Nov. 17, 1925. 1,562,056

C. W. RICE

RADIO RECEIVING SYSTEM

Filed April 21, 1921 2 Sheets-Sheet 1

Fig. 1.

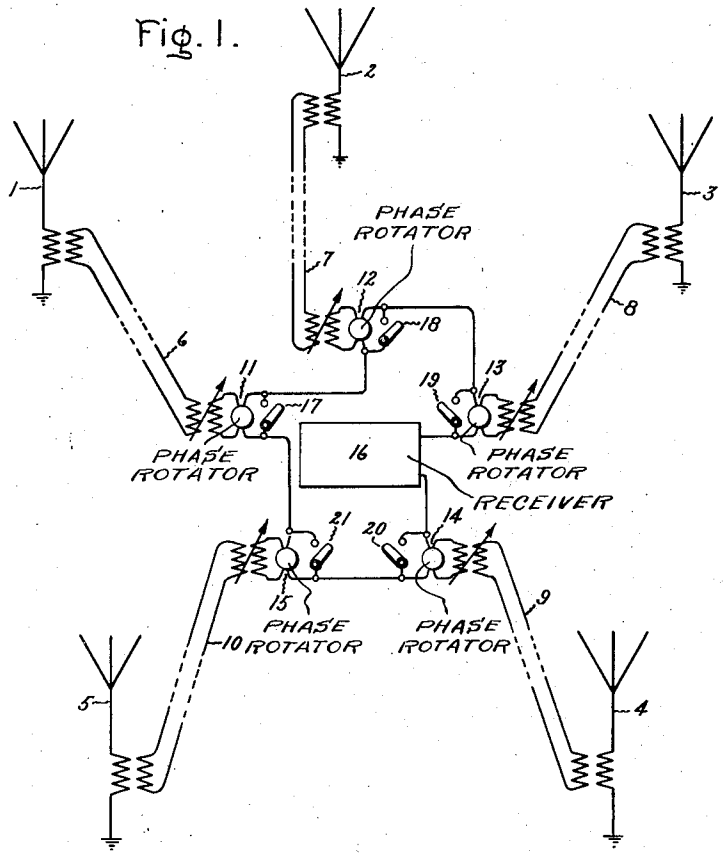
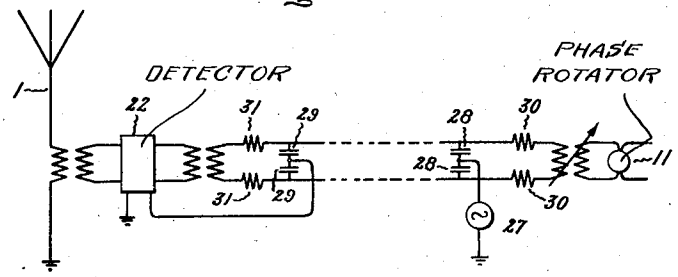


Fig. 3.



Inventor:
Chester W. Rice,
by Albert G. Davis
His Attorney.

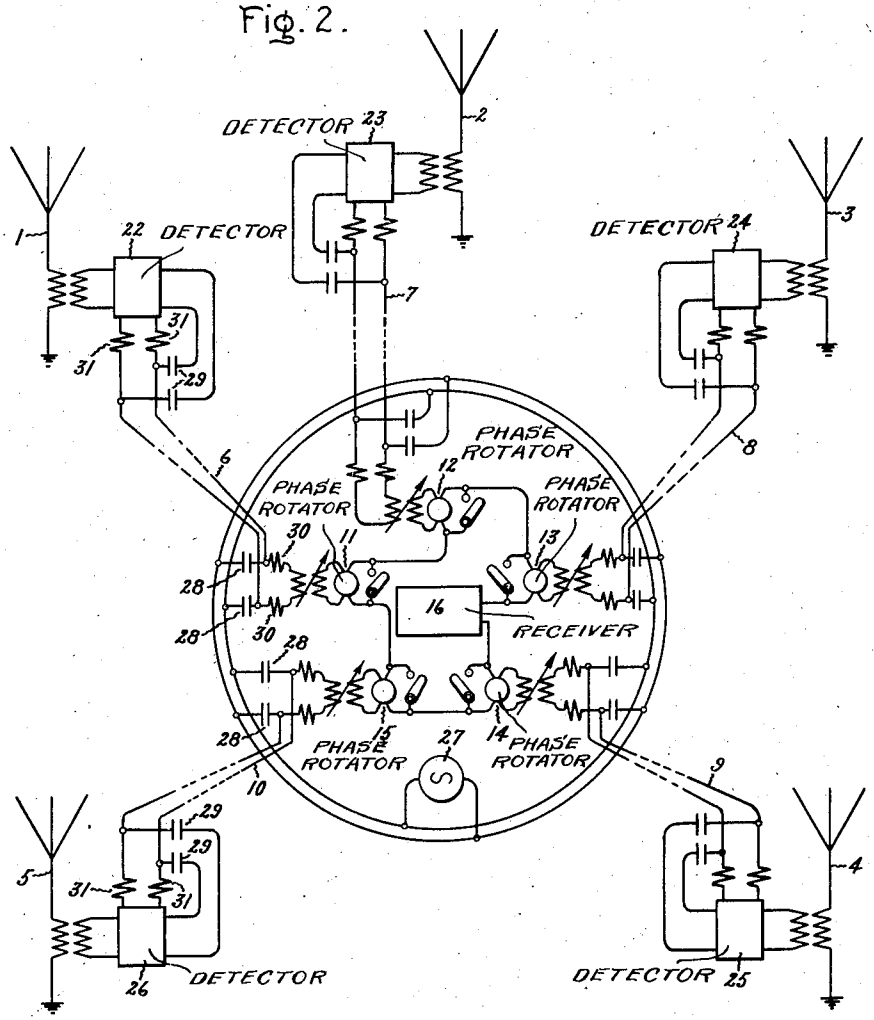
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Fig. 2.



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UNITED STATES PATENT OFFICE.

CHESTER W. RICE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

RADIO RECEIVING SYSTEM.

Application filed April 21, 1921. Serial No. 463,102.

To all whom it may concern:

Be it known that I, CHESTER W. RICE, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Radio Receiving Systems, of which the following is a specification.

My present invention relates to radio receiving systems, and more particularly to systems of the class in which a plurality of widely separated receiving antennæ are connected by transmission lines to a central receiving station.

One of the objects of my invention is to provide an improved method of operating such a system whereby an efficient reception of desired signals may be secured and the effects of disturbing influences either from nearby stations or from static may be minimized. Another object of my invention is to provide an improved system of the class described whereby a more efficient reception of desired signals may be obtained.

In order to attain the objects of my invention I provide a plurality of receiving antennæ which are located at widely separated points, so chosen geographically that the intensity or phase relation between the signaling impulses and disturbing influences will be different at the different points of reception. I also provide means for selectively impressing the currents received upon the receiving apparatus so that it will be possible to select for the desired reception the currents having the most favorable ratio between signal and disturbing influence. In addition I provide means for varying the phase and intensity of the currents impressed upon the receiving apparatus so that by suitable adjustment the designed signaling currents received upon different antennæ may be brought into phase or approximate phase with one another and caused to add amplitudes in the receiving apparatus while the disturbing influences will at the same time be more or less out of phase and will combine in heterogenous phase relation and therefore increase less rapidly than the desired signals with an increasing number of receiving antennæ. As a result what is commonly known as the stray ratio; that is, the ratio between the strength of the signaling currents and stray currents, will be greatly improved.

When the receiving antennæ are widely separated long transmission lines must be employed for transmitting the received signaling currents to the receiving station. This involves difficulties in line construction to reduce the line losses to a minimum. To overcome this disadvantage I may provide detectors at each of the receiving antennæ and transmit the detected currents over the transmission lines to the central receiving station. As a result the line construction may be greatly simplified and the line losses greatly reduced. In case continuous wave signals are to be received it is desirable that the detected currents shall all be of the same frequency. To secure this result I provide a single source of current at the receiving station for controlling the operation of all of the detectors and utilize the transmission lines for transmitting this current to the individual detectors. This source may be of a frequency near that of the signals to be received so that audible frequency beats may be readily produced by the detectors. In this case efficiency of transmission for the high frequency current is not so important as the source of control current may easily be made to furnish the small amount of energy required for the operation of the detectors even though the transmission losses are comparatively large.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, my invention itself however both as to its organization and method of operation will best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 shows diagrammatically a simple form of receiving system whereby my invention may be carried into effect when the transmission lines are employed for conveying the radio frequency signaling currents to the receiving station; Fig. 2 illustrates a modification of my invention in which detectors are provided for each receiving antenna and the control current is sent out over the transmission lines from the receiving station to each of these detectors for producing currents of lower frequency for transmission to the receiving station; and Fig. 3 illustrates

a modification in the manner of transmitting the control currents from the receiving station to the individual detectors.

As indicated in Fig. 1, my receiving system comprises a plurality of widely separated receiving antennæ 1, 2, 3, 4, 5, connected by individual transmission lines 6, 7, 8, 9, 10, to a receiving station. These antennæ may be of any particular type desired and their locations may be so chosen and so widely separated that the intensity and phase relations between the desired signaling currents and disturbing influences either of static or interfering stations will normally be different at the different antennæ.

While I have indicated all of the receiving antennæ as being located at a distance from the receiving station, it is obvious that if desired one of them may be located at the receiving station. The currents received upon the individual antennæ may be impressed by means of the usual coupling transformers upon the transmission lines and at the receiving station the signaling currents transmitted over the transmission lines may be impressed by means of intensity couplers upon phase rotators 11, 12, 13, 14, 15, all of which may be connected to the receiving apparatus. The receiving apparatus which may be of any type desired, is indicated merely by the rectangle 16. Any convenient means such, for example, as switches 17, 18, 19, 20, 21, may be employed for selectively impressing upon the receiving apparatus the currents received upon any one or more of the antennæ. By varying the adjustment of the phase rotators and intensity couplers the desired signaling currents received upon any two or more of the antennæ may be brought into phase or approximate phase with one another so as to add amplitudes in the receiving apparatus while the currents due to disturbing influences will at the same time be more or less out of phase and will combine in heterogeneous phase relation. The apparatus indicated may be utilized for receiving in a large variety of ways. It may be found that currents received upon one of the antennæ have a much more favorable stray ratio than the currents received upon any of the other antennæ, in which case the current having the most favorable stray ratio may be selected for the desired reception, and this current alone impressed upon the receiving apparatus.

By selectively combining the currents from two or more different antennæ in different ways and with varying phase and intensity adjustments, a combination may be obtained which gives a more favorable stray ratio than any antenna alone and this particular combination may then be utilized for the desired reception. By means of the apparatus indicated, the individual antenna or combination of antennæ employed for reception may be varied at will to meet varying disturbing conditions, such, for example, as disturbances produced by thunderstorms travelling across the country in such a way that at one time one of the receiving antennæ is most seriously affected while a little later one of the other antennæ is affected to a greater extent.

In the arrangement thus far described it is assumed that the signaling currents of radio frequency are transmitted over the transmission lines to the receiving station. Since these transmission lines will preferably be of considerable length special precautions may be required in the construction of the transmission lines to minimize and balance the transmission losses, and in any case, there will be unavoidable losses in transmission which may prevent satisfactory reception. To overcome such disadvantages I have shown in Fig. 2 individual detectors 22, 23, 24, 25, 26, associated with the different antennæ for detecting the received currents and producing at each receiving point a current of a lower, preferably, audible frequency for transmission over the transmission lines to the receiving station. It is of course desirable that the lower frequency currents thus produced for transmission should all have the same frequency, and to insure that they shall have the same frequency I provide a source of control current 27 at the receiving station. Current supplied by this source is transmitted over the individual transmission lines to the detectors to control their operation. This control current may be of a frequency only slightly different from that of the signaling currents. The control current may be impressed upon the transmission lines through the condensers 28 at the receiving station and from the transmission line to the detectors through condensers 29 at the separate receiving points. These condensers should be of such value as to offer a high impedance to low frequency signaling currents transmitted whereby the efficiency of transmission of the low frequency currents will be unimpaired. Choke coils 30 at the central receiving station, and 31 at the individual receiving points, may be provided to keep the higher frequency control currents from circulating in portions of the circuit where they are not desired. The individual phase rotators, intensity couplers, and selective switches are provided at the receiving station in this case, and may be operated in the same manner as the corresponding elements in the system shown in Fig. 1. In this case the transmission lines need only be designed for efficient transmission of the low frequency currents as the source 27 may readily be made large enough to supply all of the power required for the operation of

the detectors altho the line losses may be comparatively large.

In Fig. 3, I have shown diagrammatically a modification of the manner in which the control current is transmitted over the transmission lines. In this case the two conductors of the transmission line connected in parallel are used for one side of the control current circuit and a ground return is used for the other side.

While I have indicated and described the preferred embodiments of my invention, it will be apparent that my invention is by no means limited to the particular embodiments shown and described, but that many modifications in the arrangement, connections, and method of operating the apparatus, may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The method of operating a radio receiving system comprising a plurality of widely separated receiving antennæ and local detectors connected by transmission lines to a central receiving station which consists in transmitting over the transmission lines from the central receiving station to each local detector radio frequency currents, producing by means of the currents thus transmitted audio frequency currents, transmitting the audio frequency currents thus produced to the receiving station, selectively impressing upon the receiving apparatus the audio frequency currents thus transmitted, and selecting for the desired reception of signals the currents having the most favorable stray ratio.

2. The method of operating a radio receiving system comprising a plurality of widely separated receiving antennæ and local detectors connected by transmission lines to a central receiving station which consists in transmitting over the transmission lines from the central receiving station to each local detector radio frequency currents, producing by means of the currents thus transmitted audio frequency currents, transmitting the audio frequency currents thus produced to the receiving station, selectively impressing upon the receiving apparatus the audio frequency currents thus transmitted, adjusting the phase and intensity of the currents impressed upon the receiving apparatus from the different detectors so that the currents produced by desired signals will add amplitudes in the receiving apparatus, and currents produced by disturbing influences will combine in heterogeneous phase relation, and selecting for the desired reception of signals the resulting combination of currents having the most favorable stray ratio.

3. The method of operating a radio receiving system comprising a plurality of widely separated receiving intennæ and local detectors connected by transmission lines to a central receiving station which consists in transmitting over the transmission lines from the central receiving station to each local detector a current for controlling the operation of the detector, producing by means of the currents thus transmitted audio frequency currents at each detector, transmitting the audio frequency currents thus produced to the receiving station, selectively impressing upon the receiving apparatus the audio frequency currents thus transmitted, and selecting for the desired reception of signals the currents having the most favorable stray ratio.

4. The method of operating a radio receiving system comprising a plurality of widely separated receiving antennæ and local detectors connected by transmission lines to a central receiving station which consists in transmitting over the transmission lines from the central receiving station to each local detector a current for controlling the operation of the detector, producing by means of the currents thus transmitted audio frequency currents, transmitting the audio frequency currents thus produced to the receiving station, selectively impressing upon the receiving apparatus the audio frequency currents thus transmitted, adjusting the phase of the currents impressed upon the receiving apparatus from the different detectors so that the currents produced by desired signals will add amplitudes in the receiving apparatus, and currents produced by disturbing influences will combine in heterogeneous phase relation, and selecting for the desired reception of signals the resulting combination of currents having the most favorable stray ratio.

5. The combination in a radio receiving station of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of control current at the receiving station for controlling all of the detectors, means for impressing the control current upon the transmission lines, means for impressing the control current flowing in the transmission lines upon the detectors to produce currents therein of a frequency lower than that of the signals to be received, means for impressing the currents of lower frequency thus produced upon the transmission lines, means for selectively impressing the currents of lower frequency transmitted upon the receiving apparatus, and means for adjusting the phase and intensity of the currents thus impressed upon the receiving apparatus.

6. The combination in a radio receiving station of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of control current at the receiving station for controlling all of the detectors, means for impressing the control current upon the transmission lines, means for impressing the control current flowing in the transmission lines upon the detectors to produce currents therein of a frequency lower than that of the signals to be received, and means for impressing the currents of lower frequency thus produced upon the transmission lines.

7. The combination in a radio receiving station of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of high frequency control current at the receiving station for controlling all of the detectors, means for impressing the control current upon the transmission lines, means for impressing the control current flowing in the transmission lines upon the detectors to produce currents therein of a frequency lower than that of the signals to be received, and means for impressing the currents of lower frequency thus produced upon the transmission lines.

8. The combination in a radio receiving station of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of control current at the receiving station of slightly different frequency from that of the signals to be received for controlling all of the detectors, means for impressing the control current upon the transmission lines, means for impressing the control current flowing in the transmission lines upon the detectors to produce currents therein of a frequency lower than that of the signals to be received, and means for impressing the currents of lower frequency thus produced upon the transmission lines.

9. The combination in a radio receiving station, of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ for producing by means of signaling currents to be received currents of lower frequency, means for impressing the currents of lower frequency thus produced upon the transmission lines, means for selectively impressing the currents of lower frequency transmitted upon the receiving apparatus, and means for adjusting the phase and intensity of the currents thus impressed upon the receiving apparatus.

10. The combination in a radio receiving system of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of control current at the receiving station of slightly different frequency from that of the signals to be received for controlling all of the detectors, means for impressing the control current upon the transmission lines, means for impressing the control current flowing in the transmission lines upon the detectors to produce audio frequency currents therein and means for impressing the audio frequency currents thus produced upon the transmission lines.

11. The combination in a radio receiving system of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of control current at the receiving station of slightly different frequency from that of the signals to be received for controlling all of the detectors, means for impressing the control current upon the transmission lines, means for impressing the control current flowing in the transmission lines upon the detectors to produce audio frequency currents therein, means for impressing the audio frequency currents thus produced upon the transmission lines, means for selectively impressing the audio frequency currents transmitted upon the receiving apparatus, and means for adjusting the phase and intensity of the currents thus impressed upon the receiving apparatus.

12. The combination in a radio receiving station of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of control current at the receiving station for controlling all of the detectors, means for transmitting the control current to all of the detectors to produce currents therein of a frequency lower than that of the signals to be received, and means for impressing the currents of lower

frequency thus produced upon the transmission lines.

13. The combination in a radio receiving station of a plurality of widely separated receiving antennæ, receiving apparatus located at a central receiving station, transmission lines connecting each of said receiving antennæ with the receiving station, a detector associated with each of said antennæ, a source of control current at the receiving station of slightly different frequency from that of the signals to be received for controlling all of the detectors, means for transmitting the control current to all of the detectors to produce audio frequency currents therein and means for impressing the audio frequency currents thus produced upon the transmission lines.

14. The method of operating a radio receiving system comprising a plurality of widely separated receiving antennæ connected by transmission lines to a central receiving station which consists in producing at each antenna by means of signaling currents received thereon currents of lower frequency, transmitting the currents of lower frequencies over the transmission lines to the receiving station, selectively impressing upon the receiving apparatus the lower frequency currents thus transmitted, adjusting the phase and intensity of the currents impressed upon the receiving apparatus from the different transmission lines so that the currents produced by desired signals will add amplitudes in the receiving apparatus and currents produced by disturbing influences will combine in heterogeneous phase relation and selecting for the desired reception of signals the resulting combination of currents having the most favorable stray ratio.

In witness whereof, I have hereunto set my hand this 20th day of April, 1921.

CHESTER W. RICE.