

Aug. 4, 1942.

H. SHORE

2,291,767

RADIO RELAY SYSTEM

Filed Aug. 17, 1940

2 Sheets-Sheet 1

Fig. 1

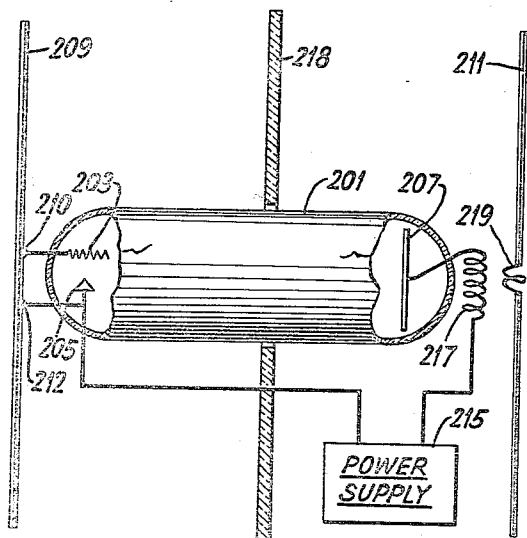


Fig. 3

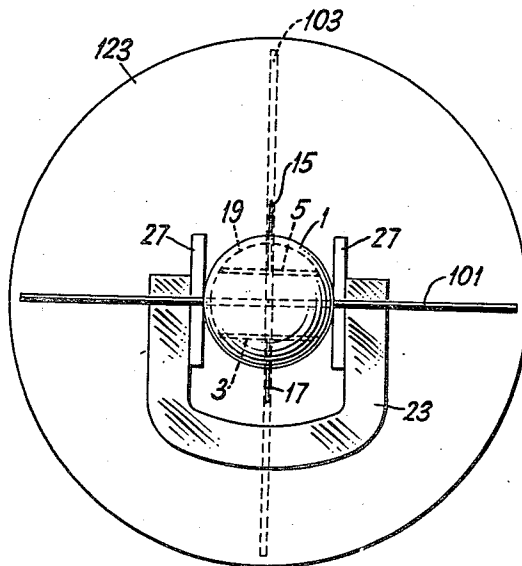
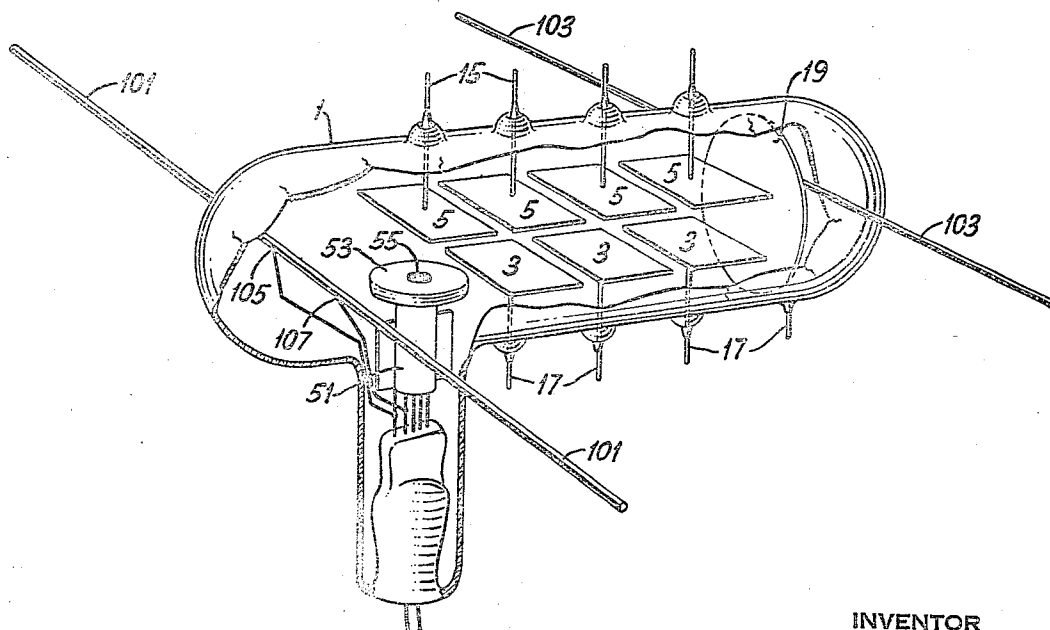


Fig. 2



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Fig. 4

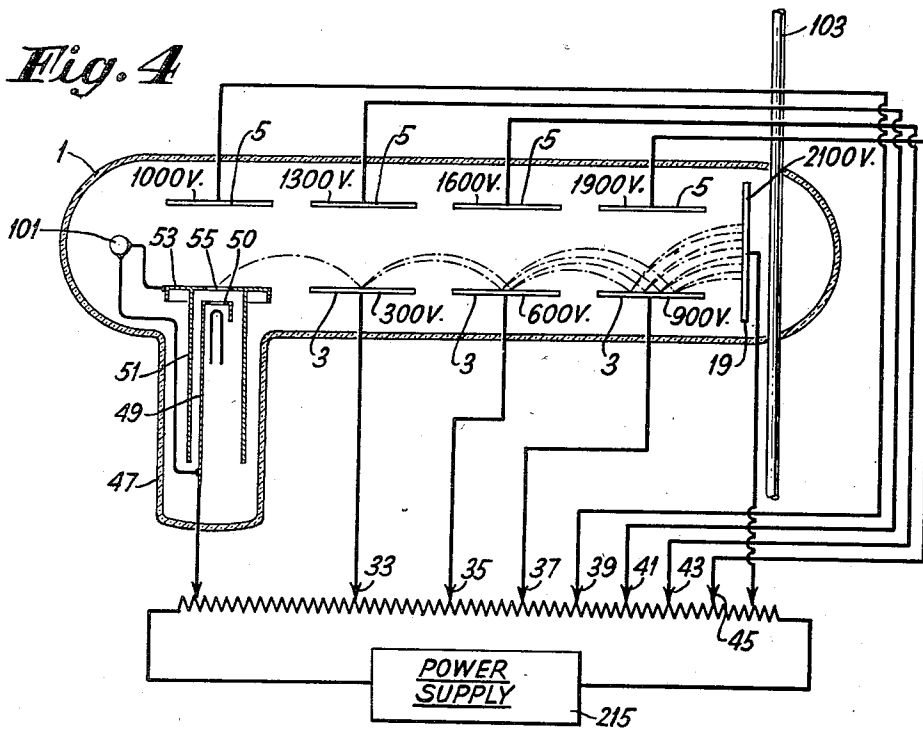
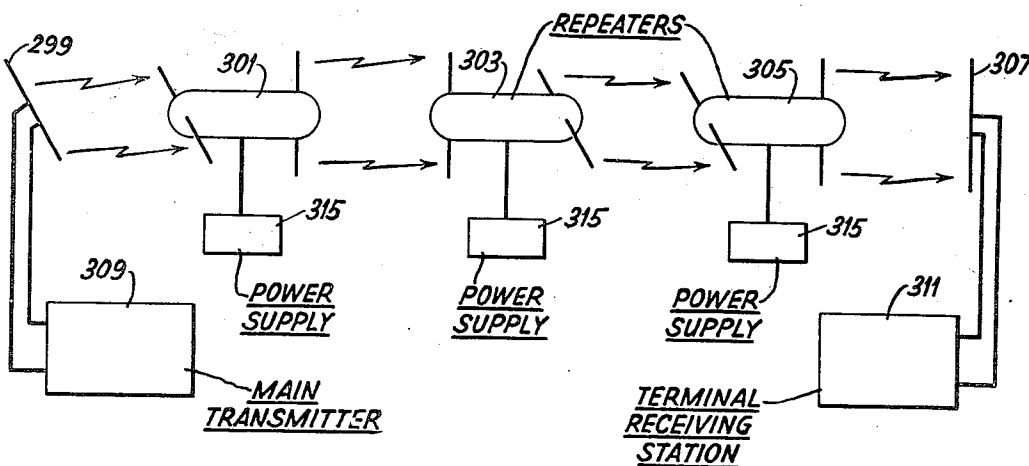


Fig. 5



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RADIO RELAY SYSTEM

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10 Claims. (Cl. 250—15)

This invention relates to signalling systems, and more particularly, to radio relay repeating stations in which the relay station comprises a receiving antenna directly coupled to a secondary electron multiplier and the transmitting antenna of the relay station directly coupled to the output circuit of the multiplier to provide a simple aperiodic repeating station.

In ultra-short wave radio transmission signalling systems the line-of-sight characteristic of the quasi-optical rays limits the distance over which transmission can be effective. For long-haul circuits, accordingly, it is necessary to provide relay or repeater stations at distances varying from on the order of 5 to 50 miles.

It is, accordingly, a purpose of this invention to provide such relay stations which shall be automatic, simple, easy to maintain, low in cost and having substantially an aperiodic frequency response over a wide band of frequencies so as to render the repeating station serviceable for television and multiplex transmission systems.

The invention also provides a repeating station which receives signals from either the main transmitter or a first repeating station and amplifies the signals substantially without distortion and retransmits them to another repeating station or a terminal receiving point.

In accordance with the invention, use is made of electron multipliers which have signal control means, such as static types described in Zworykin Patent No. 2,078,304 and the Malter Patent No. 2,073,599, and dynamic types of the kind described in Brown et al Patent No. 2,121,067 and Brown Patent No. 2,181,170. In these multipliers, it is well known that amplification is substantially distortionless over an almost limitless range of frequencies. Essentially, such types provide an electronic flow which is controlled as to its path, so that the electrons are caused to impact a predetermined number of impact surfaces which have high secondary electron emissivity and to release by virtue of the impact and the character of the surface, secondary electrons in greater number than the number of impacting electrons. In the static type of multiplier providing a plurality of stages, magnification of the original electron flow is rapidly built up. For example, if the ratio of secondary electrons to primary electrons is on the order of 5 per stage and 5 stages are provided, the total amplification is on the order of 70 db. This value of amplification is reasonable and on the order of those generally supplied to repeater stations.

In the dynamic type of multiplier, the number of secondary electron emissive surfaces is generally two, and control of amplification can be effected by regulating the number of impacts that the oscillating cloud of electrons makes.

Of course, it will be appreciated that more stages or more impacts in the secondary multiplier will increase the amplification accordingly, so that by providing a suitable number of stages or suitably controlling the number of impacts in the secondary electron multiplier, the desired gain per repeater station can be readily achieved. To simplify the repeating station, a directive dipole or di-pole antenna array receives the signals and supplies them directly to the secondary electron multiplier control means. The output of the multiplier is suitably coupled to the repeating station transmitting antenna and suitable means are provided to prevent feedback from the transmitting antenna to the receiving antenna to prevent distortion or oscillations. A suitable power supply, which, for convenience, may incorporate a rectifier and potential divider, is supplied to provide the necessary voltages for energizing the electrodes of the multiplier.

It will thus be perceived that the repeating station, therefore, embodies two di-poles, a multiplier and power supply, and in accordance with the invention, as will be pointed out below, the two di-poles themselves may be incorporated in the same envelope which houses the secondary electron multiplier.

To prevent feedback from the transmitting dipole to the receiving di-pole, a shield comprising a metallic plate, which surrounds the tube and extends outwardly beyond the periphery of the tube and beyond the ends of the transmitting and receiving antenna, may be provided.

Alternatively, the two di-poles may be positioned at right angles to each other so that, for example, the receiving antenna receives horizontally polarized waves, while the transmitting antenna transmits vertically polarized waves. The difference in the planes of polarization prevents interaction between the input and output circuits. If a number of repeating stations, embodying the invention, are used, then the alternate stations will have vertically polarized receiving antennas and horizontally polarized transmitting antennas. It will be appreciated, of course, that the shield member may also be used in addition to the two polarized antennas and that the shielding may actually take the form of parabolic reflectors to increase directivity.

To increase the range of propagation, it is

desirable to install the repeating station upon the top of a tower or pole and the repeating station, in accordance with the invention, lends itself readily to this, since the structure is small, together with the fact that its power consumption is likewise small, so that the power pack supplying the energizing voltages may also be mounted on top of the pole, since the power leads running thereto are reasonably small. The structure, of course, lends itself very readily to being mounted on power transmission lines from whence power can very readily be obtained for operating the relay repeating stations.

The foregoing summarizes, in general, the nature of the invention to be described herein and from the above summary it will be appreciated that among the aims and objects of this invention are those of providing an automatic, simple, efficient, stable and conveniently operated radio relay, especially useful and adaptable to use with ultra-short wave communication systems.

Still other objects and advantages of the invention will at once suggest themselves and become apparent to those skilled in the art to which the invention is directed by reading the following specification and claims in connection with the several figures of the accompanying drawings, wherein

Fig. 1 illustrates schematically an embodiment of the invention showing the two di-poles, the electron multiplier and shield and the power supply;

Fig. 2 shows a modification of the invention shown in Fig. 1 in which the di-poles are mounted within the envelope and a secondary electron multiplier, using electromagnetic focusing, is used;

Fig. 3 shows schematically a further modification in which the two di-poles are positioned at right angles to each other;

Fig. 4 shows schematically the connections of the multiplier from the power supply; while

Fig. 5 shows schematically a complete system using alternate planes of polarization for transmission and reception.

Referring now to the drawings, in Fig. 1 I have shown for convenience an electrostatic type of multiplier tube 201 schematically of the Zworykin-Malter type. The di-pole 209 is tapped at 210 and 212 at a suitable distance apart to provide proper voltage fed to the control electrode 203 and the cathode 205 both shown schematically. The output electrode of the multiplier 207 is connected to an inductance 217 and thence to the power supply 215. The di-pole 211 has a single loop 219 which is coupled to the inductance 217 for transferring energy, and a shield 218 surrounding the tube, which may be copper, extends beyond the ends of the di-poles 209 and 211 to prevent feedback from the di-pole 211 to the di-pole 209.

It will be appreciated, of course, that the shield 218 may take the form of two parabolas having their apices conjoin and suitably proportioned so as to place the di-poles 209 and 211 at the focal points of the parabola to increase the directivity thereof. Alternatively, an array of di-poles known as "canal guides" may be used in conjunction with both the receiving di-pole 209 and the transmitting di-pole 211 to increase directivity and power gain of reception and transmission.

Where the frequency used for relaying is on the order of 500 megacycles, the di-pole structure becomes very small, being only about 12

inches long. With such lengths it is feasible to mount the di-poles integral with the envelope containing the multiplier, as is shown in Fig. 2, in which a tube of the Zworykin-Malter type using an electromagnetic focusing field parallel to the face of the electrodes is used for focusing the electrons to impact upon the secondary emissive plates. In this figure, the receiving di-pole 101 is suitably tapped at 105 and 107 within the tube, and connected directly to the thermionic emitting cathode and the control electrode 53. The electromagnetic focusing and shield is not shown in Fig. 2, but is shown schematically in Fig. 3. The di-pole 103 is suitably coupled to the output electrode 19 to receive the amplified energy. It will be appreciated that the spacing of the tapping points 105 and 107 is such as to give a suitable voltage transfer and ordinarily, this distance is on the order of 20% of the length of the di-pole.

In operation, electrons from the thermionic cathode enclosed within the shield and control electrode 51 are accelerated by voltage applied to the electrodes 5. The traverse magnetic field causes the electrons, however, to execute a cycloidal path so that actually, the electrons impact upon the secondary emissive surface 3 to eject further secondary electrons which are brought to focus on the laterally displaced electrode 3 and so on finally arriving at the output electrode 19 in accordance with the normal operation of the secondary electron multipliers, as well understood in the art.

The received signalling energy, however, produces a fluctuating potential between the control electrode 53 and the thermionic emitting cathode so that in accordance with the signal the primary beam of electrons is modulated. There will, therefore, appear at the output electrode 19 a stream of amplified electrons, the magnitude of which is substantially a magnified replica of the originally modulated stream. The output electrode through the coupling, therefore, transfers to the transmitting di-pole 103, also sealed within the tube, energy which is then radiated by the antenna structure.

In Fig. 3 I have shown schematically an electron multiplier, having a horizontally polarized receiving di-pole 101 and a vertically polarized transmitting di-pole 103 which is coupled to the output electrode, together with a shield 123 for preventing interaction between the two antennas. Of course, it will be appreciated that a repeating station which is to receive signals from the di-pole 103 would require that the receiving di-pole be vertically polarized and the transmitting di-pole associated therewith would be horizontally polarized.

In Fig. 5 I have shown a plurality of repeating stations schematically to indicate the alternate polarizations for alternate repeating stations. Further, I have shown schematically multipliers in which the di-poles have been incorporated at 301, 303 and 305. It will be noted that, assuming that the main transmitter has a horizontally polarized antenna, the receiving antenna of the repeater 301 is horizontally polarized, while its transmitting antenna is vertically polarized. The receiving antenna of the repeater 303 is vertically polarized while its transmitting antenna is horizontally polarized. In turn, the receiving antenna of the repeater 305 is horizontally polarized, while its transmitting antenna is vertically polarized. Assuming that only three repeater stations are used, the antenna 307 at the terminal receiving station 311 is vertically po-

larized. Shields between the receiving and transmitting di-poles of the multipliers, of course, can be supplied, but are omitted in order to simplify the drawings. The alternate disposition of the plane of polarization has a further advantage in that it insures that energy will only be received from the preceding repeater and will not be received from the repeater before the preceding one.

In Fig. 4 I have shown schematically the connections from the power supply 215 to the voltage divider 29, together with the connection of the di-poles 101 and 103. It will be appreciated that there is a magnetic field set up by the fixed magnet shown in Fig. 3 or alternatively, an electromagnet which may be substituted for the fixed magnet. Electrons from the cathode 50 are accelerated toward the electrode 5 but due to the traverse magnetic field the electrons execute a cycloidal path to impact upon the first of the electrodes numbering 3 to emit secondary electrons larger in number than the impacting electrons. By supplying increasing potentials to the electrodes 3 and to the electrodes 5 in accordance with the longitudinal displacement from the cathode 50, the electrons finally arrive at the output electrode 19, which is maintained most positively. The control electrode 53 serves to modulate the primary electrons so that the current flowing from the output electrode 19 back to the voltage supply fluctuates, and this fluctuation being coupled to the antenna transfers the energy thereto, where, in turn, it is radiated.

While the invention has been described in some detail with respect to the static type of multiplier, it will be appreciated that dynamic type multipliers can be readily substituted for the static type multipliers without going beyond the scope of the invention, the static type being illustrated namely for convenience and ease of explanation.

It will be appreciated that the arrangement is one of extreme simplicity and affords a method of effecting the automatic relaying of signals on ultra-short waves with minimum equipment, expense and maintenance. It will be noted, in particular, that the absence of tuned circuits makes the system aperiodic and so avoids the necessity of tuning arrangements, as would be necessary in those types of stations known in the prior art, which utilize resonant elements of lumped characteristics.

In applicant's invention, temperature changes, for example, have substantially no effect upon the operation of the repeating stations, whereas when tuned elements are used, temperature by changing the tuning, changed the efficiency of operation, and in some cases, where the mistuning, as a result of the temperature, which is sufficiently great, rendered the system substantially inoperative. This is avoided by the present invention.

The present invention makes economically feasible ultra-high frequency relay networks such as are useful for the transmission of television programs because of its capabilities of handling extremely wide bands of modulated frequencies.

Having described my invention, what I claim is:

1. In a repeating station, the combination of a secondary electron multiplier having an input and an output circuit, a first antenna array connected to said input circuit, and a second antenna array coupled to the output circuit said multiplier, said first antenna array and said second antenna array forming a unitary structure.

2. In a repeating station, the combination of a secondary electron multiplier having an input and an output circuit, a first antenna array connected to energize said multiplier, a second antenna array coupled to the output circuit, power supply means for supplying operating voltages of substantially constant value to said secondary multiplier, and means to control the multiplier output energy in proportion to the input energy said multiplier, said first antenna array and said second antenna array forming a unitary structure.

3. In a repeating station, the combination of a secondary electron multiplier having an input and an output circuit and means to develop therein a flow of electrons, a signal receiving antenna array connected to said input circuit to modify the electron flow in proportion to signal energy received upon said antenna, a transmitting antenna array coupled to the output circuit to retransmit the received energy in an intensified state, power supply means for energizing said secondary multiplier, and means to prevent coupling between said transmitting antenna array and said receiving antenna array said multiplier, said receiving antenna array, and said transmitting antenna array forming a unitary structure.

4. A repeating station comprising an electron multiplier contained within an envelope, said multiplier having at least one input control electrode and an output electrode, a receiving di-pole antenna extending through said envelope and having a connection to said input control electrode within the said envelope, and a transmitting di-pole antenna extending through said envelope and coupled to said output electrode.

5. A repeating station comprising an electron multiplier contained within an envelope, said multiplier having at least one input control electrode and an output electrode, a receiving antenna having a connection to said input electrode within the said envelope, and a transmitting antenna coupled to said output electrode said multiplier, said receiving antenna, and said transmitting antenna forming a unitary structure.

6. A repeating station comprising an electron multiplier contained within an envelope, said multiplier having at least one input control electrode and an output electrode, a first di-pole extending through said envelope and connected to said input control electrode, a second di-pole extending through said envelope and coupled to said output electrode, and a shield member surrounding said tube and interposed between said first and said second di-poles.

7. A repeating station comprising an electron multiplier contained within an envelope, said multiplier having at least one input control electrode and an output electrode, a first di-pole extending through said envelope and connected to said input control electrode, a second di-pole extending through said envelope and coupled to said output electrode, said second di-pole being positioned in a plane substantially normal to said first di-pole to reduce coupling between said di-poles.

8. A repeating station comprising an electron multiplier contained within an envelope, said multiplier having at least one input control electrode and an output electrode, a receiving di-pole extending through said envelope and connected to said input control electrode, a radiating di-pole extending through said envelope and coupled to said output electrode, said radiating

di-pole being disposed in a plane substantially normal to that of said receiving di-pole, and a shield member surrounding said tube and interposed between said two di-poles.

9. A signalling system comprising a radio frequency transmitter, a main transmitting antenna, a plurality of repeating stations geographically separated from each other, each repeating station comprising a secondary electron multiplier having an input and output circuit, a receiving antenna coupled to the input circuit of each multiplier and a transmitting antenna coupled to the output circuit of each of said multipliers, said receiving antenna and transmitting antenna of each multiplier being an integral part thereof and lying in mutually perpendicular planes, and a terminal receiving station including an antenna for receiving energy from the last of said plurality of repeating stations.

10. A radio frequency signalling system comprising a main transmitter, an antenna for radiating energy in a predetermined plane of polarization from said transmitter, a first repeating station comprising a secondary electron multi-

plier having an input and an output circuit, an antenna having a plane of polarization substantially identical with that of said first named antenna coupled to said input circuit, a third antenna coupled to said output circuit and having its plane of polarization perpendicular to said predetermined plane of polarization, a second repeating station comprising a second electron multiplier having an input and output circuit, a receiving antenna connected to the input circuit of said second multiplier and having a plane of polarization perpendicular to said predetermined plane of polarization, a transmitting antenna connected to the output circuit of said second electron multiplier and having its plane of polarization substantially the same as said predetermined plane of polarization, and means including an antenna whose plane of polarization is substantially the same as said predetermined plane of polarization for receiving energy from said last named transmitting antenna each of said multipliers having its associated input and output coupled antenna forming a unitary structure.

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