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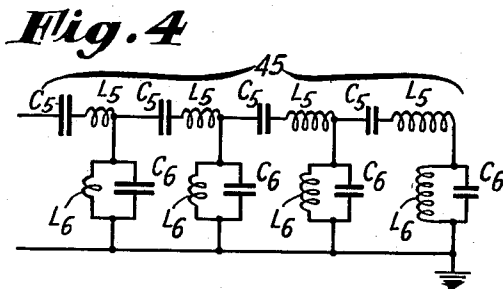
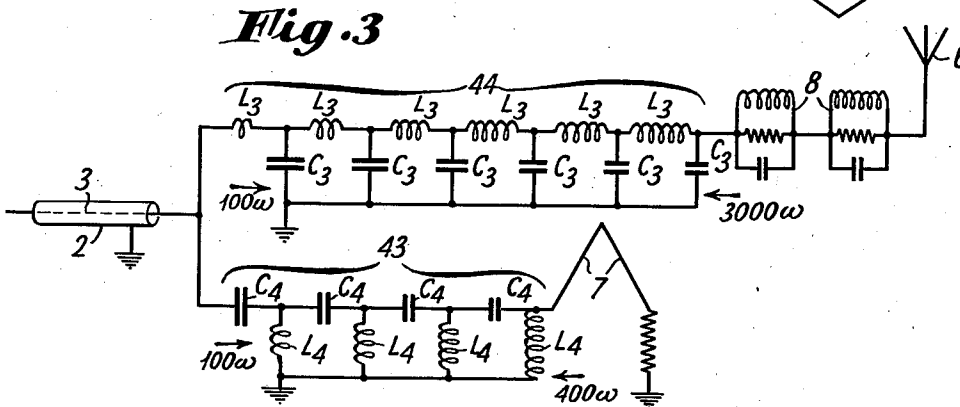
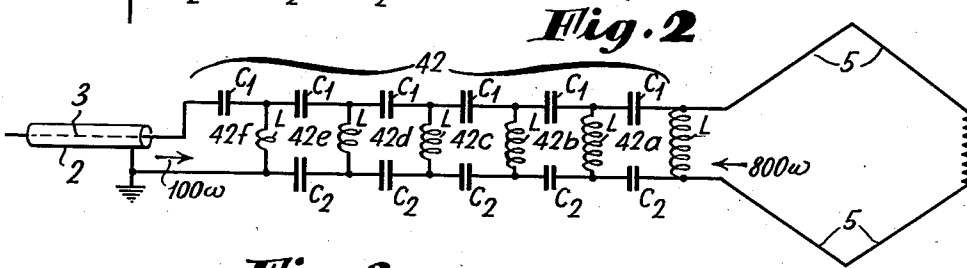
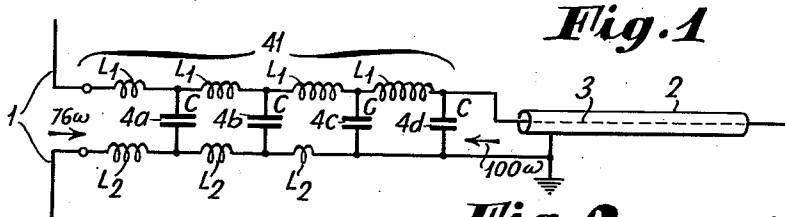
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2,264,718

AERIAL FEED AND AERIAL TUNING CIRCUIT ARRANGEMENT

Filed April 2, 1938

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 5.

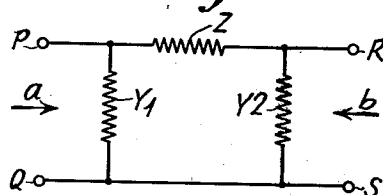


Fig. 6.

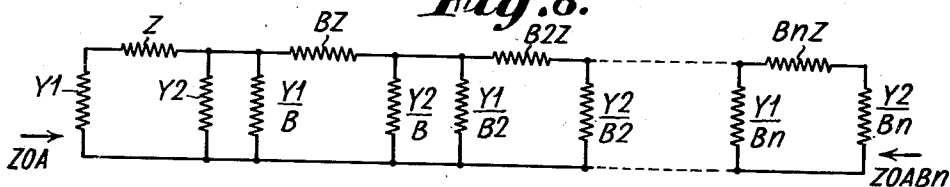


Fig. 7.

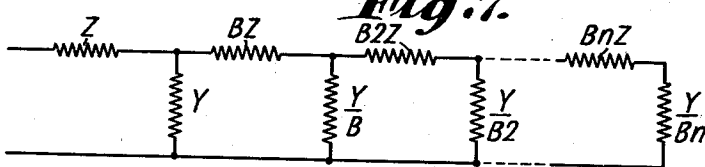


Fig. 8.

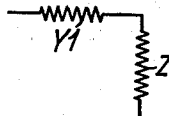


Fig. 9.

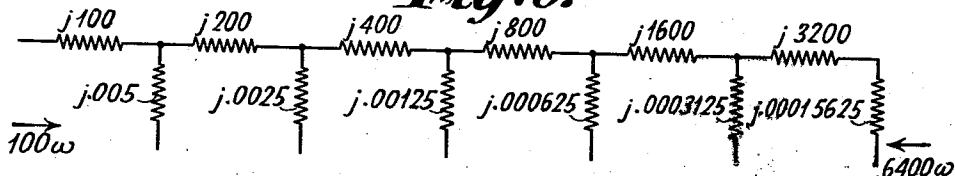


Fig. 10.

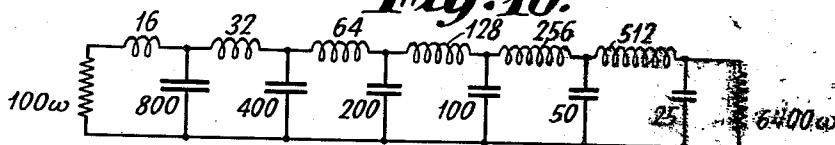
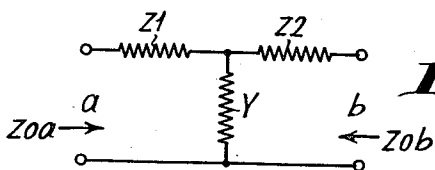


Fig. 11.



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AERIAL FEED AND AERIAL TUNING CIRCUIT
ARRANGEMENTNoël Meyer Rust and John Forrest Ramsay,
Chelmsford, England, assignors to Radio Cor-
poration of America, a corporation of DelawareApplication April 2, 1938, Serial No. 199,591
In Great Britain April 15, 1937

4 Claims. (Cl. 178—44)

This invention relates to aerial feed and aerial tuning circuit arrangements and has for its main object to provide improved arrangements wherein one or more aeri-als is or are remotely situated with respect to tuning apparatus therefor, or with respect to receiving apparatus associated therewith, said aerial or aeri-als being connected to said apparatus through a length or lengths of high frequency cable.

As is well known serious difficulties as regards impedance matching, efficient energy transfer and tuning are experienced when an aerial or aeri-als is or are remotely situated with respect to tuning or receiving apparatus associated therewith and the present invention seeks to solve these difficulties in a simple and satisfactory manner.

According to the main feature of the invention an arrangement wherein a remotely situated aerial is associated with a receiver or with tuning apparatus through a high frequency cable is characterised in that said aerial is connected to the aerial end of said cable through a reactance transformer constituted by a tapered artificial line, said line consisting of a plurality of sections of progressively different electrical dimensions whereby said line matches, at one end, the aerial impedance and at the other end the high frequency cable impedance, the impedance transformation over the line taking place in a plurality of steps determined by the number of sections in the line.

The line may be arranged to give high pass, low pass, or band pass characteristics as may be required. Further the line may be arranged to couple a symmetrical aerial, such for example as a centre feed dipole, to an asymmetrical cable, such as an ordinary concentric tubular air spaced cable with its outer conductor earthed, or vice versa.

Where it is required to couple two alternatively utilisable receiving aeri-als, one a long wave aerial and the other a short wave aerial, to a common receiver which can be tuned in either wave range, the invention enables said aeri-als to be permanently coupled to said receiver through a common high frequency cable by providing two tapered artificial lines, one between the long wave aerial and the cable and the other between the short wave aerial and the cable. With such

an arrangement reception can be effected from either aerial without adverse interference due to the other.

An important feature of the invention resides in improved arrangements for remotely tuning an aerial by tuning apparatus which may be remote both from the aerial and from associated receiving apparatus and according to this feature a series or current tuning network is interposed between two lengths of high frequency cable one of which is coupled to the aerial through one tapered artificial line and the other of which is coupled to the receiver through another tapered artificial line.

The invention is illustrated and further explained in connection with the accompanying drawings wherein Fig. 1 illustrates the invention incorporated with a dipole of the centre feed type; Fig. 2 illustrates the invention applied in an arrangement using a rhomboid aerial; Fig. 3 is a circuit diagram wherein the invention is applied to a system incorporating an ordinary medium and long wave aerial; Fig. 4 is a circuit diagram illustrating a circuit arrangement according to the invention which has band pass characteristics; and Fig. 5-11 are diagrams which are used to explain the various features and functions of the invention.

Referring to Figure 1 a receiving dipole 1 of the centre feed type is connected to remotely situated receiving apparatus or tuning apparatus (not shown) through a tubular concentric air spaced cable 2, 3, having its outer conductor 2 earthed. The aerial end of this cable is coupled to the aerial through a tapered artificial line 41. This line consists of a plurality of sections—in Figure 1 four sections 4a, 4b, 4c, 4d are shown though the more the sections the smoother will be the impedance transformation—and, where a low pass effect is required each section (except that (4d) nearest the cable) may consist of two series inductances L_1 L_2 one in each wire of the line and a shunt capacity C. In the section nearest the cable the inductance (corresponding to L_2 in sections 4a, 4b and 4c) in that wire which is connected to the earthed "outer" 2 of the cable is omitted. Thus one half of the dipole is connected to the "inner" 3 of the cable through one wire of the line, this wire consisting of four series inductances L_1 of values which progres-

sively increase in the direction of the cable. The other half of the dipole is connected to the "outer" 2 of the cable through the other line wire which consists of three series inductances L_2 whose values progressively decrease in the direction of the cable. Four shunt condensers C whose values progressively decrease in the direction of the cable, are provided between the wires of the line as shown. It will be seen that this line 41 is a low pass line presenting low impedance (a practical figure is 76 ohms as indicated) at the aerial end and a higher impedance (a practical figure is 100 ohms as indicated) at the cable end while furthermore the line not only gradually transforms the impedance but gives a gradual transformation from symmetrical connection (at the aerial end) to asymmetrical (at the cable end).

In another example in accordance with the invention and shown in Figure 2 a rhomboid aerial 5 of, say, 800 ohms, is coupled to a concentric tubular cable 2, 3, of, say, 100 ohms, through a tapered artificial line 42 of high pass characteristics and shown as having six sections 42a . . . 42f. As before one terminal of the aerial 5 is connected to the cable "inner" 3 through one wire of the line and the other terminal of the aerial is connected to the cable "outer" 2 through the other wire of the line. Said one wire of the line consists of a plurality of series condensers C_1 (as shown six) progressively decreasing in value in the direction of the cable, and said other wire consists of another plurality of series condensers C_2 (one less than in said one wire) which progressively increase in value in the direction of the cable. Shunt inductances L are provided across the line, these inductances progressively decreasing in value in the direction of the cable. The number of inductances is the same as the number of condensers C_1 the first inductance being directly across the aerial and the other inductance being so connected that the tapered line consists of a plurality of sections each (except that nearest the cable) comprising two condensers (one in each wire) and a shunt inductance. The section nearest the cable differs from the others in having no condenser C_2 . Here again the impedance transformer is smooth and there is transformation from symmetrical at the aerial end to asymmetrical at the cable end.

In the embodiment of the invention shown in Figure 3 an ordinary medium and long wave aerial 6, operable over a range of say 200-2,000 metres is permanently connected to one end of the "inner" 3 of a concentric tubular cable with an earthed "outer" 2 through a first tapered artificial line 44, and a short wave inverted V aerial 7 operable over a range of say 15-50 metres is permanently connected to the same end of said inner through a second tapered artificial line 43. In this arrangement each artificial line has one "wire" constituted by an earth connection. The remaining wire of the first artificial line 44 consists of a series of inductances L_3 of diminishing magnitude in the direction of the cable, connected at one end to the cable "inner" 3 and connected at the other (if desired through any suitable correction network or networks as known per se and indicated diagrammatically at 8) to the aerial 6. Shunt condensers C_3 of increasing magnitude in the direction of cable, are provided one between the aerial end of the inductive "wire" of the line and earth (the other "wire") and the remainder between the various

junction points of the series inductances L_3 and earth. To take practical figures the line 44 may present an impedance of about 3,000 ohms at the aerial end and an impedance of about 100 ohms at the cable end, for long and medium waves, presenting very high impedance at the cable end for the short wave range (15-50 metres) and attenuating short waves very strongly. The second line 43 consists of a series of condensers C_4 of increasing magnitude in the direction of the cable, the series being connected at one end to the short wave aerial 7 and at the other to the cable "inner" 3. Shunt inductances L_4 of diminishing magnitude in the direction of the cable, are provided between the "live" end of the inverted V aerial 7 and earth, and between the junction points of the various condensers C_4 and earth. Again to take practical figures, the second artificial line 43 may present an impedance of about 400 ohms at the aerial end and an impedance of about 100 ohms at the cable end for short waves, presenting very high impedance at the cable end for medium and long waves and attenuating these waves very strongly.

The invention is not limited to the precise forms of tapered artificial lines already described; for example, where a band pass effect is required, such a line might be as shown at 45 in Figure 4 consisting of a plurality of sections of graded dimensions, each section consisting of an inductance L_5 and a capacity C_5 in series in one wire and an inductance L_6 and a capacity C_6 in parallel between said one wire and the other wire, which is a simple conductor or an earth connection.

In series resonant type tuners large value inductances and small value condensers can be used provided that the ranges of variation of the condensers are extended enough to give the required tuning ranges. Small variable condensers of excellent maximum-to-minimum capacity ratio, and very high efficiency have already been developed for short wave working and such condensers are most suitable for use in carrying out this invention as tuning condensers. It has been found that adequate tuning ranges—often better than those normally obtainable with parallel tuned circuits—are readily obtainable and it will be realised that the external wiring is at a minimum and therefore stray capacities can be reduced to very small values. The practical limit to increasing inductance and reducing capacity in a series tuner is probably set by coil self-capacities (which increase with increase of inductance) which affect the high frequency ends of the tuning ranges. Coil losses are at their most serious in effect where low frequencies are in question, e. g. the long wave broadcast band.

In addition to the advantages already mentioned tuner arrangements as above described are readily "ganged" with remotely controlled tuning means in the receiver, e. g. in the case of a superheterodyne, with a remotely controlled local oscillator.

In experimental practice for broadcast reception it has been found advantageous to interpose long wave stopper condensers, of the order of 1,000 micro-micro-farads in the series tuner circuits. These condensers also facilitate circuit matching for "ganging" purposes.

The tuning arrangements above described are of wide application, e. g. to commercial receivers, relay station receivers, television receivers, hotel receiver installations, and so forth.

There will now be given a brief mathematical

description to facilitate the quantitative design of a reactance transformer constituted by an artificial line for use in carrying out the invention.

Consider a π section as shown in Figure 5 having terminals PQ on the end a and terminals RS on the end b . Let Z be the impedance of the series element and $Y1$, $Y2$, the admittances of the shunt elements as indicated in the figure, $Y1$ and $Y2$ being, in general, unequal.

Let

Zoa =characteristic impedance looking in at the end a .

Zob =characteristic impedance looking in at the end b .

Zag =impedance between P and Q with R and S connected together.

Zbg =impedance between R and S with P and Q connected together.

Zaf =impedance between P and Q with R and S open circuited.

Zbf =impedance between R and S with P and Q open circuited.

θ =the "line angle" of the π section (the image transfer constant).

$=\alpha+j\beta$

α =the attenuation constant of the π section.

β =the phase change constant of the π section.

Then

$$Zoa=\sqrt{(Zag Zaf)}$$

$$Zob=\sqrt{(Zbg Zbf)}$$

and

$$\tanh \theta = \sqrt{\left(\frac{Zag}{Zaf}\right)} = \sqrt{\left(\frac{Zbg}{Zbf}\right)}$$

For the π section of Figure 5 we have the following relations:

$$Zag = \frac{Z}{Y1Z+1} \quad Zbg = \frac{Z}{Y2Z+1}$$

$$Zaf = \frac{Y2Z+1}{Y1Y2Z+Y1+Y2} \quad Zbf = \frac{Y1Z+1}{Y1Y2Z+Y1+Y2}$$

$$Zoa = \sqrt{\left\{ \frac{Z}{Y1Y2Z+Y1+Y2} \cdot \frac{Y2Z+1}{Y1Z+1} \right\}}$$

$$Zob = \sqrt{\left\{ \frac{Z}{Y1Y2Z+Y1+Y2} \cdot \frac{Y1Z+1}{Y2Z+1} \right\}}$$

If

$$A = \frac{Z}{Y1Y2Z+Y1+Y2} \quad B = \frac{Y1Z+1}{Y2Z+1}$$

then

$$Zoa = \sqrt{\left(\frac{A}{B}\right)} \quad Zob = \sqrt{(AB)}$$

$$A = ZoaZob \quad B = \frac{Zob}{Zoa}$$

$$\tanh \theta = \sqrt{\left\{ \frac{Z(Y1Y2Z+Y1+Y2)}{(Y1Z+1)(Y2Z+1)} \right\}}$$

$$\sinh \theta = \sqrt{\{Z(Y1Y2Z+Y1+Y2)\}}$$

$$\cosh \theta = \sqrt{\{(Y1Z+1)(Y2Z+1)\}}$$

$$Z = \sqrt{(ZoaZob)} \cdot \sinh \theta = \sqrt{A} \cdot \sinh \theta$$

$$Y1 = \frac{\sqrt{\left(\frac{Zob}{Zoa}\right)} \cdot \cosh \theta - 1}{\sqrt{(ZoaZob)} \sinh \theta} = \frac{\sqrt{B} \cdot \cosh \theta - 1}{\sqrt{A} \cdot \sinh \theta}$$

$$Y2 = \frac{\sqrt{\left(\frac{Zoa}{Zob}\right)} \cdot \cosh \theta - 1}{\sqrt{(ZoaZob)} \sinh \theta} = \frac{1}{\sqrt{B}} \cdot \frac{\cosh \theta - 1}{\sqrt{A} \cdot \sinh \theta}$$

Consider the case of a second π section of sim-

ilar configuration having corresponding constants: Z^1 , $Y1^1$, $Y2^1$, Z^1_{oa} , Z^1_{ob} , etc.

If the second section is connected in tandem with the first, there will be no matching loss (at a specific frequency) if $Z^1_{oa}=Zob$.

Of the possible values the line angle of the second section may take, that value where it is equal to the line angle of the first section is taken (in contrast with the hitherto usual method of making the line angles unequal).

Thus $\tanh \theta^1 = \tanh \theta$.

As the second section contains three independent variables Z^1 , $Y1^1$, $Y2^1$, a third relation is necessary in order that they may be independently specified. Such a relation may be obtained by giving the sections equal taper ratios, B , i. e. $B^1=B$.

It may then be established that

$$Z^1 = BZ$$

$$Y1^1 = \frac{Y1}{B}$$

$$Y2^1 = \frac{Y2}{B}$$

the taper ratio of the sections being also the taper factor applying to the elements of the second section.

It is then possible to build up a chain of sections in which the taper ratio per section is constant, the b end of each section matching the a end of the next. The construction of such a chain is illustrated by Figure 6.

In order to secure a step up transforming action in the prototype section of Figure 5, it is necessary that B should be real, positive and greater than unity. Two cases arise, derivable from the formula for B , viz:

(1) If $|Y2| < |Y1|$, $Y1Z$ and $Y2Z$ must each be negative and numerically greater than unity, i. e. $Y1Z < -1$ and $Y2Z < -1$.

(2) If $|Y1| < |Y2|$, $Y1Z$ and $Y2Z$ must each be negative and numerically less than unity, i. e. $-1 < Y1Z < 0$ and $-1 < Y2Z < 0$.

These conditions are equivalent to conditions of zero attenuation; in case (1), however, the conditions, while necessary, are not sufficient. For zero attenuation $\tanh \theta$ must be purely imaginary, i. e. $\sinh \theta$ must be imaginary and $\cosh \theta$ real.

If $\sinh \theta$ is to be imaginary $ZY1 + ZY2 + Z^2Y1Y2$ must be negative.

In (1) $ZY1$ and $ZY2$ are negative hence

$$|Z^2Y1Y2| < |ZY1 + ZY2|$$

or

$$|ZY1 \cdot ZY2| < |ZY1 + ZY2|$$

This holds if $|ZY1| < 2$ and $|ZY2| < 2$ i. e., $-2 < ZY1 < -1$ and $-2 < ZY2 < -1$

For $\cosh \theta$ to be real and numerically less than unity this condition is also necessary and sufficient.

In (2) $ZY1$ and $ZY2$ are negative and less than unity, conditions necessary and sufficient that $\tanh \theta$ should be imaginary.

The above conditions define frequencies analogous to the cut-off frequencies of an ordinary symmetrical filter.

If the section be simplified by making the shunt arm $Y1$ vanish, only the second criteria apply, i. e. $Y1 < Y2$ and $-1 < Y1Z < 0$, $-1 < Y2Z < 0$.

The sections then take the form of Figure 7,

Y2 being replaced by Y. The fundamental formulae then have the following modified form:

$$\begin{aligned} Z_{ag} &= Z \quad Z_{bg} = \frac{Z}{YZ+1} \\ Z_{af} &= \frac{YZ+1}{Y} \quad Z_{bf} = \frac{1}{Y} \\ Z_{oa} &= \sqrt{\left\{ \frac{Z}{Y} (YZ+1) \right\}} = \sqrt{\left(\frac{A}{B} \right)} \\ Z_{ob} &= \sqrt{\left\{ \frac{Z}{Y} \frac{1}{(1+YZ)} \right\}} = \sqrt{(AB)} \\ A &= \frac{Z}{Y}, \quad B = \frac{1}{1+YZ} \\ \sinh \theta &= \sqrt{(YZ)}, \quad \cosh \theta = \sqrt{(1+YZ)} \\ \tanh \theta &= \sqrt{\left\{ \frac{YZ}{1+YZ} \right\}} = \sqrt{(1-B)} \\ B &= \operatorname{sech}^2 \theta \\ Z &= Z_{oa} \sqrt{(1-B)} = Z_{oa} \tanh \theta \\ Y &= \frac{\sqrt{(1-B)}}{B Z_{oa}} = \frac{\sinh \theta \cosh \theta}{Z_{oa}} \end{aligned}$$

For a step-up action $B > 1$, hence $\tanh \theta$ is imaginary. Since

$$ZY = \frac{1-B}{B}$$

and B is positive and greater than unity, ZY will be negative and fractional.

Given the input characteristic impedance, the frequency and the taper ratio, the first section is fully determined from the formulae

$$\begin{aligned} Z &= Z_{oa} \sqrt{(1-B)} \\ Y &= \frac{\sqrt{(1-B)}}{B Z_{oa}} \end{aligned}$$

The smaller ZY are the more the taper ratio approaches unity; and the smoother the tapering the closer will the sections adhere to a matched condition over a range of frequencies in the neighbourhood of the matching frequency.

The asymmetrical T-section may also be made the prototype section of a tapered artificial line. Such a section has series elements Z1, Z2 and shunt element Y as in Figure 11. The following relations may then be established.

$$\begin{aligned} Z_{ag} &= \frac{YZ_1Z_2+Z_1+Z_2}{YZ_2+1} & Z_{af} &= \frac{YZ_1+1}{Y} \\ Z_{bg} &= \frac{YZ_1Z_2+Z_1+Z_2}{YZ_1+1} & Z_{bf} &= \frac{YZ_2+1}{Y} \\ Z_{oa} &= \sqrt{\left\{ \frac{YZ_1Z_2+Z_1+Z_2}{YZ_2+1} \cdot \frac{YZ_1+1}{Y} \right\}} = \sqrt{\left(\frac{A}{B} \right)} \\ Z_{ob} &= \sqrt{\left\{ \frac{YZ_1Z_2+Z_1+Z_2}{YZ_1+1} \cdot \frac{YZ_2+1}{Y} \right\}} = \sqrt{(AB)} \\ A &= \frac{YZ_1Z_2+Z_1+Z_2}{Y} = Z_{oa} Z_{ob} \\ B &= \frac{YZ_2+1}{YZ_1+1} = \frac{Z_{ob}}{Z_{oa}} \\ \tanh \theta &= \sqrt{\left\{ \frac{Y(YZ_1Z_2+Z_1+Z_2)}{(YZ_1+1)(YZ_2+1)} \right\}} \\ \sinh \theta &= \sqrt{Y(YZ_1Z_2+Z_1+Z_2)} \\ \cosh \theta &= \sqrt{\{(YZ_1+1)(YZ_2+1)\}} \\ Z_1 &= \frac{\sqrt{(Z_{oa}Z_{ob})} \cdot \cosh \theta - Z_{ob}}{\sqrt{\left(\frac{Z_{ob}}{Z_{oa}} \right)} \cdot \sinh \theta} = \frac{\sqrt{A} \cdot \cosh \theta - \sqrt{(AB)}}{\sqrt{B} \cdot \sinh \theta} \\ Z_2 &= \frac{Z_{ob} \cosh \theta - \sqrt{(Z_{oa}Z_{ob})}}{\sinh \theta} = \frac{\sqrt{(AB)} \cosh \theta - \sqrt{A}}{\sinh \theta} \\ Y &= \frac{\sinh \theta}{\sqrt{(Z_{oa}Z_{ob})}} = \frac{\sinh \theta}{\sqrt{A}} \end{aligned}$$

The relations obtained above for the π and T sections have been ostensibly for low-pass con-

figurations. Similar formulae may be derived for high pass sections if in the π section Y, Z1, Z2 are written for Z, Y1, Y2 and in the T section if Y1, Y2, Z are written for Z1, Z2, Y.

- 5 The principle of asymmetry (associated with a transforming action) may be applied to chains of sections of other prototype configurations, e. g. bridge T and lattice, and to derived sections. Band pass filters having a step-up ratio in the
- 10 pass bands may also be obtained.

- The number of sections adopted in any given problem will usually be an economic compromise dependent upon the frequency range the system is expected to cover and the overall step-up required. The larger the number of sections, the smaller the step-up ratio per section and the more even the matching over a given frequency range.

- The marked advantage of proceeding on the basis of the two-element arrangement of Figure 8 (the Z arms being inductances and the Y arms condensers for a low pass line, and vice versa for a high pass line) is that the factor A is independent of frequency, the only mismatching required to be taken into account being that due to the dependence of B on frequency.

- The frequency usually taken as the matching frequency is the logarithmic mid-band or geometric mean frequency of the range considered, it being, of course, arranged that the "cut-off" frequency is outside the band. Where the band is reasonably narrow the cut-off frequency can easily be arranged to be a long way outside the band.

- 30 An actual example of design will now be given; the values applying to the two element section of Figure 8.

Frequency range = 600-1400 k. c.

Input impedance, $Z_{oa} = 100\Omega$

- 40 Output impedance, $Z_{ob} = 6400\Omega$

Impedance ratio = 64/1

Matching frequency, $\frac{\omega m}{2\pi} = 1000$ k.c.

- 50 No. of sections, $n = 6$

Taper ratio per section, $B = \sqrt[6]{(64)} = 2$

$$Z = Z_{oa} \sqrt{(1-B)} = j.100$$

$$Y = \frac{\sqrt{(1-B)}}{B Z_{oa}} = j.0.005$$

- 50 The sections may then be built up into a chain with successive values as shown in Figure 9. Realised in an actual structure the line is as shown in Figure 10, the values of the inductances being in microhenries and those of the capacities in micro-microfarads.

- 55 The "cut-off" frequency for the low pass section having series inductance L and shunt capacity C is derived from

$$ZY = -1$$

- 60 i. e.

$$\omega_0^2 LC = 1$$

where

$$\frac{\omega_0}{2\pi}$$

- 65 is the cut-off frequency.

If the matching frequency is $\omega m / 2\pi$

$$Z_m = j\omega m L \quad Y_m = j\omega m C$$

where

$$\omega_0 = \omega m \sqrt{\frac{j}{(Z_m Y_m)}}$$

In the above example

$$W_0 = 1000 \sqrt{\frac{j}{(j^2 C.5)}} = 1414 \text{ k.c.}$$

- 75 a frequency lying outside the required range.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:

1. In an arrangement for connecting a dipole antenna of the center feed type to remotely situated receiving apparatus, a concentric cable having an inner conductor and an outer conductor said outer conductor being grounded, means including a plurality of inductances connected in series for connecting one side of the dipole antenna to the inner conductor, the inductance values of said inductances being progressively greater in the direction from the dipole toward the concentric cable, means including a plurality of inductances in series for connecting the other side of the dipole antenna to the outer conductor of said cable, the inductance values of said last named inductances being progressively smaller in the direction from the dipole toward the concentric cable, and a plurality of condensers shunted between said two last named means at various points along the lengths thereof, said condensers having capacity values which progressively decrease in the direction from the dipole toward the concentric cable.

2. In an arrangement for connecting a remotely situated receiver, capable of being tuned to receive both long waves and short waves, to a long wave antenna and a short wave antenna through a common high frequency cable, said cable having an inner conductor and an outer conductor, the outer conductor being grounded, a connection including a plurality of series inductances between said long wave antenna and the inner conductor of said concentric cable, the inductance values of said series inductances being progressively smaller in the direction from the antenna toward the cable, a plurality of shunt condensers of increasing magnitude in the direction between the antenna and the cable connected one thereof between ground and the aerial end of said connection and the remainder thereof between ground and the various junction points of said series inductances, a second connecting line connected between the short wave antenna and said inner conductor and including a series of condensers of increasing magnitude in the direction between the short wave antenna and the cable, a plurality of inductances of diminishing

magnitude in the direction between the antenna and the cable, one thereof being connected between ground and the short wave antenna and the others being connected between ground and the junction points of the said series condensers.

3. In a signalling system the combination of a long wave antenna, a short wave antenna and a receiver arranged so as to be tunable either over a band of long waves and over a band of short waves, a common high frequency cable for feeding energy picked up from either of said antennae to the common receiver, an artificial line for connecting one end of said cable to the long wave antenna, said last named means comprising a plurality of filter sections of progressively different electrical dimensions, said line matching the cable impedance at one end and the long wave antenna impedance at the other end, the impedance transformation over the line taking place in a plurality of steps determined by the number of filter sections in the line, a second artificial line comprising a plurality of filter sections of progressively different electrical dimensions for coupling the short wave antenna to said end of the common cable, said second line matching the cable impedance at one end and the short wave antenna impedance at the other end, the impedance transformation over the second line taking place in a plurality of steps determined by the number of filter sections in the line.

4. Impedance transforming arrangement for matching the impedance of a source constituting a terminating impedance to the impedance of a load constituting another terminating impedance, one of said terminating impedances being balanced and the other thereof being unbalanced, a line comprising a plurality of impedance transforming sections connected in cascade between said terminating impedances, the section connected to the balanced terminating impedance having substantially equal reactance elements in both sides of the line, the section connected to the unbalanced terminating impedance having its series reactance substantially solely in one side of the line, the intermediate sections having progressively different proportions of series reactance in the two sides of the line.

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