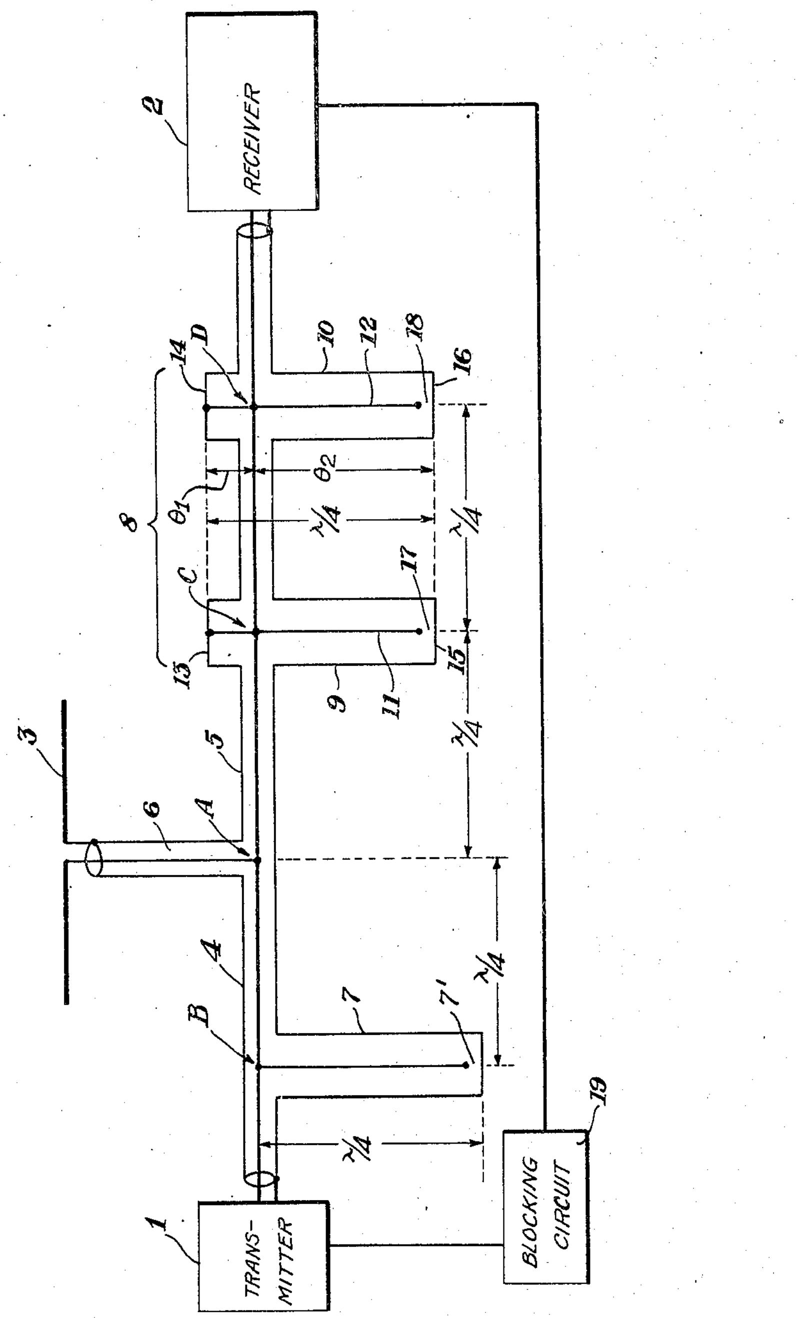
Oct. 25, 1949. A. G. KANDOIAN 2,485,606

PROTECTIVE COUPLING CIRCUIT

Filed June 27, 1944 2 Sheets-Sheet 1

Fig. 1.



INVENTOR.
ARMIG G. KANDOIAN

BY

R P Morris
ATTORNEY

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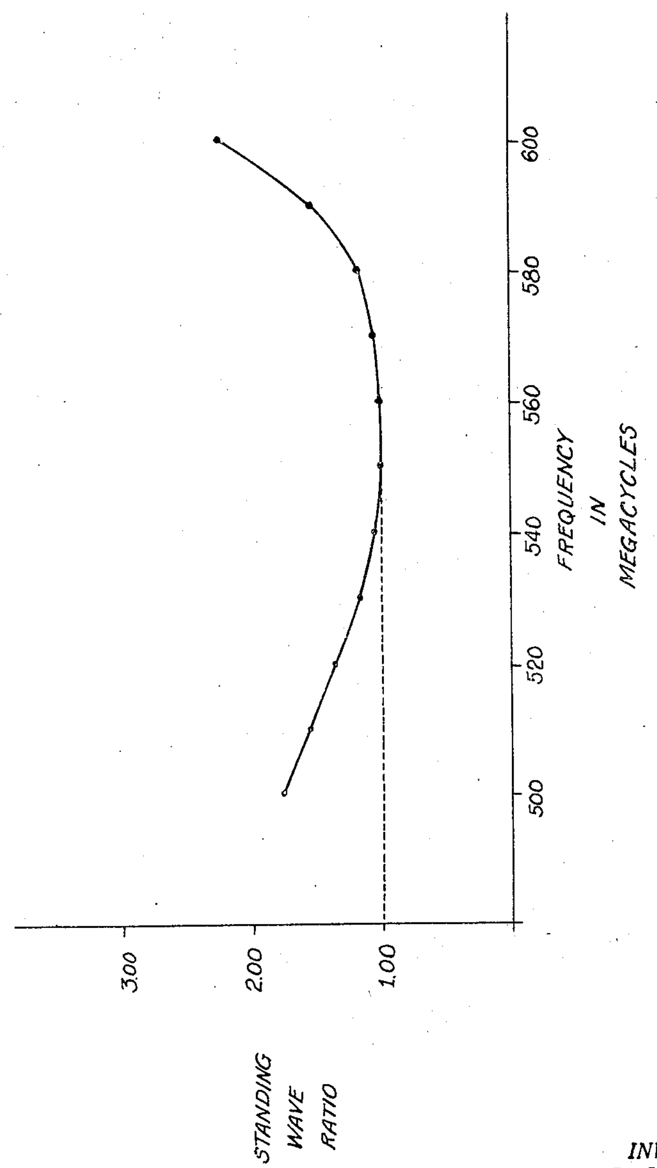
Fig. 2.



INVENTOR.
ARMIG G. KANDOIAN

BY

R P Morris
ATTORNEY

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PROTECTIVE COUPLING CIRCUIT

Armig G. Kandoian, New York, N. Y., assignor to Federal Telephone and Radio Corporation, New York, N. Y., a corporation of Delaware

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7 Claims. (Cl. 250—13)

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My invention relates to improvements in protective circuits, and more particularly to arrangements for coupling both a transmitter and a receiver to a common antenna so as to prevent high transmitter voltages from entering the receiver.

In my co-pending application, Serial Number 469,174 filed December 16, 1942, I have disclosed a protective circuit wherein a gap is bridged across the midpoint of a half-wave impedance transformer in the receiver-transmission line. This system is satisfactory for fairly wide frequency band operation but does not provide a high resonant voltage stepup for the gaps. Although high resonant voltage stepup for the gaps is desirable for long gap life and satisfactory receiver protection, in the usual resonant sections the selectivity is very sharp and hence not satisfactory for wide frequency band operation.

It is accordingly an object of the present invention to provide means whereby the blocking of high transmitter voltages from a receiver connected to a common antenna is possible over a relatively wide frequency range. Another object of the present invention is to provide high resonant impedance points for the gaps, to insure maximum voltage stepup for protective discharge gaps over the desired frequency range.

Another object of the present invention is to provide a protective circuit which is particularly adapted for use with transmitter-receiver systems employing coaxial transmission lines.

A further object of the present invention is to provide a protective circuit for transmitter-receiver systems which will cause little or no mismatch in the line even at the limits of the operating frequency band.

Other objects and advantages of the invention will be apparent from the following description of a preferred form of the invention and from the drawing, in which:

Fig. 1 is a schematic diagram of a transmitter-receiver system incorporating a preferred form of the present invention; and

Fig. 2 is a curve showing the degree of mismatch introduced into the receiver-transmission line of Fig. 1 over a predetermined band of frequencies.

The main purpose of the preesnt invention is to permit the use of a common antenna by a transmitter and receiver over a relatively wide band of frequencies, while at the same time automatically preventing the high transmitter voltages from being impressed upon the receiver. Fig. 1 illustrates a transmitter 1 and a receiver 2 adapted to be connected to a common antenna 3. Transmitter 1 is connected to a coaxial transmission line 4, while

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receiver 2 is connected to a coaxial transmission line 5. Lines 4 and 5 are joined at point A, from which point a common coaxial transmission line 6 leads to antenna 3.

Connected in the transmitter-transmission line 4 is an impedance-matching line section 7 which also serves to block received energy from transmitter 1 in a manner hereafter to be described. This line section 7 comprises a section of coaxial line open at the far end where a spark gap 7′ is placed. When the transmitter is on, the gap 7′ breaks down so that section 7 offers little disturbance to the flow of energy to the antenna. When however the antenna is used for reception, the received signal being small does not break down the gap 7′. The impedance across point B becomes substantially zero, thus preventing any of the received energy from going into the transmitter.

Connected in the receiver-transmission line 5 is a blocking network 8, this network 8 consisting of two spaced-apart coaxial line sections 9 and 10. Inner conductors 11 and 12 of line sections 9 and 10 are respectively connected to the inner conductor of receiver-transmission line 5 at points C and D, these connections preferably being adjustable so that the position of points C and D along inner conductors 11 and 12 respectively may be varied. Likewise the junctions between line 5, and the outer conductors of lines 9 and 10 are preferably similarly adjustable, so that these sections 9 and 10 may be moved as a whole with respect to line 5.

Inner conductors 11 and 12 of coaxial line sections 9 and 10 each have one end thereof connected to the closed ends 13 and 14 of their respective line sections. The other ends of the inner conductors 11 and 12 are each separated from the closed ends 15 and 16 of their respective line sections by space discharge devices such as gaps 17 and 18 respectively.

The present invention is designed to be effective over a predetermined band of frequencies. The length of each of the coaxial line sections 9 and 10 is accordingly made substantially equal to one-quarter wavelength at the mid-frequency of this band, and the spacings A—B, A—C and C—D are also each made equal substantially to one-quarter wavelength at this mid-frequency. As a result, when the transmitter 1 is in operation energy transmitted on all frequencies between the limits of this predetermined band is substantially precluded from reaching the receiver 2. How this is brought about will now be described.

Without the protective features of the present invention, energy from transmitter 1 would divide at point A, a portion being radiated from antenna 3 and the remaining portion being conducted by transmission line 5 to receiver 2 to result in damage to the receiver or other undesirable effects. According to the present invention, however, this portion of the transmitter energy is substantially blocked from the receiver 2 by the network 8.

It is known that by moving the point of connection of an energy source from the closed end toward the open end of a stub line section, the frequency response of the line section may be broadened. That is, by connecting the source at or near the closed end, the section will be resonant at substantially only a single frequency. However, by moving the energy input connection toward the open end, operation becomes less critical, and the section may be made to resonate over a relatively wide band of frequencies.

For the purpose of illustration, let it be assumed that the range over which the system of the present invention is designed to operate covers the band between 500 and 600 megacycles. It was stated above that the length of each of the line sections 9 and 10 is chosen to be substantially one-quarter wavelength at the mid-frequency of this band, or 550 megacycles. If the distance between points C and D and closed ends 13 and 14 respectively of line sections 9 and 10 be designated as θ_1, and if the distance between points C and D and closed ends 15 and 16 respectively of the line sections be designated as θ_2, then

$$\theta_2 = 90° - \theta_1$$

and a decrease in the value of θ_2 will effect a broadening of the frequency band over which line sections 9 and 10 will be resonant. If θ_2 is now chosen so that line sections 9 and 10 as a unit will be resonant over the band between 500 and 600 megacycles, the energy from transmitter 1 on any frequency within this band will cause a voltage transformation along line sections 9 and 10, as is well-known in the art. In other words, the voltage at gaps 17 and 18 will be much higher than at points C and D in receiver-transmission line 5.

The dimensions of gaps 17 and 18 are so chosen that the voltage built up in the manner above described exceeds the breakdown voltage of the gaps. When breakdown occurs, an effective short circuit across receiver-transmission line 5 results, and this effective short circuit acts to block the transmitter voltages from receiver 2. It should be noted that due to the one-quarter wave spacing between points A and C, the effective short circuit at point C results in line 5 presenting a relatively high, substantially infinite, impedance at point A. The blocking action of network 8 will thus have no appreciable effect on the transmission of energy between transmitter 1 and antenna 3.

The reactance presented by line section 9 at point C is generally primarily inductive. Since point D is a one-quarter wavelength from point C, the reactance presented by line section 10 is primarily capacitive. Therefore line sections 9 and 10 together act like a parallel coil-condenser circuit of high Q.

An alternative mode of operation in the example given is to adjust θ_2 so that line section 9 will resonate more or less sharply at 500 megacycles, and so that line section 10 will resonate more or less sharply at 600 megacycles. Energy from transmitter 1 on a 500 megacycle frequency will then break down gap 17, while the voltage transformation of non-resonant line section 10 is insufficient to break down gap 18. At 600 megacycles, gap 18 only would break down. By selecting proper values of θ_2, and choosing proper dimensions for gaps 17 and 18, energy on an intermediate frequency within the band may be made to break down either or both gaps 17 and 18 according to its departure from the mid-frequency of the band.

It is common in connection with a transmitter and receiver connected to the same antenna to block the operation of the receiver during the operation of the transmitter. In Fig. 1 is shown a blocking circuit 19 that may be used for this purpose if desired.

In the above description I have illustrated how the transmitter voltages are blocked from receiver 2. However, the system of the present invention is also effective in permitting energy received by antenna 3 to be conducted to receiver 2 with a minimum of attenuation when the transmitter 1 is not operating.

Under receiving conditions, energy picked up by antenna 3 is conducted by transmission line 6 to point A, where it would normally divide to flow over both transmission lines 4 and 5. However, due to the action of line section 7, an effective partial short circuit is produced in transmission line 4 at point B, a quarter-wavelength from point A. The partially short-circuited line section between A and B accordingly presents a relatively high impedance to energy incoming over line 6, blocking in part the flow of energy to transmitter 1. Accordingly most of the received energy is applied to receiver 2.

The energy received by antenna 3 passing through network 8 is of a value much lower than the value of the energy from transmitter 1. Consequently, the breakdown voltage of gaps 17 and 18 is not reached, no blocking occurs, and the received energy is conducted without appreciable loss to receiver 2.

Fig. 2 illustrates the relatively low degree of mismatch that is introduced in transmission line 5 by the action of blocking network 8, the curve covering the band between 500 and 600 megacycles which has been used above as an illustration. It will be observed that the line is substantially flat between 530 and 580 megacycles, and that even at the limits of the frequency band the standing wave ratio does not exceed approximately 2 to 1.

For best results, the surge impedance of the line sections 9 and 10 should be greater than the surge impedance of the transmission lines. For example, if a standard 50 ohm transmission line is employed, the line sections 9 and 10 may have an impedance in the order of 150 ohms.

While the space discharge devices 17 and 18 have been illustrated, by way of example, as spark gaps, it will be clear to those skilled in this art that any other space discharge devices such as neon tubes may be employed in place thereof. Also, while the invention has been described in connection with coaxial lines, it will be clearly understood that other types of transmission lines such as open wire lines may be employed if desired.

Moreover, while the receiver and transmitter are shown coupled to a common antenna, it is clear that they may be coupled to some other form of utilization circuit such as a common carrier transmission line, without departure from the scope of my invention.

While I have described above the principles of my invention in connection with a specific system, it will be clearly understood that this description is made only by way of example and not as a limitation on the scope of my invention as set forth in the objects and the accompanying claims.

I claim:

1. In combination, a transmitter, a receiver, a common utilization circuit for said transmitter and receiver, a first transmission line leading from said transmitter to said utilization circuit, a second transmission line interconnecting said receiver and said first transmission line, and a protective network in said second transmission line, comprising a pair of spaced-apart resonant stub lines open-circuited at one end and short-circuited at the other coupled to said second line at a point intermediate their ends, and means forming a space discharge device between the conductors of each of said stub lines at the respective open-circuited ends thereof.

2. A combination according to claim 1, wherein one of said resonant stub lines is spaced from the junction of said second transmission line and said utilization circuit substantially a quarter wavelength at the operating mid-frequency of the system.

3. In a system of the type in which a receiver and a transmitter operating over a relatively wide band of frequencies are both coupled to a common antenna, said transmitter and receiver being connected to said antenna by a first transmission line and a second transmission line respectively, the combination of a protective network in said second transmission line to substantially block high transmitter voltages from said receiver, comprising a pair of spaced-apart resonant line sections open-circuited at one end and short-circuited at the other, the sharpness of the resonance

curve of each section depending on the distance between the open-circuited end of the section and the point of connections between the section and said second transmission line, and means comprising a space discharge device between the open-circuited ends of the conductors of each of the sections.

4. A system according to claim 3, in which said two line sections are each resonant at the mid-frequency of the said operating band.

5. A system according to claim 3, in which said two line sections are resonant at the respective frequency limits of the said operating band.

6. A system according to claim 3, in which said two line sections are spaced apart along said second transmission line a distance equal to approximately one-quarter wavelength at the mid-frequency of the operating band.

7. A system according to claim 3, in which one of said two line sections is spaced approximately one-quarter wavelength at the mid-frequency of the operating band along said second transmission line from the junction between said first and second transmission lines, and the other of said two line sections is spaced approximately one-quarter wavelength at the mid-frequency of the operating band along said second transmission line from said one line section.

ARMIG G. KANDOIAN.

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