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RADIO REPEATING SYSTEM FOR ULTRA SHORT WAVES

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FIG. 1

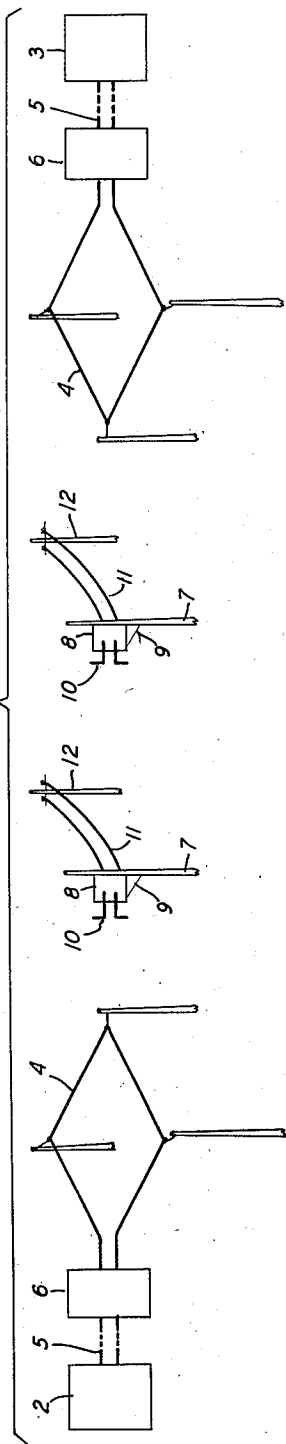


FIG. 3

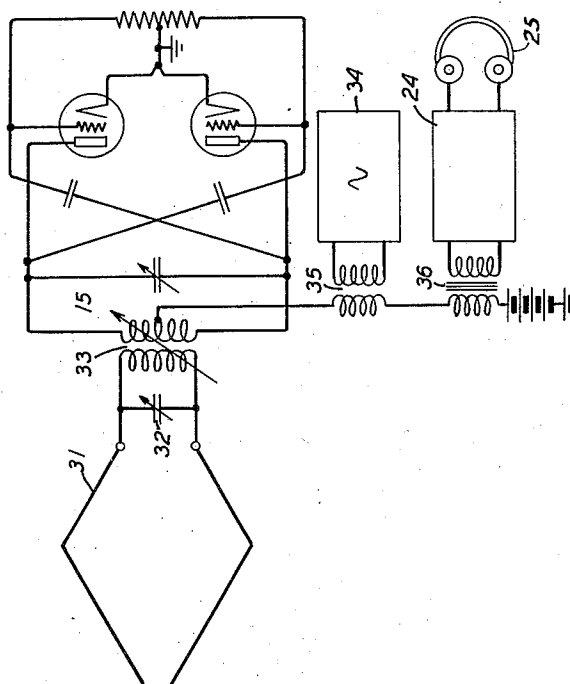
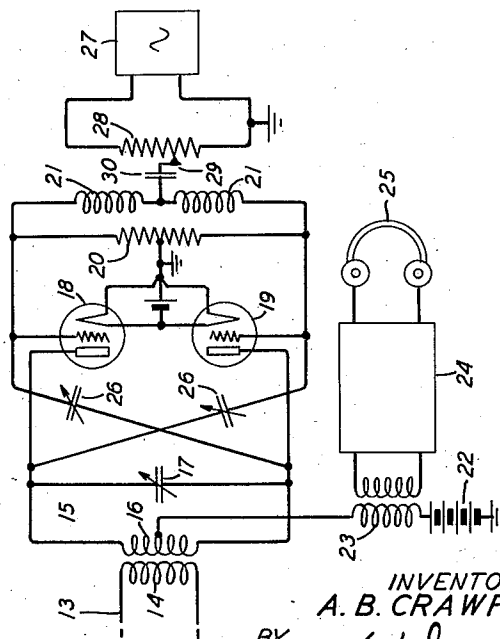


FIG. 2



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RADIO REPEATING SYSTEM FOR
ULTRA-SHORT WAVESArthur B. Crawford, Red Bank, N. J., assignor to
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8 Claims. (Cl. 250-15)

This invention relates to radio repeating systems and more particularly to radio repeating systems for ultra-short waves.

An object of the invention is to simplify the apparatus required for ultra-short wave systems operating over distances in excess of the longest possible direct optical path with a consequent reduction in the cost of their installation, maintenance and operation.

Radio repeating stations of the prior art have required some expedient to prevent the local transmitter element of the repeating station from impressing its output energy on the local receiver element and thus setting up the condition of feedback or oscillation which is known as "singing". Among expedients which have been used to prevent this action with its resulting instability and distortion are change of carrier frequency in the repeating station, conjugate connections for associating a common antenna with the local transmitting and receiving elements of the repeating station, intermittent energization in alternation of the transmitter element and the receiver element, separate directive antennae for the transmitting and receiving elements, and shielding of the receiving element antenna so that the amplified output energy of the transmitting element antenna may not affect the receiving antenna.

According to the present invention, the various expedients of the prior art for preventing singing at a radio repeater station may be dispensed with and the same apparatus at the radio repeating station that is to serve as the receiving element for the weak incoming signal waves may be used as the transmitter element of the amplified outgoing waves. This is accomplished by employment of the so-called super-regenerative circuit in which an amplifier having a feed-back that would tend to permit or produce continuous oscillations is associated with a quenching oscillator which periodically checks the reamplifying process so that the reamplified waves do not build up to an intensity that would overload the amplifier and thus do not produce a distortion which would make the signals unrecognizable.

For distances somewhat in excess of the physically possible direct optical path, a single intermediate repeater station may suffice. For considerably longer distances a series of repeater stations each of which repeats to the next adjacent station may be employed. The repeating stations may be separated from each other and from the terminal stations by distances of the order of fifty miles or less, depending upon their respective elevations above sea level and, also,

upon the extent to which the intervening terrain may tend to intercept or block the direct optical path.

Other objects and aspects of the invention will be apparent from a detailed consideration of the specification and claims taken in connection with the appended drawing in which,

Fig. 1 indicates schematically a two-way radio telephone system employing two radio repeating stations located between the transmitting and receiving terminal stations;

Fig. 2 is a diagram of one form of the fundamental circuit which may be used at the radio repeating station; and

Fig. 3 illustrates a modification of the circuit of Fig. 2.

Referring to Fig. 1, telephone terminal stations 2 and 3 may represent telephone subscribers' stations, central office stations or the terminal stations of a private point-to-point system which are to be associated for two-way radio telephone, radio telegraph, or other radio communication or radio control wave purposes. Each of the stations 2 and 3, is preferably associated with a directive antenna 4 of any well-known type through the circuit 5 and ultra-short wave terminal radio transmitting and receiving apparatus 6. The terminal radio transmitting and receiving apparatus may be of any desired type. To prevent undesired interaction between the terminal transmitter element and its local terminal receiver element, the transmitter and receiver may be connected conjugately to the common antenna or may be connected to it intermittently in alternation or may comprise a super-regenerative circuit of the type employed at an intermediate radio repeater station. The antennae 4 are preferably directive to lessen the interference which they occasion and to increase effective transmission range of the terminal stations for low power outputs.

Intermediate radio repeater stations, of which two only are illustrated, each comprise a pole, tower or elevated support 7 to increase the effective length of the available optical path, two-way radio repeating apparatus 8 housed in a weather-proof casing and supported by a bracket 9 at a point well up on the pole 7, and an absorbing and emitting antenna 10 which may, for example, be a suitably dimensioned dipole of the type commonly used for ultra-short wave transmission.

Energy for the radio repeating apparatus 8 is derived from a power circuit 11, the conductors of which are supported by power transmission line supports 12.

The circuit of apparatus 8 is illustrated in Fig. 2. It will be understood that the unidirectional sources of current, although indicated in Fig. 2 by the conventional symbols for batteries, may, in practice, be of any suitable type. For example, the circuit 11 may serve directly as a source of unidirectional current or it may provide unidirectional current energy through the instrumentality of a motor generator system or of a rectifying system. It is to be understood, however, that all essential energy for the radio repeating station circuits is preferably derived from the respectively associated power circuits.

Referring to Fig. 2, a dipole or other suitable type of antenna 13 is shown associated by means of a transformer 14 with a super-regenerative receiving circuit comprising a closed tuned loop 15 consisting of a secondary winding 16 of transformer 14 and variable tuning capacity element 17. The anodes of two symmetrical circuit three-element thermionic amplifiers 18 and 19 are directly connected to the opposite terminals of the tuning capacity 17. The grid cathode circuit of the amplifiers comprises a high resistance leak path 20 to the terminals of which the grids of the amplifiers 18 and 19 are connected and to a central point on which the grounded common cathode lead is connected. Shunted across the resistance 20 are so-called "self tuned chokes" or inductance coils 21 which contain the proper number of turns so that their self-inductance and inherent shunt capacities cause the coils to be self resonant at the operating ultra-short wave frequency. These coils each constitute in effect an anti-resonant circuit of high impedance to the ultra-short waves to which antenna 13 and tuned circuit 15 are most responsive but do not exclude oscillations of the much lower quenching frequency. Plate current energy for the discharge devices 18 and 19 is supplied by a source of unidirectional current 22, the negative terminal of which is connected to ground as indicated, the positive terminal of which is connected through the primary winding of an audio-frequency transformer 23 to the mid-tap of secondary winding 16. The secondary winding of transformer 23 is connected to an audio-frequency amplifier which supplies to a monitoring receiver 25 audio-frequency signals as, for example, speech currents resulting from an incidental demodulation of the ultra-short waves occurring in the super-regenerative receiving circuit.

Each thermionic amplifier is provided with a feed-back path through a variable capacity element 26 connected between its grid and the anode of the other thermionic device. As is well known, the capacity elements 26 may each be so adjusted as to enable the circuit as a whole to experience any desired amount of feed-back. Preferably, the capacities are of such magnitude as to enable weak incoming signal oscillations transferred from antenna 13 to tuned circuit 15 to impress the resulting potentials built up across the terminals of capacity 17 upon the grid cathode circuit of the thermionic amplifiers 18 and 19. At the same time, the capacity elements 26 should be of such magnitude with respect to the other elements of the circuit as to permit the symmetrical amplifying circuit to reamplify in the manner of the well-known super-regenerative circuit.

A quenching oscillator 27 is provided with an output circuit including a potentiometer resistance 28, one terminal of which is connected to ground as illustrated. A variable position tap 29 associated with the potentiometer and connected

through a large capacity blocking condenser 30 to the common terminal of coils 21 enables the oscillator 27 to impress quenching oscillations of any desired intensity upon the grid cathode circuit of the super-regenerative amplifier.

In operation, weak incoming oscillations received at a repeater station from one of the terminal stations or another repeater station are amplified by the super-regenerative receiver circuit of the radio repeating station and appear in the tuned anode circuit 15 with greatly increased intensity. These amplified oscillations are impressed through transformer 14 upon the antenna 13 by which they are emitted with an intensity sufficient to enable satisfactory reception at the second radio repeating station or a terminal station. In like manner, the second radio repeating station amplifies the received signals and retransmits them augmented in strength to be received on the antenna associated with the terminal receiving station. Monitoring at the radio repeating stations is effected by use of the amplifier 24 and receiver 25.

Any form of ultra-short wave oscillator may be used for the super-regenerative receiver. Moreover, the quenching action may be provided by any of the well-known methods. Quenching voltages derived from an oscillator or from an oscillator and amplifier may be impressed on the grids or on the plates of the ultra-short wave oscillator. It is also within the scope of the invention to make the high frequency oscillator oscillate also at the quenching frequency thus providing its own quenching voltage in accordance with circuits well known in the art.

In the case of multiplex ultra-short wave transmission the principal carrier wave may be simultaneously modulated by a plurality of subsidiary or intermediate frequency carrier waves each of which is in turn modulated in accordance with an individual message wave. In that event the transformer 23 at the repeater station is preferably designed to transmit the band of modulated intermediate frequency waves involved. The apparatus 24 is accordingly made to include band frequency selecting apparatus to enable any one or all of the intermediate frequency carrier bands to be separated from the others and demodulating apparatus for demodulating the selected intermediate frequency band. That would also involve an individual monitoring telephone connected to each demodulator or the usual monitoring operator's switching apparatus to enable receiver 25 to be connected to any demodulator at will.

Fig. 3 illustrates a modification of the repeater circuit of Fig. 2 in which an open ended or un-terminated rhombic antenna is used and the quenching oscillations are applied to the anodes of the ultra-short wave oscillator. The horizontal rhombic antenna 31 which may be of the type disclosed in the application of E. Bruce, Serial No. 513,063, filed February 3, 1931 is coupled by means of a variable tuned circuit 32 and variable coupling transformer 33 to the tuned circuit 15 of the ultra-short wave oscillator of the super-regenerative circuit. In most respects the ultra-short wave oscillator is identical with that of Fig. 2 although any suitable type of super-regenerative circuit may be employed. The quenching oscillator and amplifier 34 is connected by a high frequency transformer 35 to the plate circuit path of the high frequency oscillator. This enables the high impedance choke coils 21 to be dispensed with and simplifies the

circuit. The monitoring apparatus 24 and 25 may be identical with that of Fig. 2 and may accordingly serve as a simple audio-frequency amplifier with a magnetic core transformer 36, as shown in the case of a single channel, or as a multiplex channel selecting and detecting apparatus if the principal carrier wave be modulated by a plurality of intermediate frequency carrier waves for multiplex transmission.

10 What is claimed is:

1. The method of repeating attenuated radiant energy waves which comprises absorbing said waves by an absorbing conductor, super-regeneratively amplifying said waves, and reimpressing the resulting amplified waves upon the absorbing conductor for emission whereby amplification free from excessive distortion is provided.

2. An ultra-short wave radio repeater comprising an elevated support, a dipole absorbing and emitting antenna mounted thereon and a super-regenerative amplifier coupled to said antenna to receive weak incoming energy therefrom and to impress amplified outgoing energy thereon.

3. An electrical wave repeater comprising a receiving and retransmitting circuit and means associated therewith including a super-regenerative amplifier for receiving weak oscillations from said circuit, amplifying said oscillations, and impressing the amplified oscillations upon said circuit.

4. A radio repeater comprising an antenna and means connected thereto for receiving waves therefrom, amplifying said received waves and impressing said amplified waves upon said antenna for reradiation thereby, the incoming energy connections and the outgoing energy connections to said antenna being non-conjugate.

5. A two-way ultra-short wave radio telephone system comprising telephone stations, circuits respectively connecting each of said stations to an ultra-short wave radio transmitting and receiving station, the terrain between said ultra-short wave stations or the distance between

them being such that there is no direct optical path connecting them and a two-way radio repeating station located effectively between said ultra-short wave stations and comprising a super-regenerative amplifier electrically connected to a radiant energy absorbing and radiating element.

6. An ultra-short wave radio repeater circuit comprising two electric discharge amplifiers each having a cathode, a control element and an anode, an input path connecting said control elements symmetrically with respect to said cathodes, a source of quenching oscillations connected between said cathodes and a central point of said input path, a tuned circuit symmetrically connected between said anodes and feedback paths connecting the control element of each amplifier to the anode of the other amplifier.

7. The method of communication between two points by means of electric waves traversing a medium connecting said points, in which the separation of the points is such that the normal attenuation experienced in the medium by the waves in direct transmission from one point to the other is in excess of that permissible for satisfactory direct communication therebetween, comprising diverting a portion of the electric wave energy from said medium at a point electrically intermediate the two first-mentioned points, reamplifying said energy repeatedly at said intermediate point, reimpressing it upon the medium in greatly augmented volume and checking the reamplification at an intensity short of that which would cause excessive distortion.

8. An ultra-short wave radio repeater comprising an absorbing and emitting antenna and a super-regenerative amplifier coupled to said antenna to receive weak incoming oscillations therefrom and to amplify said oscillations and to impress the amplified oscillations thereon to be retransmitted therefrom as outgoing oscillations.

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