

Aug. 16, 1938.

S. BOBIS

2,127,201

WAVE TRANSMISSION NETWORK

Filed March 23, 1935

4 Sheets-Sheet 1

FIG. 1

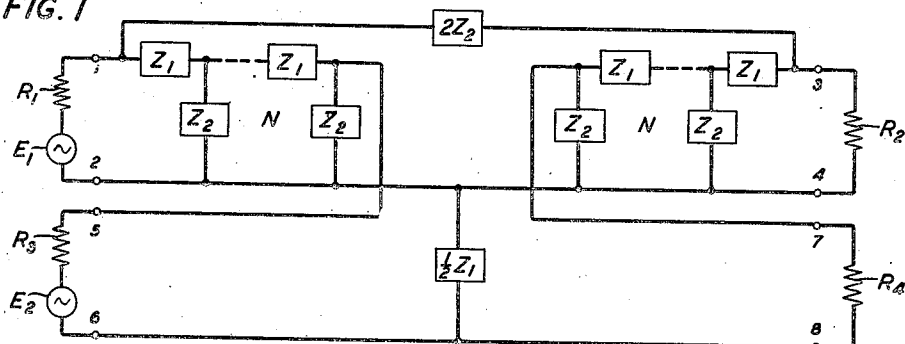


FIG. 2

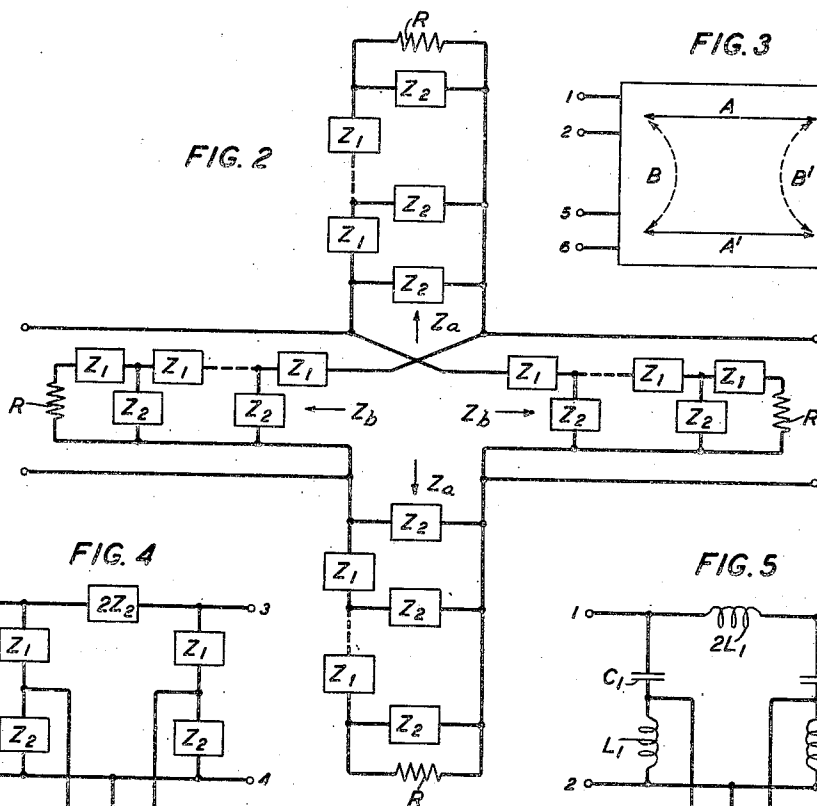


FIG. 3

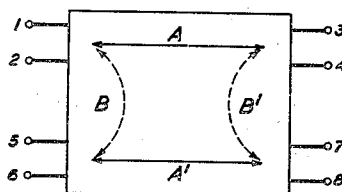


FIG. 4

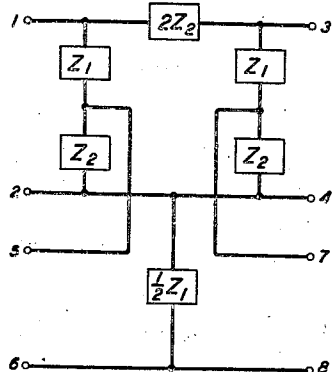
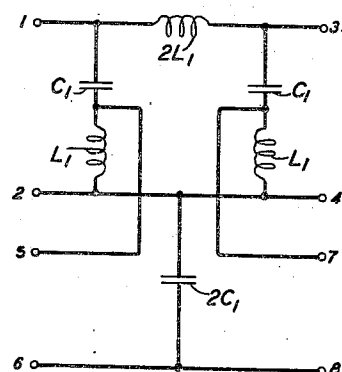


FIG. 5



INVENTOR
S. BOBIS

BY

E. V. Briggs
ATTORNEY

Aug. 16, 1938.

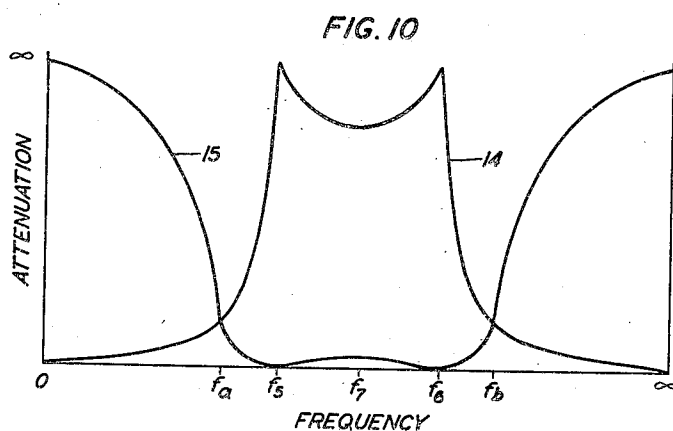
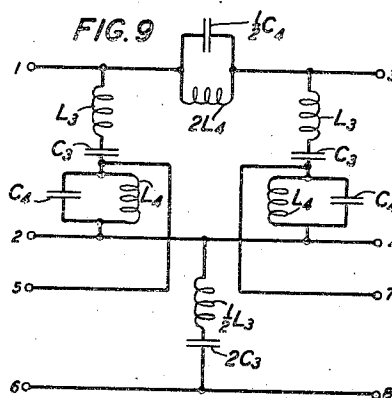
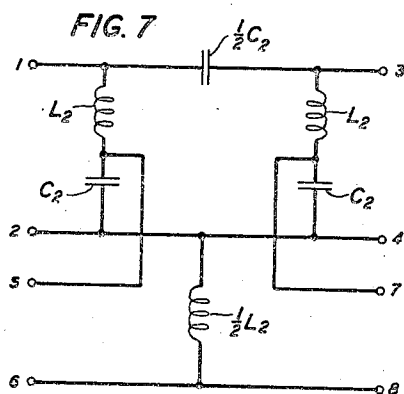
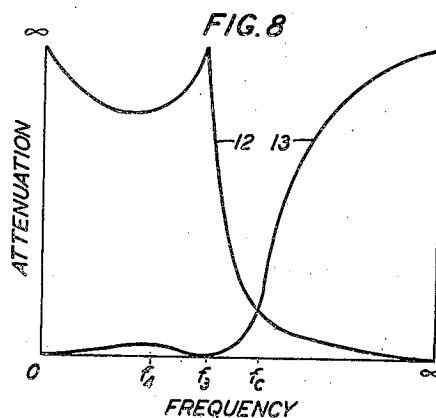
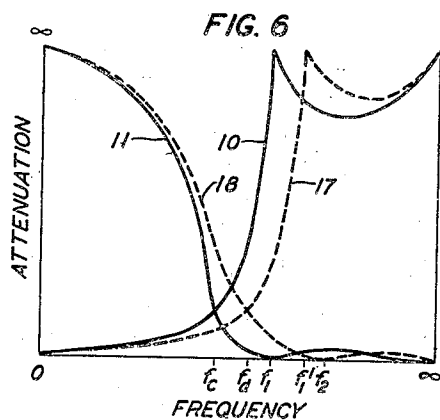
S. BOBIS

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4 Sheets-Sheet 2



BY

INVENTOR
S. BOBIS

E. V. Briggs
ATTORNEY

Aug. 16, 1938.

S. BOBIS

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WAVE TRANSMISSION NETWORK

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4 Sheets-Sheet 4

FIG. 16

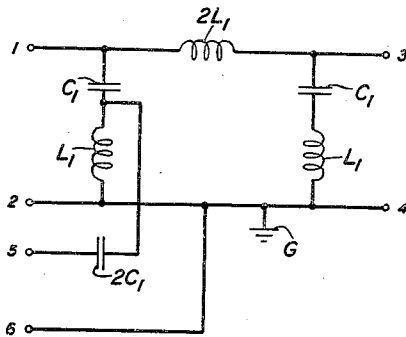


FIG. 17

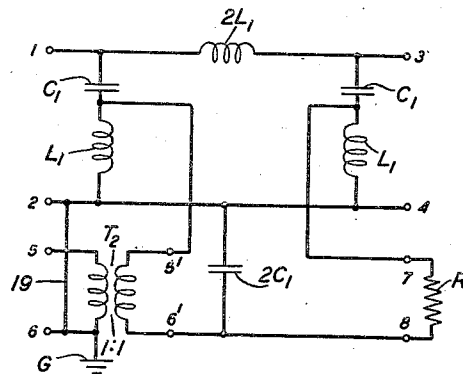


FIG. 18

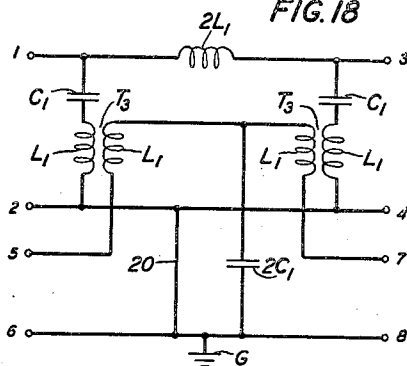


FIG. 19

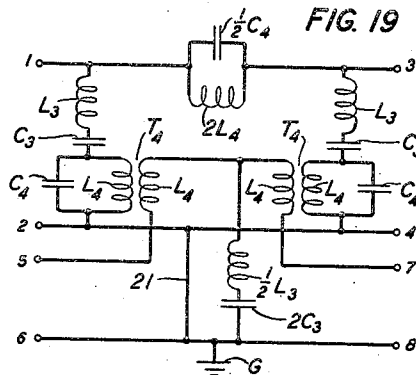
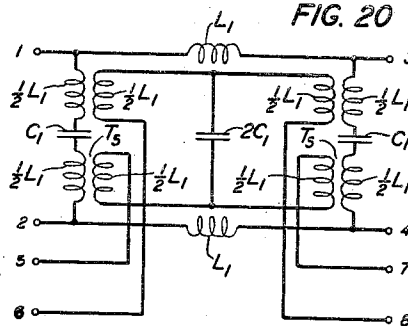


FIG. 20



BY

INVENTOR
S. BOBIS

E. V. Griggs
ATTORNEY

UNITED STATES PATENT OFFICE

2,127,201

WAVE TRANSMISSION NETWORK

Stephen Bobis, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application March 23, 1935, Serial No. 12,598

13 Claims. (Cl. 178-44)

This invention relates to selective wave transmission networks having a constant non-reactive characteristic impedance at all frequencies, and more particularly to networks of this type which have a plurality of transmission paths. This application is a continuation in part of my co-pending application, Serial No. 714,346, filed March 6, 1934 which was patented June 9, 1936 as U. S. Patent No. 2,043,345.

An object of the invention is to reduce the reflection effects at the junction points between a wave filter and its associated terminal loads.

Another object is to provide a plurality of transmission channels in a single network structure.

In carrier telephone and telegraph systems the problem often arises of separating signal currents into two groups, one of which comprises all frequencies lying above a certain cut-off frequency, and the other of which includes the frequencies lying below this cut-off point. An example is the separation of voice from carrier frequencies. In order to minimize the effects of reflections at the junctions between the filter and its connected terminal impedances it is desirable that the characteristic impedance of the filter should match the load impedance. Since the impedance of the load is usually a constant pure resistance the impedance of the filter should be of the same character.

In accordance with the present invention all of these requirements are fulfilled in a single transmission network having eight terminals, arranged in four pairs. The characteristic impedance of the network at each pair of terminals is a pure resistance constant in value at all frequencies. The network may be designed, for example, to have a low frequency transmission path between terminals 1, 2 and 3, 4 and a second low frequency path between terminals 5, 6 and 7, 8, while at the same time having a high frequency path between terminals 1, 2 and 5, 6 and a second high frequency path between terminals 3, 4 and 7, 8. No energy will be transmitted directly between terminals 1, 2 and 7, 8 or between terminals 3, 4 and 5, 6. Other types of transmission paths may be provided if desired. Also, the network may be used as a six terminal network simply by connecting a resistance between one pair of terminals, without affecting the characteristic impedances at the other sets of terminals.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawings, of which:

Fig. 1 is a diagrammatic representation of the network of the invention;

Fig. 2 is a lattice structure equivalent to the networks of Fig. 1 to which reference is made in explaining the invention;

Fig. 3 is a diagram showing the four transmission paths obtainable in the network of the invention;

Fig. 4 represents the network of Fig. 1 when the partial filters comprise but a single section;

Figs. 5, 7 and 9 show networks according to Fig. 4 when the partial filters are respectively high-pass, low-pass and band-elimination structures;

Figs. 6, 8 and 10 represent typical attenuation characteristics obtainable with the networks of Figs. 5, 7 and 9, respectively;

Fig. 11 shows a modification of the network of Fig. 5 permitting the location of the attenuation peak at any desired frequency;

Fig. 12 shows a modification of the network of the invention in which the partial filters are of the m-derived type permitting the realization of attenuation peaks in all of the transmission channels;

Fig. 13 is a lattice structure equivalent to the network of Fig. 12;

Fig. 14 represents a typical attenuation characteristic obtainable with the network of Fig. 12;

Figs. 15, 16 and 17 are modified forms of the network of Fig. 5 showing how it may be used as a six terminal network;

Figs. 18 and 19 are modified forms of the networks shown respectively in Figs. 5 and 9 in which a common ground may be used for both transmission paths; and

Fig. 20 shows a modified form of the network of Fig. 5 in which the transmission paths are of balanced construction.

Fig. 1 shows one form of the network of the invention having eight terminals numbered 1 to 8, respectively, arranged in four pairs. The terminals 1, 2 and 5, 6 may be considered the input terminals and terminals 3, 4 and 7, 8 the output terminals. In the figure R_1 and R_3 represent the impedances of the loads connected, respectively, to the two pairs of input terminals. A source of electromotive force E_1 is shown connected in series with the load R_1 and a second source of electromotive force E_2 in series with R_3 . The loads connected to the two pairs of output terminals are represented by R_2 and R_4 , respectively. The network is completely symmetrical in form and the resistances R_1 , R_2 , R_3 , and R_4 are equal to each other and equal to R . The network may

be connected between four sections of transmission lines or to other terminal loads of suitable impedance.

The network shown in Fig. 1 comprises two similar ladder type partial networks N, N, one extending to the right of terminals 1 and 2 and the other extending to the left of terminals 3 and 4. The partial network N may contain any desired number of sections comprising series impedances Z_1 and alternately disposed shunt impedances Z_2 . The network N is a filter of the constant-k type such as is described in U. S. Patent 1,227,113 to G. A. Campbell, issued May 22, 1917 and may be either a low-pass, high-pass, band-pass or band-elimination structure. The main network is completed by an impedance branch equal to $2Z_2$ connected directly between terminals 1 and 3 and an impedance branch equal to $\frac{1}{2}Z_1$ having connections on one side to terminals 2 and 4 and connections on the other side to terminals 6 and 8. When the network is designed as hereinafter set forth, its characteristic impedance at each pair of terminals will be a constant pure resistance equal to R at all frequencies.

The design parameters of the partial network N are the cut-off frequency f_c and the characteristic impedance K' . The frequency f_c is the cut-off of the various transmission channels to be described hereinafter and is chosen as required under the particular circumstances. The characteristic impedance K' is made equal to K, the characteristic impedance of the network as a whole. It will be noted that the network N has a full series impedance branch Z_1 at one end and a full shunt impedance branch Z_2 at the other end.

The transmission properties of the network shown in Fig. 1 are most conveniently studied by considering its electrically equivalent lattice structure which may be obtained, for example, by means of Bartlett's bisection theorem given in the Philosophical Magazine (London) vol. 4, page 902, November, 1927. As shown in Fig. 2 the equivalent lattice structure comprises a pair of equal line impedances which may be designated Z_a , Z_a and a pair of diagonal impedance branches Z_b , Z_b . Each of the component impedance branches of the lattice network consists of a ladder-type partial network comprising series impedances Z_1 and alternately disposed shunt impedances Z_2 , terminated at the distant end in a resistance R.

The propagation constant P and the characteristic impedance K of the lattice network of Fig. 2 are given by the expressions:

$$\tanh \frac{P}{2} = \sqrt{\frac{Z_a}{Z_b}} \quad (1)$$

and

$$K = \sqrt{Z_a Z_b} \quad (2)$$

It is apparent from the Equation (2) that in order to make the characteristic impedance K a constant resistance at all frequencies, it is necessary that the impedances of the branches Z_a and Z_b should be inverse with respect to K^2 over the entire frequency range. Also an inspection of Equation (1) shows that in the region where Z_a and Z_b are of the same sign,

$$\tanh \frac{P}{2}$$

is real and therefore the structure attenuates the

energy passing through it, and where Z_a and Z_b are purely reactive but of opposite sign

$$\tanh \frac{P}{2}$$

is imaginary and the structure freely transmits energy.

It will be noted in Fig. 2 that the line impedance branches Z_a , Z_a consist of ladder-type networks in which the first branch is a shunt impedance Z_2 while in the diagonal impedances Z_b , Z_b the first branch is the series impedance Z_1 . Since the partial networks are of the same type and have the same cut-off frequencies but have, respectively, shunt and series terminations, the impedances Z_a and Z_b will be inherently inverse with respect to K^2 throughout the whole frequency range both within and without the transmission band. The impedances Z_a and Z_b will be purely resistive and of course of the same sign in the transmission band of the partial networks and therefore the lattice structure will attenuate in this range. On the other hand, where the partial networks are attenuating, the impedances Z_a and Z_b are purely reactive and of opposite sign and therefore the lattice structure will transmit freely the frequencies lying within this region. To restate the proposition simply, the lattice network of Fig. 2 will have a constant non-reactive characteristic impedance at both ends and will have its transmission band located where the ladder partial structures are attenuating, and the attenuating region of the lattice will coincide with the transmission band of the partial structures. By virtue of the equivalence pointed out above, the same criteria as to the location of transmitting and attenuating regions apply also to the network of Fig. 1.

The same equivalent lattice structure shown in Fig. 2 is obtained for the network of Fig. 1 whether the transmission path between terminals 1, 2 and 3, 4 is considered or the transmission path between terminals 5, 6 and 7, 8. As demonstrated above, the network of Fig. 1 will have a characteristic impedance at each pair of terminals which is a constant pure resistance at all frequencies and will have two transmission paths, one between terminals 1, 2 and terminals 3, 4 the other between terminals 5, 6 and terminals 7, 8, the transmission range corresponding with the attenuating regions of the partial networks. It is axiomatic in connection with transmission networks having a non-reactive characteristic impedance that at all frequencies the input energy must be dissipated in resistive loads. In the transmission bands just mentioned, the input energy supplied by E_1 and E_2 is dissipated, respectively, in the load impedances R_2 and R_4 throughout the transmission range. In the attenuating region, however, the energy from E_1 is dissipated in the load R_3 , while the energy from E_2 is dissipated in the load R_1 . It follows, therefore, that there is a transmission path between terminals 1, 2 and terminals 5, 6 for frequencies which fall within the transmitting band of the partial networks. There will also be a second transmission path for the same frequencies between terminals 3, 4 and terminals 7, 8.

The various transmission paths just described are indicated schematically in Fig. 3 in which the solid line arrows A, A' represent the transmission channels corresponding to the attenuating range of the partial networks and the dotted arrows B, B' represent the transmission channels corresponding to the transmitting ranges of the

partial networks. The attenuation of the channels A, A' is dependent upon the impedance balance obtainable in the partial networks of the equivalent lattice shown in Fig. 2, whereas the attenuation in the channels B, B' depends upon the transfer constants of the partial networks. As the number of sections in the partial networks is increased the attenuation in the latter channels is correspondingly increased. The channels A and B will be mutually exclusive but will have contiguous boundaries on one side.

When each partial network N of the structure shown in Fig. 1 consists of only one series impedance branch Z_1 and one shunt impedance branch Z_2 the resulting configuration will be as shown diagrammatically in Fig. 4. Some of the more specific structures of the network of the invention following the structure of Fig. 4 will now be considered. It is to be understood, however, that in the case of all of the circuits illustrated multi-section partial networks may be employed, as shown in the network of Fig. 1. In some instances, it is found advantageous to make the multi-section partial networks composite structures comprising component sections which differ from each other in type.

If, for example, the partial networks of Fig. 4 are high-pass filters in which the impedance Z_1 is a capacitance of value C_1 and Z_2 is an inductance of value L_1 , the network shown in Fig. 5 will be obtained. The capacitance C_1 represents the full series branch and the inductance L_1 represents the full shunt branch of a constant-k structure and their values are found from the following equations:

$$C_1 = \frac{1}{4\pi f_c' K} \quad (3)$$

$$L_1 = \frac{K}{4\pi f_c'} \quad (4)$$

where

$$f_c' = \frac{f_c}{\sqrt{2}} \quad (5)$$

In these equations K is the characteristic impedance of the network as a whole and f_c represents the boundary frequency between the two channels. The network of Fig. 5 has a low-pass transmission path between terminals 1, 2, and terminals 3, 4 and a second low-pass path between terminals 5, 6 and terminals 7, 8. The network also has a high-pass transmission path between terminals 1, 2 and terminals 5, 6 and a second high-pass path between terminals 3, 4 and terminals 7, 8. The networks may be connected simultaneously in two separate channels of impedance R , the first channel being connected between terminals 1, 2 and terminals 3, 4 and the second channel between terminals 5, 6 and terminals 7, 8. The network will have the transmission paths enumerated above, but there will be no direct transmission of energy between terminals 1, 2 and 7, 8 or between terminals 3, 4 and 5, 6. If the terminal load connected to each of the pairs of terminals is a non-reactive impedance equal to R , the characteristic impedance at each pair of terminals will be a constant pure resistance equal to R at all frequencies.

The transmission loss characteristics of the network of Fig. 5 will be as shown symbolically in Fig. 6 in which curve 10 represents the transmission loss of channels A, A' and curve 11 represents the transmission loss of channels B, B'. The curve 10 has a peak of attenuation at the frequency f_1 at which point the branch impedances Z_a and Z_b of the equivalent lattice struc-

ture of Fig. 2 are equal to each other, and at infinite frequency the curve again becomes infinite in value. Curve 11 is a high-pass characteristic similar to that of a constant-k type filter having a cut-off at f_c . The curve will fall to zero at the frequency f_1 but at higher frequencies will have a slight hump as indicated at the frequency f_2 which in most cases will not exceed more than a few tenths of a decibel in magnitude. At the common cut-off frequency f_c which approximately coincides with the crossover point of the two curves, the value of each is about three decibels.

When the partial networks of the structure shown in Fig. 4 are low-pass filters of the constant-k type, the resulting network will be as shown in Fig. 7, in which the impedance Z_1 is the inductance L_2 and the impedance Z_2 is the capacitance C_2 . The elements L_2 and C_2 may be evaluated from the following expressions:

$$C_2 = \frac{1}{\pi f_c'' K} \quad (6)$$

$$L_2 = \frac{K}{\pi f_c''} \quad (7)$$

where

$$f_c'' = f_c \sqrt{2}. \quad (8)$$

The transmission paths A and B are high-pass and low-pass channels, respectively, as shown by curves 12 and 13 of Fig. 8, in which f_c represents the common cut-off frequency. The curve 12 has a peak of attenuation at the frequency f_3 and rises to infinite loss at zero frequency. Curve 13 is similar to the attenuation characteristics of a low-pass constant-k filter except for the slight rise in the characteristic shown at the frequency f_4 . At the frequency f_3 curve 13 has zero loss.

When the partial networks of the circuit of Fig. 4 are band-pass filters of the constant-k type, the resulting network will be as shown in Fig. 9 in which the series impedance Z_1 is constituted by an inductance L_3 and a capacitance C_3 in series and the shunt impedance Z_2 consists of an inductance L_4 and a capacitance C_4 in parallel. The transmission loss characteristic of the network shown in Fig. 9 is given in Fig. 10 in which curve 14 represents channel A and curve 15 represents channel B, as indicated in Fig. 3. Curve 14 has peaks of attenuation at the frequencies f_5 and f_6 at which frequencies curve 15 is zero. Curve 15 has the characteristic of a constant-k type band-pass filter except for the slight rise shown at f_7 which in ordinary cases will not exceed a small fraction of a decibel in magnitude. In this case there will be two cut-off frequencies f_a and f_b .

A certain amount of freedom in the choice of the location of the attenuation peak in the low-pass channel of the filter shown in Fig. 5 may be obtained by resorting to the modification shown in Fig. 11 in which the inductance $2L_1$ is replaced by the four winding transformer T_1 . The primary of this transformer may be considered to be the two equal inductances $\Phi^2 L_1$ and $\Phi^2 L_1$, and the secondary, the two windings each equal in value to L_1 . The mid-points of the primary and secondary windings are connected together by the strap 16 shown in Fig. 11. Assuming a high coefficient of coupling between the primary and secondary windings of the transformer T_1 , it will have an impedance ratio of $\Phi^2:1$. The values of the remaining elements of Fig. 11 will be the same as those given in Fig. 5. By a proper choice of the factor Φ^2 the peak of attenuation shown in curve 10 of Fig. 6 at the frequency f_1 may be located at any desired frequency as, for example,

at the frequency f_1' in which case the new attenuation characteristic will be that shown by the dotted line curve 17 of Fig. 6. The attenuation characteristic of the high-pass channel will also be changed somewhat by this modification and will assume the position shown by the dotted curve 18 of Fig. 6. The cross-over point of the two curves is raised from the frequency f_c to f_d . By this same process the attenuation peak of curve 10 may be located at a lower frequency, if desired. In the network of Fig. 11 the characteristic impedance at each pair of terminals will be a constant pure resistance equal to R at all frequencies.

In order to provide a peak of attenuation in both the high-pass and the low-pass channels, the network shown in Fig. 12 may be used. This network has an inductance $2L_6$ connected directly between terminals 1 and 3, an antiresonant loop consisting of a capacitance C_5 and an inductance L_5 connected between terminals 1 and 5 and a similar combination connected between terminals 3 and 7. The two inductances L_5 , L_5 have a mutual inductance M_1 equal to L_5 effective between them and are connected series aiding. Between the terminals 5 and 7 are disposed two inductances each equal to $\frac{1}{2}L_6$ having a mutual inductance M_2 equal to $\frac{1}{2}L_6$, also connected series aiding. Between the common terminal of the two inductances last-mentioned and the path connecting terminals 2 and 4 extends an arm comprising an inductance of value $2L_7$, a capacitance $2C_7$ and an capacitance $2C_6$, all connected in series. The network is completed by another condenser of value $2C_8$ connected from the common terminal of the two last-mentioned condensers to the path joining terminals 6 and 8.

The design of the network of Fig. 12 is most conveniently worked out by means of its equivalent lattice structure, which is shown in Fig. 13. Each line impedance branch Z_a consists of a single section shunt derived m-type high-pass filter, mid-shunt terminated at each end. The diagonal impedance branches Z_b are series derived m-type high-pass filters mid-series terminated at each end. When properly designed the impedances of these two structures are inherently inverse with respect to K^2 and the network as a whole will, therefore, have a constant resistance characteristic impedance. It will be noted that the elements appearing in one branch of the equivalent lattice structure shown in Fig. 13 do not appear in the other branch. That is to say, the elements comprising the series impedance branch Z_a are C_5 , L_5 and L_6 whereas the elements comprising the lattice branch Z_b are C_6 , C_7 and L_7 . This is accomplished by means of the two mutual inductances M_1 and M_2 shown in Fig. 12, and permits the provision of a peak of attenuation in the high-pass channel, as well as one in the low-pass channel.

The design parameters of the Z_a impedance branch of the network of Fig. 13 are f_c the cut-off of the network as a whole, f_s the frequency of infinite attenuation of the partial network and K'' the characteristic impedance of the partial network. The factor K'' may be made equal to K , the characteristic impedance of the network as a whole, or it may be given either a larger or a smaller value. Upon the choice of K'' depends the location of the frequency f_s at which the peak of attenuation in the low-pass channel occurs. With the required parameters determined the values of the elements C_5 , L_5 and L_6 may readily be computed from standard formulas. The values

of the reactances in the diagonal branches, namely, C_6 , C_7 and L_7 may now be found from the relationships given below:

$$\frac{L_5}{C_7} = \frac{L_6}{C_6} = \frac{L_7}{C_5} = K^2 = R^2 \quad (9)$$

If the two inductances each equal to $\frac{1}{2}L_6$ of Fig. 12 do not have perfect coupling, the inductance $2L_7$ may be decreased in value in order to make up for the leakage inductance. A typical transmission loss characteristic of the network of Fig. 12 is shown in Fig. 14. The peaks of attenuation in the high-pass and low-pass channels occurring, respectively, at the frequencies f_8 and f_9 may be controlled as indicated above.

The low-pass-high-pass filter of Fig. 5 may be used as a six terminal network simply by connecting a resistance R across the terminals 7 and 8 as shown in Fig. 15. The network will have a constant non-reactive characteristic impedance equal to R at the three remaining pairs of terminals and will have a low-pass transmission channel between terminals 1, 2 and 3, 4 and a high-pass channel between terminals 1, 2 and 5, 6. The channels are those marked A and B in the schematic diagram of Fig. 3. The network may be used, for example, in place of a line filter set to separate low frequencies from high frequencies. The source of both low and high frequencies is connected to terminals 1 and 2, the low frequency channel is connected to terminals 3 and 4 and the high frequency channel is connected to terminals 5 and 6.

If it is not required that the characteristic impedance of the network be a constant non-reactive impedance at all of the terminal pairs, the resistance R of Fig. 15 may be omitted entirely in which case the network will have a constant non-reactive characteristic impedance equal to R at terminals 1, 2 but not at terminals 3, 4 and terminals 5, 6. When the resistance R is omitted, the capacitance $2C_1$ may be placed in the other side of the high-pass channel, that is, instead of being placed in series with the lead to terminal 6, it is placed in series with the lead to terminal 5 as shown in Fig. 16. This modification will permit one side of each of the channels to be connected to a common ground as shown at G in Fig. 16. One of the channels is thus no longer left floating with respect to the other as is the case with the circuits heretofore described.

Another arrangement which permits both transmission channels of the network of Fig. 15 to be grounded to a common ground is shown in Fig. 17, in which a transformer T_2 having a 1:1 impedance ratio is interposed between terminals 5, 6 and 5', 6'. Transformer T_2 should be of the so-called ideal type, that is, one having very large winding inductances and a high coefficient of coupling. The terminals 2 and 6 may now be connected together by means of the strap 19 and grounded as shown at G.

The use of the ideal transformer of Fig. 17 is eliminated in the structure shown in Fig. 18, in which the two inductances L_1 , L_1 are replaced by the two transformers T_3 , T_3 having primary and secondary windings each equal to L_1 and having a high coefficient of coupling. The paths between terminals 2 and 4 and between terminals 6 and 8 may be connected together by the strap 20 and connected to the common ground G. The replacement of the ideal transformer T_2 shown in Fig. 17 by the two transformers T_3 , T_3 of Fig. 18 having finite

winding inductances is desirable because the latter transformers are less expensive to build and have such a small value of direct current resistance as compared to R , the impedance of the load, that the constant resistance properties of the network are not disturbed by their introduction.

The modification illustrated by Fig. 18 may also be applied to the band-pass-band-elimination filter of Fig. 9 resulting in the network shown in Fig. 19 in which the two inductances L_4 , L_4 are replaced by a pair of transformers T_4 , T_4 , the windings of which are each equal to L_4 . The two equipotential sides of the respective transmission paths may be connected by the strap 21 and a common ground G employed.

The two low-pass channels of the network shown in Fig. 18 may be made completely balanced in form by the introduction of the modifications shown in Fig. 20. The series inductance $2L_1$ is divided into two equal parts, one of which is placed in each side of the line. The two transformers T_3 , T_3 are replaced by a pair of transformers T_5 , T_5 having divided primary and secondary windings, the capacitances C_1 , C_1 being placed between the divided primary windings. One-half of each divided secondary winding is placed in the path between terminals 5 and 7 and the other half is connected in the path between terminals 6 and 8, thus making the structure completely balanced.

What is claimed is:

1. A wave transmission network having eight terminals arranged in four pairs, the characteristic impedance at each of said pairs of terminals being a constant pure resistance at all frequencies, said network having four transmission paths, the attenuation in two of said paths depending upon the impedance balance between two component partial networks, the attenuation in the remaining two paths depending upon the propagation constants of said component partial networks, two of said paths having a single transmission band with substantial attenuation at all frequencies outside of said band, and the attenuation characteristic of each of said transmission paths having a peak of attenuation at a finite frequency other than zero.

2. A wave transmission network having eight terminals arranged in four pairs, the characteristic impedance at each of said pairs of terminals being a constant pure resistance at all frequencies, said network having four transmission paths, a component impedance element of said network being common to a plurality of said paths, two of said paths having a single transmission band with substantial attenuation at all frequencies outside of said band, and the attenuation characteristic of each of said transmission paths having a peak of attenuation at a finite frequency other than zero.

3. A wave transmission network having eight terminals arranged in four pairs, the characteristic impedance at each of said pairs of terminals being a constant pure resistance at all frequencies, said network having a transmission path between one pair of said terminals and a second pair of said terminals, a second transmission path between a third pair of said terminals and the remaining pair of said terminals, and a third transmission path between said first mentioned pair of terminals and said third pair of terminals, said first mentioned transmission path and said second transmission path being adapted to pass without appreciable attenuation

a band of frequencies extending from the lower cut-off frequency to the upper cut-off frequency, said network having a component impedance element common to a plurality of said transmission paths, and each of said transmission paths having a peak of attenuation at a finite frequency other than zero.

4. A wave transmission network having eight terminals arranged in four pairs, the characteristic impedance at each of said pairs of terminals being a constant pure resistance at all frequencies, said network having a transmission path between one pair of said terminals and a second pair of said terminals, a second transmission path between a third pair of said terminals and the fourth pair of said terminals, a third transmission path between said first mentioned pair of terminals and said third pair of terminals, and a fourth transmission path between said second pair of terminals and said fourth pair of terminals, said first mentioned path and said second path being adapted to pass without appreciable attenuation a band of frequencies extending from the lower cut-off frequency to the upper cut-off frequency, said third path and said fourth path being adapted to pass a second band of frequencies, said first mentioned band of frequencies and said second band of frequencies being contiguous, said network having a component impedance element common to a plurality of said transmission paths, and each of said transmission paths having a peak of attenuation at a finite frequency other than zero.

5. A selective wave transmission network having eight terminals arranged in four pairs, the characteristic impedance at each of said pairs of terminals being a constant pure resistance at all frequencies, said network having a transmission path between a pair of said terminals and a second pair of said terminals, and a second transmission path between said first mentioned pair of terminals and a third pair of said terminals, said two transmission paths being adapted to pass with appreciable attenuation bands of frequencies which are mutually exclusive but which are contiguous to each other, said network having a component impedance element common to both of said transmission paths, and each of said transmission paths having a peak of attenuation at a finite frequency other than zero.

6. A selective wave transmission network having eight terminals arranged in four pairs, the characteristic impedance at each of said pairs of terminals being a constant pure resistance at all frequencies, said network having a transmission path between one pair of said terminals and a second pair of said terminals, and a second transmission path between said first mentioned pair of terminals and a third pair of said terminals, said first mentioned path being adapted to transmit without appreciable attenuation frequencies lying above a certain cut-off point, and said second path being adapted to transmit without appreciable attenuation frequencies lying below said cut-off point, said network having a component impedance element which is common to both of said transmission paths, and each of said transmission paths having a peak of attenuation at a finite frequency other than zero.

7. In a multichannel wave transmission network having eight terminals designated 1 to 8 arranged in four pairs, an impedance comprising an inductance connected between terminals

- 1 and 5, a second impedance comprising a second inductance connected between terminals 3 and 7, a mutual inductance M_1 effective between said two inductances, a third impedance connected between terminals 1 and 3, a third inductance comprising two equal windings coupled by mutual inductance M_2 connected in series between terminals 5 and 7, a fourth impedance connected on one side to the junction point of said two equal windings and on the other side to terminals 2 and 4, and a fifth impedance connected on one side to a point in said fourth impedance and on the other side to terminals 6 and 8, said impedances being proportioned to provide a transmission path between one of said pairs of terminals and a second pair of said terminals, and a second transmission path between said first-mentioned pair of terminals and a third pair of said terminals.
8. A multichannel wave transmission network in accordance with claim 7 in which the bands of frequencies passed by said two transmission paths are mutually exclusive.
9. A multichannel waves transmission network

in accordance with claim 7 in which one of said transmission paths passes all frequencies lying above a cut-off frequency and the other of said transmission paths passes all frequencies lying below a cut-off frequency.

10. A multichannel wave transmission network in accordance with claim 7 in which each of said transmission paths has a peak of attenuation at a finite frequency other than zero.

11. A multichannel wave transmission network in accordance with claim 7 in which the characteristic impedance at each of said pairs of terminals is a constant pure resistance at all frequencies.

12. A transmission network in accordance with claim 7 in which said first-mentioned inductance, said second inductance and the mutual inductance M_1 are all substantially equal.

13. A transmission network in accordance with claim 7 in which the mutual inductance M_2 is substantially equal to the inductance of each of said two equal windings of which said third inductance is comprised.

STEPHEN BOBIS.