio apparatus at Rocky Point may consist of a band filter FE₂ for passing a voice frequency band, an intermediate stage modulator M₂ of the well-known balanced type arranged to suppress the carrier, the band filter FE'₂ for suppressing one of the side bands resulting from the first

stage of modulation, for example, the lower side band, and a second modulator M'₂ of the carrier suppression type, by means of which the selected side band may be modulated upon a higher carrier. A band filter FE''₂ is located on the output side of the modulator M'₂ for selecting one of the side bands which is finally to be transmitted from the antenna AT. The power amplifier PA is a high power arrangement of well-known type, which amplifies the side band currents selected by the filter FE''₂ and applies them to the radiating antenna.

While both modulators M₂ and M'₂ are arranged to suppress the carrier, complete suppression is not actually possible by virtue of a balanced arrangement, and consequently, some carrier energy will be radiated from the antenna AT during idle periods of the transmitter. Furthermore, even if no carrier leak occurred, noises picked up by means of the line LE₁ from other lines in the same cable, as well as noises generated in the modulating apparatus itself, would produce side band modulations of the carrier which would be radiated by the transmitting antenna AT. In a typical case actually encountered in connection with a radio telephone system between New York city and London, it was found that the radio transmitter located at Rugby, England, radiated, during idle periods, an amount of energy such as to produce upon the receiving station located at Wroughton, England, a distance of about 80 miles from Rugby, an effect comparable with that of the desired signal from New York. It is therefore obviously necessary to provide some means for actually disabling the radio transmitter, itself, during its idle periods.

Before describing the disabling means, however, it should be noted that the radio receiver, which, in the case illustrated, is assumed to be located at Riverhead, Long Island, and which is schematically indicated at RR, is connected to the Patchogue repeater station by means of a line LW₃. At the repeater station, an amplifier RW₁ is interposed between the line LW₃ and a line LW running from Patchogue to New York, at which point a one-way amplifier RW is interposed between the terminals of the line LW and the hybrid coil 10, through which it is associated with the telephone line L.

Coming, now, to the echo suppressor apparatus, an echo suppressor equipment, comprising an amplifier-detector DW₁ and a voice-operated relay VR₁, is bridged across the line from the radio receiver to Patchogue on the output side of the amplifier RW₁. This apparatus is of the type well known in the art, and it is therefore unnecessary to describe it further than point out that the general effect of the amplifier-detector DW₁ is to amplify and rectify voice currents so that a direct current component thereof ener-

gizes the voice-operated relay VR_1 . A similar echo suppressor unit comprises an amplifier-detector DE_1 , and a voice-operated relay VR'_1 is bridged at Patchogue across the line running from New York to the radio transmitter. Preferably, this bridge is applied on the output side of the amplifier RE_1 . The echo suppressor unit associated with the receiving line controls a contact 1, which, when the distant transmitter is talking, is operated to short circuit the line $LE-LE_1$ at Patchogue. This same contact also short circuits the echo suppressor unit $DE_1-DR'_1$ associated with the transmitting line, thereby preventing false operation. Similarly, the echo suppressor unit associated with the transmitting line controls a contact 2 which, when the subscriber at the distant end of the line L is talking, functions to short circuit the receiving line $LW-LW_3$. This contact also short circuits the echo suppressor unit controlling the contact 1 to prevent false operation.

In order to prevent singing over the local circuit, comprising the four-wire system and the radio path from the local transmitting antenna AT to the local receiving antenna RT, it has heretofore been proposed to provide the echo suppressor unit $DE_1-DR'_1$ with a second contact, normally short circuiting the line LE_1 at Patchogue. This would have the effect of normally disabling the transmission path. When the subscriber on the telephone line talks, however, the echo suppressor unit $DE_1-VR'_1$ would open this contact so that transmission could take place between New York and the radio transmitter. In order to provide the necessary time whereby this contact could be opened by the echo suppressor unit before the voice wave initiating the operation should have arrived at the point where the short circuit was to be applied, a delay circuit X is interposed between the bridge point A and the short circuiting point, which in systems heretofore proposed has been located at B. If desired, an additional one-way amplifier RE'_1 may be provided to make up for the transmission loss introduced by the delay circuit.

An arrangement such as above described would be effective were it not for the interference radiated from the antenna AT during idle periods of the transmitter. As has already been pointed out, this interference is due to incomplete suppression of the carrier and also to modulation of the carrier by a line noise picked up by the line LE_1 , and also noise generated in the modulating apparatus, itself. In order to overcome this difficulty, it is proposed, in accordance with the present invention, to replace or supplement the short circuit at B by a short circuiting contact 4 at the point C just beyond the second modulator M'_2 of the radio transmitter, and just ahead of the high-power amplifiers PA. A short circuit applied at this point will have

the advantage of absolutely preventing the transmission of any interference originating either in the modulating apparatus or in the transmission line running from New York to the radio transmitter. By arranging the short circuit on the input side of the power amplifier, the amount of energy which it is required to commutate is quite minute as compared with the energy which it would be required to control if located on the output side of the amplifier PA. The amount of noise originating in the high-power amplifier PA is practically negligible, so that it is quite possible to locate the short circuiting contact 4 at the point indicated and still attain the desired effect.

In order to control the contact 4 from the Patchogue repeater station, the bridge terminals at A may be connected at the latter station to an auxiliary line AL running from Patchogue to Rocky Point, and, at the latter station, an amplifier-detector DE_2 and a voice relay VR_2 , similar to the corresponding elements already described at Patchogue, are located at Rocky Point, at the terminal of the line AL. The voice-operated relay VR_2 controls the contact 4, so that whenever the subscriber at the distant end of the line L talks, the contact 2 is operated to disable the line transmitting from east to west; and the short circuit 4 is removed at the point C, thus enabling the subscriber to talk from west to east.

Briefly, the operation is as follows: Normally, the contact 4 completes a short circuit at the point C, so that no noise originating in the transmitting line or in the radio apparatus can be radiated by the antenna AT. Hence, no noise is picked up by the receiving antenna RT during idle periods of the transmitter. If transmission is being received from the distant transmitting apparatus, it will be picked up by the antenna RT and translated to audio form by radio receiver RR at Rocky Point. The audio telephone currents will be then transmitted over the line LW_3 to Patchogue and amplified by the amplifier RW_1 . The amplified currents are then transmitted over the line LW and through the amplifier RW to the line L. Part of the energy amplified by the amplifier RW_1 at Patchogue, however, serves to operate the voice relay VR_1 and closes contact 1, thereby short circuiting the line $LE-LE_1$ at A, and also disabling the echo suppressor unit $DE_1-VR'_1$, as well as the distant echo suppressor unit DE_2-VR_2 at Rocky Point. Thus, during reception, the entire transmitting channel between New York and Rocky Point is inoperative. If the short circuiting contact 1 were not provided, an echo current passing through the line LW and through the hybrid coil 10 might pass over the line LE and operate the echo suppressor unit

associated with the transmitting channel and thereby cause a false operation.

When transmission is not being received from the distant point, and the subscriber associated with the line L talks, the voice currents are passed from the line L through the hybrid coil 10, through the amplifier RE and over the line LE to Patchogue. Here, the amplifier RE₁ amplifies the voice currents and impresses them upon the delay circuit X. While passing through the delay circuit (which may obviously be located at any point between A and C), a part of the amplified energy is diverted into an echo suppressor DE₁—VR'₁, thereby operating the contact 2 to short circuit the line LW₃—LW. Also, the echo suppressor unit DE₂—VR₂ operates to open the contact 4 and to remove the short circuit at C. This occurs before the amplified voice currents are passed through the delay circuit X, amplifier RE'₁ and over the line LE₁ to the radio transmitting apparatus at Rocky Point. The voice currents, upon arriving at Rocky Point, pass through the filter FE₂ and modulate the intermediate carrier frequency normally supplied to the modulator M₂. The modulator suppresses the carrier, but transmits both side bands to the filter FE'₂, which serves to suppress one side band,—for example, the lower side band. The upper side band is then impressed upon the second modulator ME'₂ to modulate the carrier supplied thereto. This carrier likewise is suppressed, and both resultant side bands are applied to the filter FE''₂, which again suppresses one of the side bands and permits the remaining side band to pass to the power amplifier PA (the contact 4 having been opened by this time). The power amplifier PA amplifies the side band currents for transmission to the distant receiving station.

The arrangement illustrated in Fig. 1 has the disadvantage of requiring two echo suppressors associated with the transmitting channel,—one at Patchogue and one at Rocky Point. Fig. 2 illustrates an arrangement by which one echo suppressor unit will perform both functions. Here, the detector tube D₁ of the amplifier-detector unit DE₁ has its plate circuit connected through a relay VR'₁, located at Patchogue, to a line wire 40 extending to Rocky Point. Here, the line wire is connected to one terminal of a similar relay VR₂, the other terminal of the relay being connected over a return wire 41 to a B battery located at Patchogue. The relay VR'₁ will control the contact 2, as in Fig. 1, and similarly, the relay VR₂ will control the contact 4, as in Fig. 1. The line wires 40 and 41 may be simplex circuits derived from telephone pairs in ordinary telephone cables. It will, of course, be obvious that this arrangement is much cheaper than the arrangement illustrated in Fig. 1.

An alternative arrangement employing only a single line wire between Patchogue and Rocky Point, for operating the relays VR'₁ and VR₂, is shown in Fig. 3, where the B battery is connected directly to the terminal of the relay VR₂ and there grounded. This arrangement has the disadvantage, as compared with the arrangement of Fig. 2, that it is more susceptible to interference impulses picked up from the ground.

Another modification is illustrated in Fig. 4, in which the relay VR₂ is controlled through a contact of the relay VR'₁ instead of being included directly in the plate circuit of the detector tube as in Figs. 2 and 3. Normally the relay VR₂ is deenergized by reason of the fact that the upper contact of the relay VR'₁ short-circuits its winding, a resistance 45 being included in series with the operating battery of the relay VR₂ to prevent the short circuit from running down the battery. Whenever voice currents operate the detector tube so that the relay VR'₁ is energized, it causes the operation of the distant relay VR₂ by opening the short-circuit above described.

A further modification is illustrated in Fig. 5, this modification being along the lines of Fig. 1 in that a separate echo suppressor unit is provided at the repeater station and at the distant radio transmitting station, but in this case, the echo suppressor unit at the transmitting station is connected to the transmission line locally so as to be operated by voice currents transmitted over the normal telephone transmission line instead of over a supplemental line. In order to accomplish this result a delay circuit X₂ is inserted at the Rocky Point transmitting station ahead of the band filter FE₂, shown in Fig. 5, and the amplifier-detector DE₂ is bridged across the line terminals ahead of the delay circuit X₂. The auxiliary line AL, provided in Fig. 1, is omitted entirely, and voice currents to operate the amplifier-detector unit DE₂ are transmitted over the regular transmission line LE₁. The delay circuit X₂ is necessary to enable the relay VR₂ to remove the short-circuit at 4 before the voice currents (which cause the operation of the relay VR₂) have had time to reach the point at which the short-circuit is applied. The amplifier-detector unit DE₁, at the Patchogue repeater station, will be arranged as in Fig. 1 to apply a short-circuit at 2 to the receiving path LW₃.

While not essential to the arrangement of Fig. 5, the relay VR'₁ may also be arranged to apply a short-circuit 3 to the transmitting line at the point B, in which case the delay circuit X will be provided, as shown, to enable the relay VR'₁ to remove the short-circuit before the arrival of the operating voice currents. This arrangement is desirable because it is essential that the receiving path always be disabled whenever the short-circuit 4 is removed from the transmitting path at C.

As it is necessary to control this disablement of the receiving path from the amplifier-detector unit DE_1 , it might happen that if the amplifier-detector unit DE_2 were more sensitive than the similar arrangement DE_1 , the unit DE_2 would respond to weak noise currents and remove the short-circuit at C, while the unit DE_1 would not disable the receiving path. Therefore the unit DE_1 is arranged to control a local short-circuit 3 at B, so that noise currents transmitted from the line L over the transmitting path will not arrive at C to cause false operation in the manner above described. On the other hand, voice currents transmitted from the line L will operate the amplifier-detector unit DE_1 to short-circuit the receiving path at 2 and to remove the short-circuit 3 at B, whereupon the voice currents are transmitted over the line LE_1 to cause the operation of the amplifier-detector unit DE_2 , which in turn removes the short-circuit 4 at C, thus rendering the transmitting path operable.

This modification has the obvious advantage that the auxiliary line AL of Fig. 1 may be dispensed with. The arrangement also has the advantage over Figs. 2, 3 and 4, that where the auxiliary line, whether it be a one-wire or two-wire circuit, is of considerable length (because of the distance between the repeater station and the radio transmitting apparatus) it is cheaper to provide an additional amplifier-detector unit at the radio transmitter station than to provide an auxiliary line between the repeater station and the radio transmitter station.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a signaling system, a two-way telephone transmission line, a radio transmitter including a modulator, a radio receiver, a transmitting antenna into which said modulator works, a receiving antenna separate from said transmitting antenna and associated with said radio receiver, a first one-way path between said line and said radio transmitter for transmitting signals from the line to the transmitter, a second one-way path for transmitting signals from said radio receiver to said line, echo suppressor equipment located at a point through which both of said paths pass, said echo suppressor equipment comprising an echo suppressor unit associated with the first path and responsive to signals transmitted thereover to disable the second path, a second echo suppressor unit associated with the second path and responsive to signals transmitted thereover for disabling said first path, a disabling means normally applied on the output side

of the modulator of the radio transmitter between said modulator and the transmitting antenna to prevent the radiation of interference during idle periods of the transmitter, and means responsive to the application of signals to said first path for removing said last mentioned disabling means in response to voice currents applied to said first mentioned one-way path.

2. In a signaling system, a two-way telephone transmission line, a radio transmitter including a modulator, a radio receiver, a transmitting antenna into which said modulator works, a receiving antenna separate from said transmitting antenna and associated with said radio receiver, a first one-way path between said line and said radio transmitter for transmitting signals from the line to the transmitter, a second one-way path for transmitting signals from said radio receiver to said line, echo suppressor equipment located at a point through which both of said paths pass, said echo suppressor equipment comprising an echo suppressor unit associated with the first path and responsive to signals transmitted thereover to disable the second path, a second echo suppressor unit associated with the second path and responsive to signals transmitted thereover for disabling said first path, a disabling means normally applied on the output side of the modulator of the radio transmitter between said modulator and the transmitting antenna to prevent the radiation of interference during idle periods of the transmitter, and means responsive to the application of signals to said first path and controllable from the point at which said echo suppressor equipment is located for removing said disabling means in response to voice currents applied to said first mentioned one-way path.

3. In a signaling system, a two-way telephone transmission line, a radio transmitter including a modulator, a radio receiver, a transmitting antenna into which said modulator works, a receiving antenna separate from said transmitting antenna and associated with said radio receiver, a first one-way path between said line and said radio transmitter for transmitting signals from the line to the transmitter, a second one-way path for transmitting signals from said radio receiver to said line, echo suppressor equipment located at a point through which both of said paths pass, said echo suppressor equipment comprising an echo suppressor unit associated with the first path and responsive to signals transmitted thereover to disable the second path, a second echo suppressor unit associated with the second path and responsive to signals transmitted thereover for disabling said first path, a short circuit normally applied on the output side of the modulator of said radio transmitter between said modulator and the transmitting antenna to pre-

vent the radiation of interference during the idle condition of said transmitter, and means controllable from the point at which the echo suppressor equipment is applied for removing said short circuit in response to the application of voice currents from said telephone line to said first-mentioned path.

4. In a signaling system, a two-way telephone line, a radio transmitter and a radio receiver, said radio transmitter comprising means for modulating the carrier frequency in accordance with speech and a power amplifier for amplifying modulated oscillations in their high frequency form, a first one-way path for transmitting signals from said two-way line to said radio transmitter, a second one-way path for transmitting signals from the radio receiver to said two-way line, echo suppressor equipment located at a point through which both of said one-way paths pass, said echosuppressorequipment comprising an echo suppressor unit associated with said first one-way path and responsive to signals transmitted from said telephone line to the radio transmitter to disable said second path, a second echo suppressor unit associated with the second path responsive to signals transmitted from the radio receiver to a line to disable said first path, disabling means normally applied to said radio transmitter between the output side of the modulator thereof and the input side of the high frequency amplifier thereof, and means controllable from the point at which said echo suppressor equipment is applied to remove said disabling means in response to voice currents applied to said first-mentioned one-way path.

5. In a signaling system, a two-way telephone line, a radio transmitter and a radio receiver, said radio transmitter comprising means for modulating the carrier frequency in accordance with speech and a power amplifier for amplifying modulated oscillations in their high frequency form, a first one-way path for transmitting signals from said two-way line to said radio transmitter, a second one-way path for transmitting signals from the radio receiver to said two-way line, echo suppressor equipment located at a point through which both of said one-way paths pass, said echo suppressor equipment comprising an echo suppressor unit associated with said first one-way path and responsive to signals transmitted from said telephone line to the radio transmitter to disable said second path, a second echo suppressor unit associated with the second path responsive to signals transmitted from the radio receiver to the line to disable said first path, a short circuit normally applied to said radio transmitter between the output of the modulator thereof and the input of the high frequency amplifier thereof, said short circuit functioning to normally prevent the radiation of interference

during idle periods of the transmitter, and means controllable from the point at which said echo suppressor equipment is located and responsive to telephone currents applied to said first one-way path to open said short circuit.

6. In a signaling system, a two-way telephone line, a radio transmitter including a modulator, a radio receiver, a transmitting antenna into which said modulator works, a receiving antenna separate from said transmitting antenna and associated with said radio receiver, a first one-way circuit for transmitting signals from said telephone line to said radio transmitter, a second one-way circuit for transmitting signals from said radio receiver to said two-way line, echo suppressor equipment located at a point through which both one-way paths pass, said echo suppressor equipment comprising an amplifying and rectifying unit associated with said first-mentioned path, a relay associated with said unit and responsive to voice currents transmitted over said first one-way path to disable said second one-way path, a second amplifying and rectifying unit associated with said second path, a relay associated with said second unit and responsive to rectified voice currents transmitted over said second path to disable said first path, a normally disabling means applied on the output side of the modulator of said radio transmitter between said modulator and the transmitting antenna for preventing the radiation of interference during idle periods thereof, and a relay for controlling said disabling means, said relay being connected to be operated by rectified voice currents from the output of said first-mentioned amplifying and rectifying unit.

7. In a signaling system, a two-way telephone line, a radio transmitter including a modulator, a radio receiver, a transmitting antenna into which said modulator works, a receiving antenna separate from said transmitting antenna and associated with said radio receiver, a first one-way circuit for transmitting signals from said telephone line to said radio transmitter, a second one-way circuit for transmitting signals from said radio receiver to said two-way line, echo suppressor equipment located at a point through which both one-way paths pass, said echo suppressor equipment comprising an amplifying and rectifying unit associated with said first path, a relay connected to the output side of said unit and responsive to rectified voice currents transmitted over said first path to apply a short circuit to said second path, an amplifying and detecting unit associated with said second path, a relay connected to the output side of said second unit and responsive to rectified voice currents transmitted over said second path to short circuit said first path, a short circuit normally applied on the output side of the modulator of said radio transmit-

ter between said modulator and the transmitting antenna for preventing the radiation of interference during idle periods of the transmitter, and a relay for removing said last-mentioned short circuit, said relay being connected to be operated by rectified voice currents from the output of said first-mentioned amplifying and detecting unit.

In testimony whereof, I have signed my name to this specification July 11, 1927.

HAROLD S. HAMILTON.