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WAVE TRANSMISSION NETWORK

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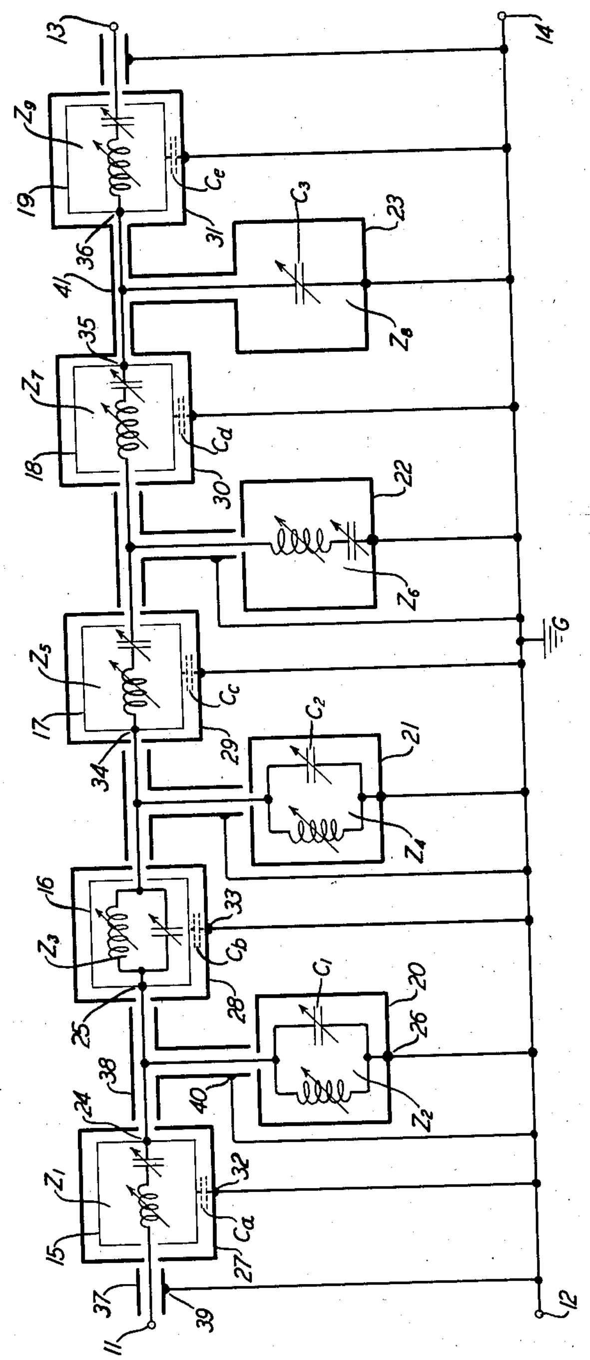

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WAVE TRANSMISSION NETWORK

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This invention relates to wave transmission networks and more particularly to shielding arrangements for use in such networks.

The principal object of the invention is to improve the transmission characteristics of wave transmission networks designed for use at high frequencies.

Another object is to provide adequate electrostatic and electromagnetic shielding for the component impedance elements used in transmission networks.

Another object is to make the impedance of a network element independent of its surroundings.

A further object if the invention is to take account of the stray admittances associated with the component impedance branches comprising such a network.

A feature of the invention is a radio frequency filter the branches of which have double shielding, with the capacitance between shields utilized as part of the lumped impedances required in the filter design.

In wave transmission networks, as ordinarily built, there are always present certain stray admittances between the component elements, and also mutual impedances resulting from stray magnetic fields. These couplings impair the transmission characteristics of the network by changing the values of the lumped impedance elements, and also by introducing additional paths for the currents. These harmful effects are especially noticeable in networks designed for use at high frequencies. These couplings may be decreased in magnitude, to a certain extent, by a physical separation of the elements, but there are obvious limits to the extent to which this method can be employed practically. In the case of electrostatic coupling to ground, it is scarcely of any value, and in any case excessive separation of the parts of a circuit introduces other errors due to the length of the wiring involved. In accordance with the present invention, these difficulties are overcome by the use of individually shielded elements and, where necessary, by resorting to double shielding for the elements. A single shield, if made from material of high conductivity and properly spaced from the inductors, will generally reduce the stray magnetic fields to a tolerable magnitude and will also make definite the impedance effective between the terminals of the element. Variable elements may be used in combination and adjusted within their shield to have the required frequencies of resonance and anti-resonance. When the individually shielded elements or combinations are assembled in a complete network, however, there will be introduced capacitances between each shield and every other shield, and also between the shields and ground. In order to localize these stray capacitances and make definite their magnitudes, a second or outer shield is placed around certain of the impedance elements. These secondary shields are usually all connected to ground or otherwise fixed at the same potential, and shielded wiring is used to connect the individual elements. Additional capacitances between the outer and inner shields will thus be introduced, but these are taken into account by connecting them in parallel with the lumped capacitances called for in the network design and by making proper allowance therefor.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawing, the single figure of which shows an embodiment of the invention in a wave transmission network.

The figure illustrates schematically the application of the invention to an unbalanced composite wave filter comprising sections of the type illustrated and described in the United States patents to George A. Campbell, 1,227,113 issued May 22, 1917 and 1,493,600 issued May 13, 1924, and Patent 1,559,638 to William H. Martin issued November 3, 1925. The filter is of the series-shunt type, comprising lumped impedance branches in series with the direction of wave propagation and in alternation therewith impedances connected in shunt with the line. The network has a pair of input terminals 11, 12 and a pair of output terminals 13, 14 by means of which it may be connected between two sections of a transmission line or other apparatus. One side of the filter, the path between terminals 12 and 14, may be ground or otherwise fixed in potential, as shown at G. For a detailed explanation of how such a filter may be designed, reference is made to the above mentioned patents.

If no shielding is used for the individual elements of the network, certain electromagnetic and electrostatic couplings will exist when the physical elements are assembled into the composite structure, thus impairing the transmission characteristics of the filter. These undesired effects are most apparent in networks designed to operate at high frequencies, and may result in a shifting of the transmission band, an increase of attenuation in the band, a decrease of attenuation in the attenuating regions or a change in the characteristic impedance. In accordance with the invention, the stray fields are confined, and the capacitative couplings are localized and made definite, by enclosing each impedance branch of the filter in a separate conductive shield. Thus, as shown in the figure, the series impedances Z_1, Z_3, Z_5, Z_7 and Z_9 are surrounded, respectively, by the individual shields 15, 16, 17, 18 and 19. In like manner, the shunt impedance branches Z_2, Z_4, Z_6 and Z_8 are enclosed, respectively, in the individual shields 20, 21, 22 and 23. The shields are moderately thick, made of material of high conductivity as, for example, copper and are suitably spaced from the enclosed elements. Each shield is electrically connected to one terminal of the impedance branch which it surrounds, as shown at 24, 25 and 26. The inductors and capacitors may be made variable, as indicated schematically by the arrows shown in the figure, so that the branch impedances may be adjusted within their individual shields to have the proper magnitudes and the desired resonant and anti-resonant frequencies. The effective impedance between the terminals of any one of the shielded branches will now be fixed and definite, irrespective of how it is physically associated with the other component elements in the assembled filter. There will, however, be capacitances between each shield and every other shield and also between each shield and ground. In the case of the shunt impedance branches these stray capacitances may be short-circuited, and thereby eliminated, by tying each shield to the grounded side of the enclosed impedance, as shown at 26. In accordance with the invention, the stray capacitances associated with the series branches are localized and made definite in magnitude by surrounding each series impedance with an outer or secondary shield, shown in the figure as parts 27, 28, 29, 30 and 31. These outer shields are electrically connected to the grounded side of the filter, as shown at 32, 33. The capacitance between each inner shield and its associated outer shield is now fixed in magnitude and may be represented by the dotted capacitances C_a, C_b, C_c, C_d and C_e shown in the figure. In accordance with the invention these capacitances are taken into account and allowed for by adjusting the values of certain of the lumped capacitances called for in the filter design. For example, if the inner shields 15, 16 of the series impedances Z_1, Z_2 are connected to the terminals adjacent the common shunt branch Z_2, as shown at 24, 25, the capacitances C_a, C_b will be placed effectively in parallel with the capacitance C_1 of the Z_2 branch, and may be allowed for by an adjustment in the value of C_1. If the value of the required capacitance in the shunt branch Z_2 is C_1', then the proper magnitude of C_1 is found by subtracting from C_1' the sum of C_a and C_b. In equation form,

$$C_1=C_1'-(C_a+C_b). \quad (1)$$

Likewise, with the inner shield 17 of the series impedance branch Z_5 connected to the terminal 34, as shown in the figure, the capacitance C_c is placed effectively in parallel with the capacitance C_2 of the shunt impedance Z_4. If C_2' is the design capacitance required for the shunt impedance Z_4, the value of C_2 is given by the following equation:

$$C_2=C_2'-C_c. \quad (2)$$

Also, when the inner shields 18 and 19 are tied, respectively, to the terminals 35, 36 the capacitances C_d and C_e will be effectively in shunt with the capacitance C_3, the correct value of which is given by

$$C_3=C_3'-(C_d+C_e), \quad (3)$$

where C_3' is the required design capacitance.

The component impedance branches of the filter are connected together by shielded conductors, such, for example, as the concentric conductor cable shown schematically in the figure at 37, 38, and the shield of each connector is tied to ground, as indicated at 39, 40. Or, if desired, the connecting shields may be made integral with the other shields, as indicated at 41. In some instances, if the wiring is sufficiently short, the shielded connectors may be dispensed with and open wiring employed in its stead.

If the shields are arranged as described above, and the capacitances in the shunt impedance branches are adjusted as explained, the assembled filter will operate satisfactorily in any surroundings. Networks shielded in this manner may be designed to provide desired transmission characteristics which, without the use of such shielding, could not be realized.

The invention has been described in connection with an unbalanced filter but it is apparent that the same principles may be applied to a balanced structure. Also, the invention is applicable to other types of transmission networks such, for example, as equalizers, phase correctors, delay networks and balancing networks.

What is claimed is:

1. In a wave transmission network comprising a plurality of impedance branches, an impedance branch enclosed in a shield of conductive material, and a separate outer shield of conductive material surrounding said first mentioned shield, the capacitance between said two shields being utilized as a part of the lumped impedance of another of said branches.

2. In a wave transmission network, means for electrostatically and electromagnetically shielding a component branch impedance comprising a metallic shield completely surrounding said impedance, and a separate metallic shield completely enclosing said first mentioned shield, the capacitance between said two shields being utilized as a part of the lumped impedance of a different impedance branch of said network.

3. In a wave filter of the series-shunt type comprising impedance branches in series with the line and additional impedance branches alternately disposed in shunt therewith, an individual shield around each of said branches, and outer shields enclosing certain of said branches, the capacitance between said outer shields and their respectively associated inner shields being utilized as a part of the lumped impedances of said filter.

4. In a wave transmission network comprising impedance in series with the direction of wave propagation, and in alternation therewith impedances connected in shunt with the line, two separate shields surrounding each of said series impedances, the capacitance between said two shields forming a part of said shunt impedances.

5. A plurality of impedance branches disposed between a pair of input terminals and a pair

of output terminals to form a wave transmission network, an individual shield completely surrounding each of said impedance branches, and secondary shields enclosing certain of said branches, the capacitance between each of said secondary shields and its associated inner shield being utilized as a part of the lumped impedances of said network.

6. In a wave filter comprising a plurality of impedance branches disposed in series-shunt relation, an individual shield surrounding each of said impedance branches, and an individual outer shield enclosing each series branch, the capacitance between said two shields enclosing each of said series branches forming a part of the shunt impedances of said filter.

7. In a wave transmission network having a plurality of impedance branches, an electromagnetically and electrostatically shielded impedance branch comprising a lumped impedance, an inner metallic shield surrounding said lumped impedance, and a separate metallic shield surrounding said inner shield, said inner shield being electrically connected to a terminal of said lumped impedance, and said outer shield being connected to ground, the capacitance between said inner shield and said outer shield being utilized as a part of the lumped impedance of an adjacent impedance branch of said network.

8. In a wave transmission network comprising a plurality of impedance branches a completely shielded branch comprising a lumped impedance, an inner shield made of conductive material surrounding said impedance, and a separate outer shield of conductive material enclosing said inner shield, said outer shield being at ground potential, whereby the stray magnetic fields from said impedance are effectively confined and the stray admittances between said inner shield and ground are localized between said two shields, the capacitance between said two shields being utilized as a part of one of the lumped impedances of said network.

9. In a wave filter comprising a plurality of impedance branches connected between a pair of input terminals and a pair of output terminals, double shielding for certain of said impedance branches, said double shielding comprising an inner shield of conductive material and a separate outer shield completely surrounding said inner shield, the capacitance between said inner and said outer shields being utilized as a part of the lumped impedances of said filter.

10. A wave transmission network having a pair of input terminals and a pair of output terminals, said network comprising an electrical path between each input terminal and a corresponding output terminal, two impedances connected in series in one of said paths, a third impedance connected between the junction point of said two series impedances and a point in the other of said paths, a separate inner shield surrounding each of said series impedances, said shields being electrically connected to said junction point, and individual outer shields surrounding each of said inner shields, the capacitance between each of said inner shields and its associated outer shield being so connected into the circuit as to form a part of said third impedance.

11. A wave transmission network having a pair of input terminals and a pair of output terminals, said network comprising an electrical path between each input terminal and its associated output terminal, one of said paths being grounded, a plurality of impedances in series in the other of said paths, a shunt impedance branch connected between each junction point formed by said series impedances and the grounded side of said network, an individual shield surrounding each of said series impedances and making electrical connection with one terminal thereof, a separate shield enclosing each of said shunt impedance branches, said last mentioned shields being conductively connected with the grounded side of said network, and an outer shield surrounding each of said series impedances, said outer shields being electrically connected to the grounded side of said network.

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