May 28, 1940. L. M. LEEDS 2,202,699

TRANSMISSION APPARATUS

Filed Dec. 21, 1935 2 Sheets-Sheet 1

Fig. 1.

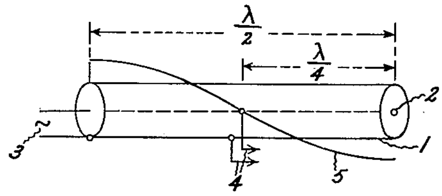


Fig. 2.

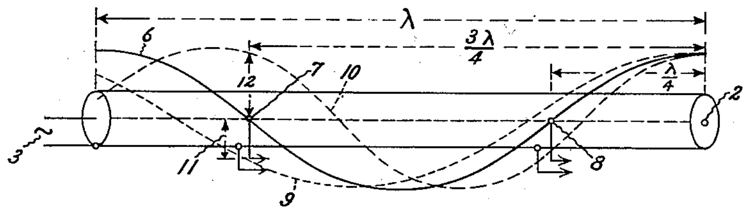


Fig. 3.

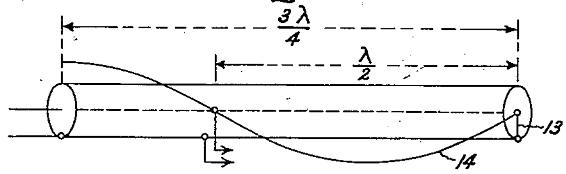
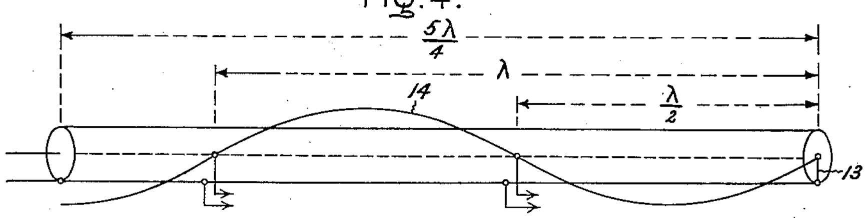


Fig. 4.



Inventor:
Laurance M. Leeds,
by Harry E. Dunham
His Attorney.

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Fig. 5

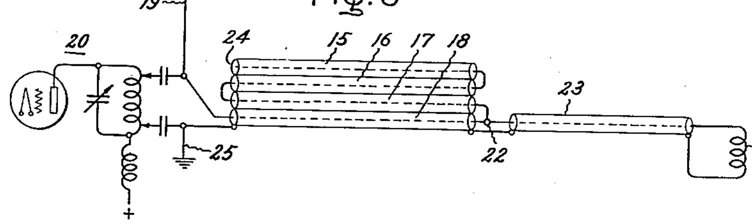


Fig. 6.

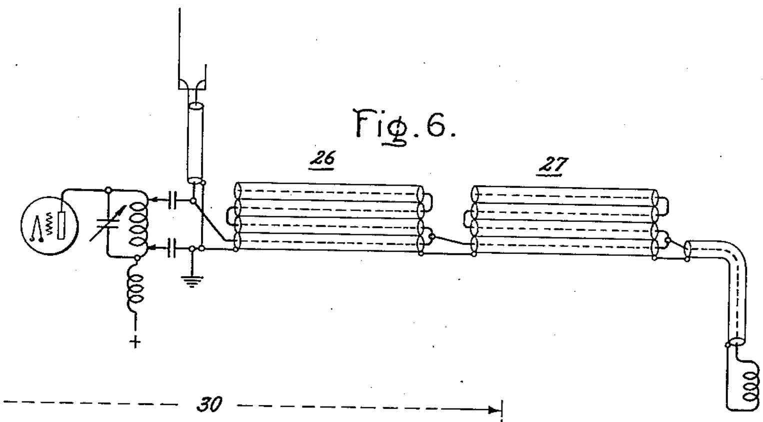


Fig. 8.

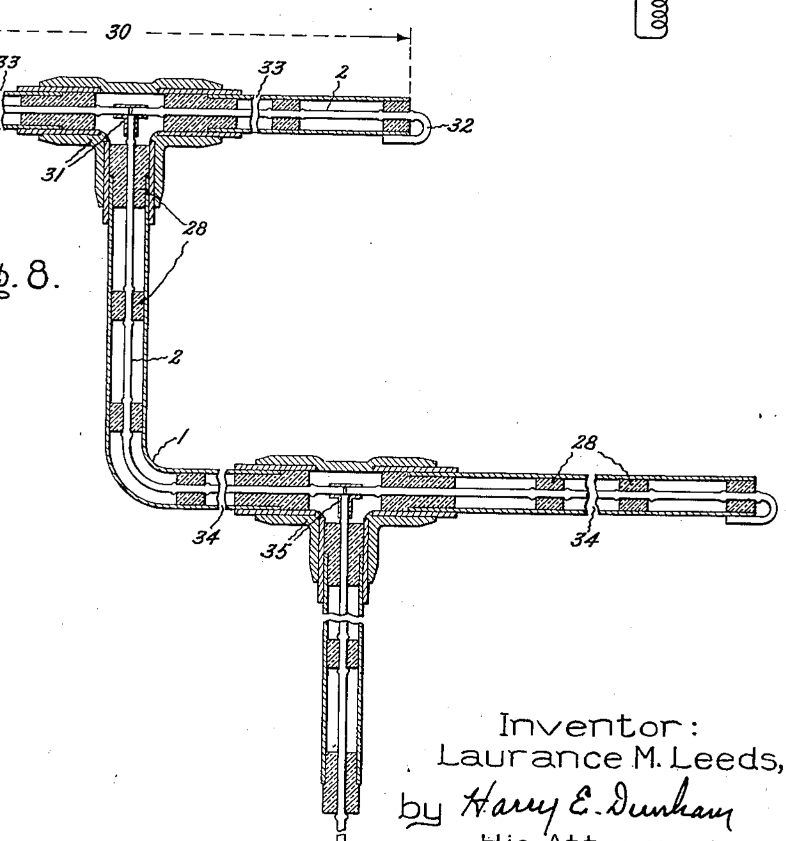
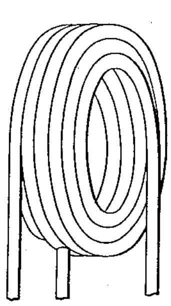


Fig. 7.



Inventor:
Laurance M. Leeds,
by Harry E. Dunham
His Attorney.

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UNITED STATES PATENT OFFICE

2,202,699

TRANSMISSION APPARATUS

Laurance M. Leeds, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application December 21, 1935, Serial No. 55,584

5 Claims. (Cl. 250—9)

My invention relates to short wave apparatus and more particularly to frequency selective transmission apparatus for operation at short wavelengths.

One of the objects of my invention is to provide a short wave transmission system having an improved band elimination characteristic.

A further object of my invention is to provide such a system capable of efficiently transmitting currents of a desired frequency and of highly attenuating currents of undesired frequency even though the frequencies be spaced relatively closely in the short wave range of the frequency spectrum.

My invention is particularly adapted for use, for example, in police communication systems for efficiently separating oscillations to be received, for example, in an automobile receiver, from oscillations radiated from a transmitter at the same time and from the same automobile and which may be connected, for example, to the same antenna. One range of frequencies commonly employed for such communication extends approximately from thirty to forty-two megacycles. Since the receiver on a police automobile, or at a police station, for simultaneous transmission and reception must operate at a frequency different from that at which the associated transmitter operates, and since the frequency band is comparatively narrow, it is important that means be associated with the receiver which will greatly attenuate the transmitter frequency. In this way the spacing between transmitted and received frequencies may be reduced and the band may be more efficiently utilized. An object of my invention is to provide improved means for this purpose.

The use of concentrated inductances and capacitors connected in conventional frequency selective circuits are quite unsatisfactory for operation at short wavelengths because of excessive attenuation at the desired frequencies produced by reason of the high resistance of such circuit elements at the frequencies involved. In addition stray inductance and capacity undesirably affect the impedance values obtainable and thus reduce the selectivity of the apparatus and in general detract from the quality of the filter characteristic obtainable.

It has been found in accordance with my invention that these difficulties are greatly reduced by the use of the standing wave transmission line in the manner which I shall presently describe.

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 together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawings. Figs. 1 to 4 respectively illustrate the use of standing wave transmission lines of different length in accordance with my invention, and Figs. 5, 6, 7, and 8 illustrate certain structural details of such a line when utilized in accordance with my invention.

Referring to Fig. 1 I have indicated therein a section of a concentric transmission line comprising an outer conducting tube 1 and an inner centrally disposed conductor 2. If oscillations be impressed upon the conductor 2 of this concentric line, as indicated at 3, it will be seen that a standing wave will be produced upon the line. This standing voltage wave has a maximum at the right end of the line, since the transmission line is there open circuited, a minimum value at a point one-quarter of a wavelength of the impressed oscillations from the right end, and a maximum at a half wavelength from the right end, all as indicated by the curve 5. Such a standing wave is produced upon the line irrespective of the frequency impressed, but the point upon the transmission line at which the nodal point of the standing wave exists is, of course, dependent upon the frequency of the standing wave. Accordingly, if the source 3 be one producing an undesired frequency, the receiving equipment may be connected to the transmission line at the nodal point of the undesired wave, as for example by conductors 4, and substantially no voltage of the undesired frequency will be impressed upon the receiving equipment. Voltage of any other frequency present may be received.

Fig. 2 is similar to Fig. 1 with the exception that the transmission line is represented as having a length equal to a full wavelength of the frequency which it is desired to exclude from the receiving equipment. The standing wave of this undesired frequency is represented by the curve 6 thereon. It will be observed that this wave has two nodal points, one occurring at the point 7, which is three-quarters of a wavelength from the right end thereof and the other at the point 8, which is one-quarter of a wavelength from the right end thereof. Of course, if the transmission line be longer these points occur at each odd multiple of a quarter wavelength of the undesired oscillation from the open end of the transmission line. Curves 9 and 10 represent the standing waves of two frequencies respectively lower and higher than the undesired frequency and which may also be impressed on the line from source 3. It will be observed that the nodal points of these frequencies occur at points considerably displaced along the transmission line from the nodal points of the curve 6 and further, that the amplitude of these latter oscillations at the points 7 and 8 corresponding to the nodal points of the undesired wave are of considerable magnitude as is indicated at 11 and 12. Accordingly, if the receiving equipment be connected between the central conductor 2 and the shield 1 at these nodal points the undesired wave 6 will be completely excluded therefrom whereas oscillations of the frequency corresponding to waves 9 and 10 will be received.

It will further be noticed that the amplitude of oscillations of the frequency represented by the curves 9 and 10 is greater at the point 7 than at the point 8. Accordingly, while the receiving equipment may be connected at either of these points preferably it is connected at the point 7. In addition the amplitudes of oscillations represented by curves 9 and 10 at the point 7 of the transmission line are far greater than the amplitude of oscillations supplied to the line by the source 3. Thus by suitable selection of the point of connection of the receiving equipment the undesired wave may not only be excluded but a substantial step up in voltage of the desired wave may be obtained.

Figs. 3 and 4 differ from Fig. 1 in that they represent transmission lines in which the inner conductor is connected to the outer conductor at the right end thereof as indicated at 13. It will be seen on these lines that nodal points of the undesired wave represented by the curves 14 occur at points spaced from the closed end 13 by a half wavelength of the undesired wave or any multiple thereof. Accordingly, these points are points at which a receiving apparatus may be connected to receive oscillations of frequencies other than that which it is desired to exclude.

Fig. 5 represents an application of my invention in which the transmission line comprises a number of sections 15, 16, 17, 18 of transmission line of any desired length connected in series and folded back upon each other into a layer. Of course, if desired the shield may be extended over the inner conductor at the ends of the sections in any suitable manner. Oscillations of a frequency to be received are impressed upon this transmission line from an antenna 19. This antenna, as in the police application above referred to, in addition to its function as a receptor of radiant energy which it is desired to receive may also act as the radiating member for transmitting equipment, a portion of which is indicated at 20. This transmitting equipment may operate at a frequency different from that which it is desired to receive through the transmisison line, and accordingly the receiving equipment, an input element of which is represented on the drawing by the coil 21, is connected to the transmission line at a point 22 corresponding to a nodal point of voltage of the frequency at which the transmitting equipment 20 operates. This connection of the receiving equipment 21 may be made through a shielded cable 23 upon which either standing or travelling waves occur. It will be seen that the inner conductor of the transmission line 15, 16, 17, 18 is disconnected from the shield at the end 24 and accordingly the point 22 is spaced from the end 24 by a distance along this line equal to a quarter of a wavelength of the frequency at which the transmitter operates, or some suitable odd multiple thereof. The different sections of the line may be folded back upon each other as indicated and the shields thereof securely conductively bonded together and grounded as indicated at 25. In this way the line is prevented from itself acting as a receptor of radiant energy and all of the energy impressed upon the line is received either from the antenna 19 or transmitter 20 and appears on the line as oscillations between the inner and outer conductors.

It has been found in accordance with my invention that such an equipment operates very efficiently at short waves to exclude undesired frequencies. That is, the equipment has a highly desirable band pass frequency characteristic. In fact, it has been found that when operating in the 30 to 42 megacycle band with equipment in accordance with my invention adapted for police operation that oscillations radiated by a transmitter mounted on the automobile carrying my equipment could be satisfactorily eliminated from the receiving equipment by use of my invention even though the frequency which it was desired to receive was spaced only approximately 1 megacycle from the frequency at which the transmitter operated. By use of my invention even closer spacing is entirely practical.

Such a filter, it will be seen, possesses further advantages in the manner in which it may be mounted in an automobile. Since the outer conductor of the different sections is at ground potential and completely shields the inner conductor upon which the standing wave occurs, it may be conveniently mounted permanently into the frame or body of the automobile, or if desired it may be rolled up as indicated in Fig. 7 and stored in the rear end trunk now commonly provided upon automobiles.

In the case of a high power transmitter, for example, where one section of filter is insufficient to exclude the undesired frequency to the extent desired, a number of sections may be provided as shown in Fig. 6 where two sections 26 and 27 are indicated as connected in cascade, the input to section 27 being connected to a point on section 26 where a nodal point of the voltage which it is desired to exclude occurs, and similarly the receiving equipment being connected to a point on section 27 where a nodal point of the undesired wave occurs.

Fig. 8 represents in greater structural detail a two-section filter, such as that shown in Fig. 6. It will be seen that the center conductor 2 is mounted within the shield 1 of the concentric transmisison line by means of suitable insulating beads 28 of a type now commonly employed in concentric transmission line practice. The length 30 of the transmission line of Fig. 8 comprises a filter section corresponding to the section 26 of Fig. 6. The second section of the filter corresponding to section 27 of Fig. 6 is then connected to the length 30 by means of suitable T joints 31, this connection, of course, being made at a nodal point of the undesired wave. Since in this figure the inner conductor 2 is indicated as connected to the shield at the point 32, the T connection is, of course, made at a distance from the end 32 equal to a half wavelength, or a suitable multiple thereof, of the oscillations which it is desired to exclude. It will be noted that the length 30 is indicated as broken at the point 33 to indicate additional length. Similar breaks for the same purpose are indicated at 34 in the second section of the filter. The receiver is connected to the second section of the filter by means of the T joint connection 35.

The transmission line constructed as illustrated in the drawings, of course, has an input impedance at the antenna end, as in Figs. 5 and

6 for example, which is high as compared with the impedance of the antenna which might be utilized at 19 in the wave band referred to. This input impedance, may for example, be in the neighborhood of several thousand ohms whereas the impedance of the antenna utilized upon an automobile and connected as shown in Fig. 5 may be about thirty-six ohms. In a particular transmission line of three quarters of an inch in diameter and a multiple of a quarter wavelength in length the input impedance was of the order of 10,000 ohms. This, of course, aids materially in eliminating from the receiver the transmitted wave. The transmitted power of course divides between the antenna and transmission line in inverse proportion to these impedances and hence it is but a small portion of it which penetrates the transmission line. The line, of course, may be constructed to have as large input impedance as practicable to aid in eliminating the transmitted wave from the receiver.

While in the different figures of the drawings I have shown filters comprising transmission lines of the concentric type, it will be understood that I do not wish to be limited thereto since open wide transmission lines comprising merely a pair of parallel conductors may likewise be employed. The concentric line, however, has decided advantages over an open, or unshielded, wire line. An unshielded line, for example, produces a certain amount of radiation with the result that it possesses a certain amount of radiation resistance. This in turn results in greater voltage of the undesired frequency at the points of minimum voltage of the undesired wave. The concentric line, on the other hand, produces substantially no radiation and its radiation resistance is substantially zero with the result that substantially no voltage of the undesired frequency exists at the nodal points of the undesired wave.

While I have shown particular embodiments of my invention it will be understood that I do not wish to be limited thereto since different modifications may be made without departing from the spirit and scope of my invention. I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. In a short wave radio signal system comprising a short wave antenna, and a transmitter and receiver connected thereto and adapted for operation at different wavelengths, a standing wave transmission line connected to said antenna to have oscillations of each of said wavelengths at which said transmitter and receiver operate impressed between the two conductors thereof at the end of said line adjacent said antenna, means to excite on said line standing waves of each of said different wavelengths and to produce on said line a node of voltage of the wavelength at which the transmitter operates between said conductors at a certain point where exist substantial voltages of the wavelength at which the receiver operates, and means to connect said receiver between said conductors at said point.

2. In a short wave radio receiving system comprising an antenna for intercepting waves of a desired short wavelength, said antenna having waves impressed thereon of different undesired short wavelength, and a receiving device, a high frequency standing wave transmission line connected to said antenna to have said waves of each of said wavelengths impressed on the opposite conductors thereof in opposite phase, means including said antenna to produce in said transmission line a standing wave of said undesired wavelength having a plurality of nodal voltage points thereon and to cause the voltage wave of the desired wavelength to have an amplitude at one of said nodal points larger than the voltage of the desired wavelength at said antenna, and means to connect said receiving device between said conductors at said point.

3. In a short wave radio signal system comprising a short wave transmitter, a short wave receiver and a short wave antenna connected to both said transmitter and receiver, a standing wave transmission line connected to said antenna and having a length equal to a multiple of a quarter of a wavelength of the wave radiated by said antenna, means including said antenna to produce a standing wave of said wavelength on said transmission line, means to connect said receiver across said line at a point where said standing wave has a nodal point of voltage, said transmission line having an input impedance substantially higher than the impedance of said antenna whereby but a small portion of the energy produced by said transmitter penetrates said transmission line.

4. In a short wave radio receiving system comprising an antenna for intercepting waves of a desired short wavelength, an associated transmitter, said antenna having waves impressed thereon of different undesired short wavelength from said associated transmitter, and a load device for utilizing oscillations of said desired short wavelength, a band elimination filter comprising a pair of concentric conductors having a length equal to a multiple of a quarter of a wavelength of said undesired wavelength, means to connect said conductors at adjacent ends thereof to said antenna, means including said antenna to produce a standing wave in said pair of conductors having a nodal point of voltage of said undesired wavelength, and means to connect said load device between said conductors at said nodal point of voltage of said undesired wavelength, the impedance of said antenna being low as compared with the input impedance of the line comprising said pair of concentric conductors whereby but a small portion of the energy of said undesired wavelength penetrates said line.

5. In a short wave radio apparatus for mounting and operation on a motor vehicle comprising a short wave transmitter and a short wave receiver adapted to operate at different wavelengths, and a short wave antenna mounted on said motor vehicle and connected to both said transmitter and receiver, a standing wave transmission line connected to said antenna and having a length equal to a multiple of a quarter of a wavelength of the wave radiated by said antenna, means including said antenna to produce a standing wave of said wavelength on said transmission line, and means to connect said receiver across said line at a point where said standing wave has a nodal point of voltage.

LAURANCE M. LEEDS.