Sept. 14, 1926. 1,599,453

H. A. AFFEL

ANTENNA STRUCTURE

Filed June 24, 1922

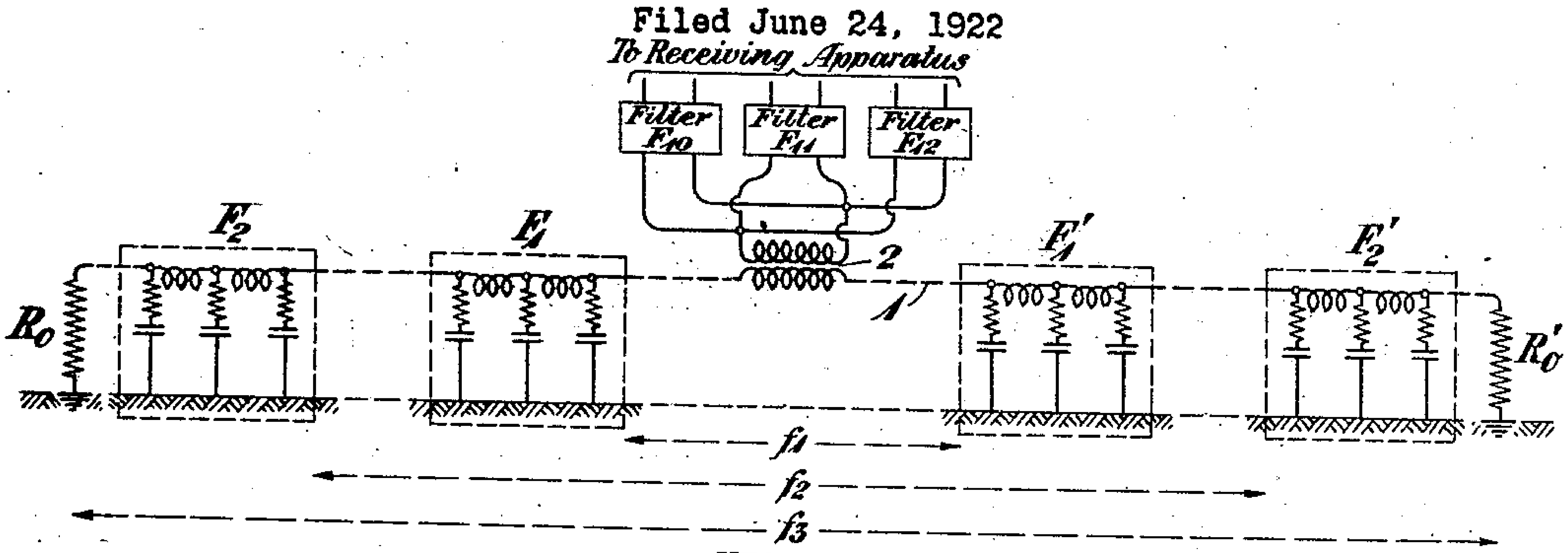

Fig. 1

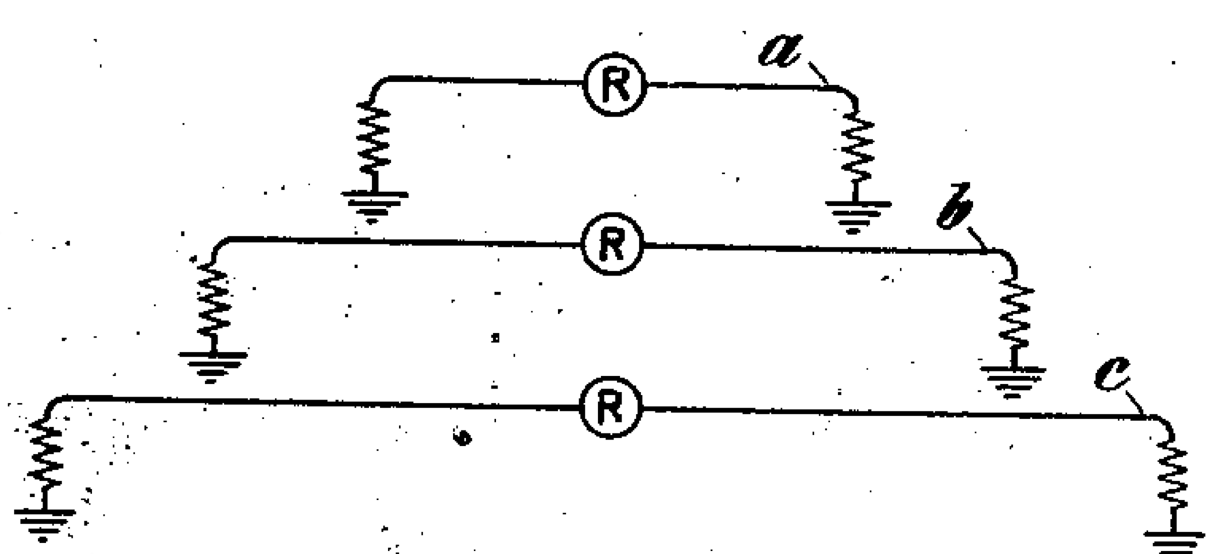

Fig. 2

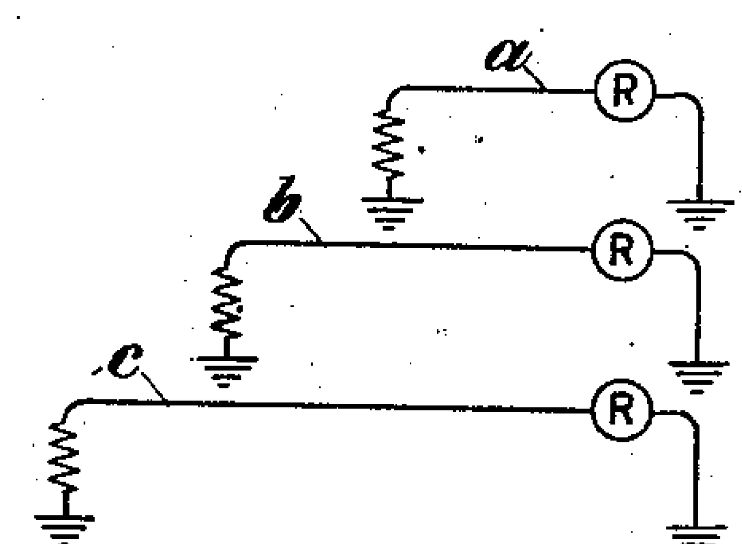

Fig. 4

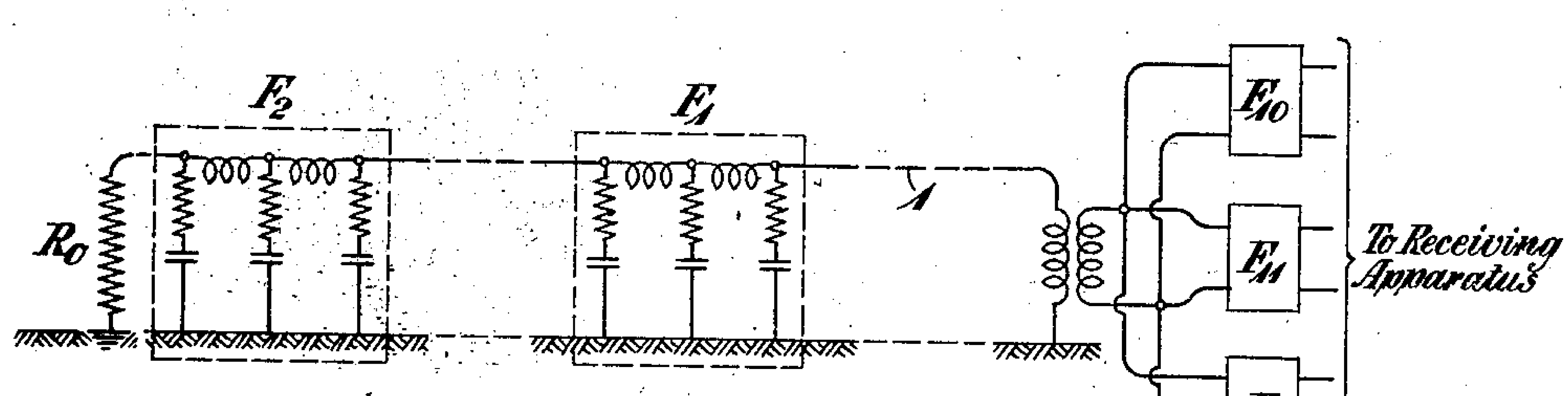

Fig. 3

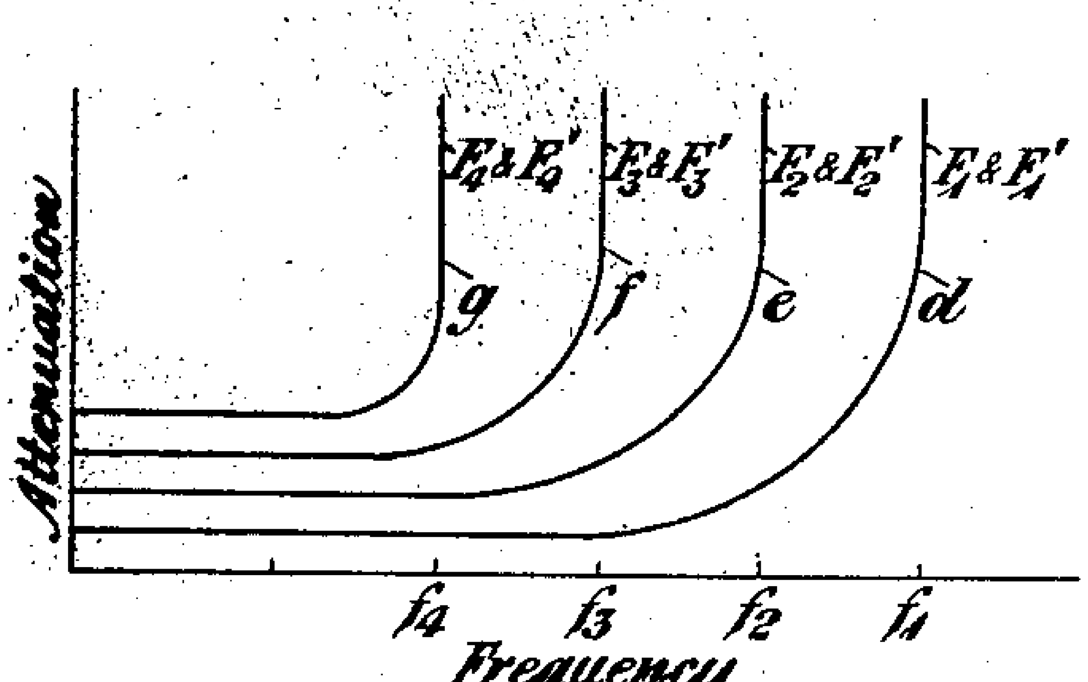

Fig. 5

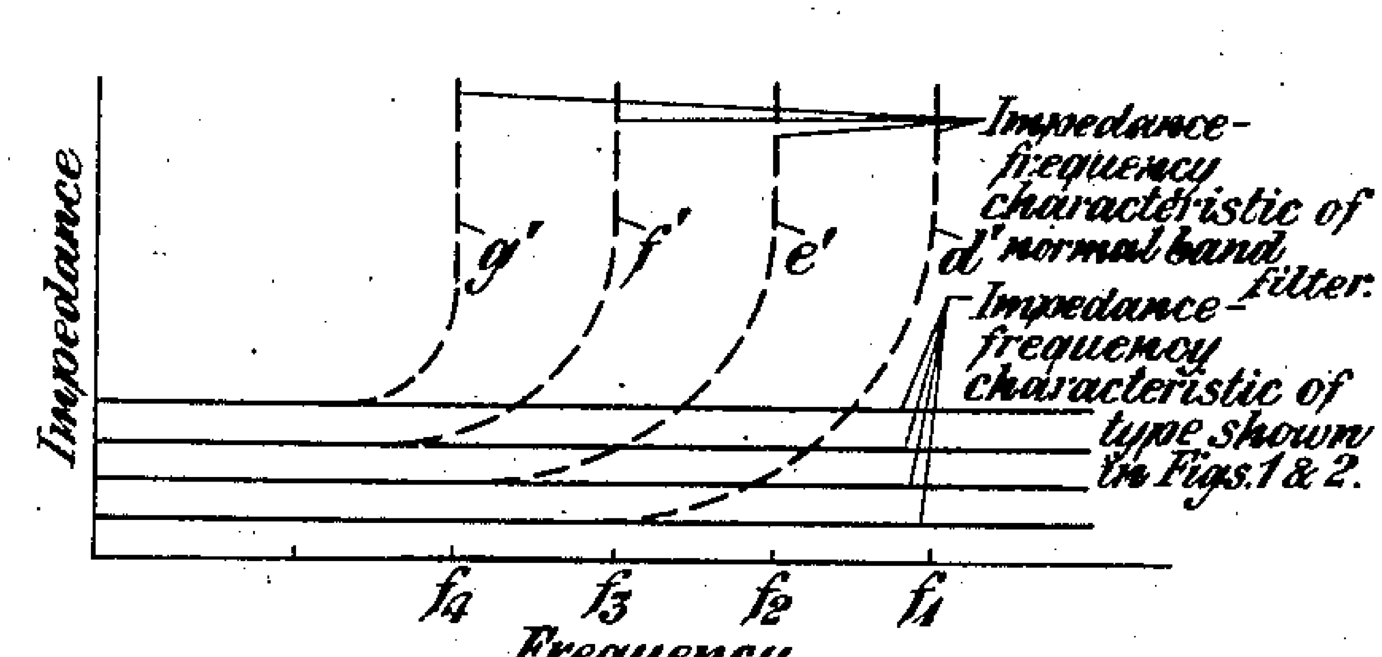

Fig. 6

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UNITED STATES PATENT OFFICE.

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ANTENNA STRUCTURE.

Application filed June 24, 1922. Serial No. 570,540.

This invention relates to antenna structures, and particularly to means for adapting a long antenna for the efficient operation with a plurality of different wave lengths.

For some time past it has been known that long horizontal antennæ are particularly well adapted for the reception of signals, since they possess a high degree of directivity. On the other hand, a particular long antenna structure is adapted to receive only the long wave lengths efficiently, which consequently precludes its use for satisfactory shorter wave length reception.

It is the object of this invention to provide means for rendering a long antenna structure capable of functioning efficiently with waves of a plurality of different lengths.

This invention will be better understood from the following description when read in connection with the attached drawing, of which Figure 1 shows the invention embodied in an antenna of the dumb-bell type; Fig. 2 shows schematic equivalent circuits of the arrangement shown in Fig. 1, Fig. 3 shows the invention embodied in an antenna of the inverted L type; Fig. 4 shows schematic equivalent circuits of the arrangement in Fig. 3; and Figs. 5 and 6 are groups of curves which serve to describe the manner in which the invention functions.

In Fig. 1, 1 represents an antenna of the long horizontal type, the distant ends of which may if desired be terminated through resistances R_0 and R_0', which, as described in my copending application, Serial No. 585,435, filed August 31, 1922, simulate the characteristic impedance of the antenna. Connected at the midpoint of the antenna by means of the inductive coupling 2 is a plurality of receiving circuits which are rendered selective to particular frequencies or bands of frequencies by means of the filters F_{10}, F_{11} and F_{12}. The antenna 1 has connected therewith at predetermined points throughout its length the filters F_1 and F_1', F_2 and F_2'. Although four filters are shown connected with the antenna, the invention is not limited to the particular number shown, since any number of filters may be connected, depending upon the number of wave lengths which the antenna is designed to receive.

As has been briefly referred to heretofore, every antenna circuit should have a particular optimum length for the particular wave length or range of wave lengths intended to be received in order to attain efficient operation of the system. My invention consists in inserting in the antenna structure at predetermined locations a plurality of low-pass filters arranged as shown in Fig. 1 in groups of two each, which serve to terminate the antenna structure for particular frequencies at the points wherein they are inserted and render the intervening section of antenna adapted for the reception of a particular frequency. Thus, for axample, the filters F_1 and F_1' would have the attenuation-frequency characteristic represented by the curve *d* in Fig. 5. This is the characteristic for a low-pass filter having a cut-off point at the frequency f_1. It will be seen, therefore, that by inserting a group of two of these filters in the antenna 1 at a predetermined point, depending upon the length of a wave having a frequency f_1, the antenna is, in effect, terminated at the said points for the said frequency. Furthermore, since the filters F_1 and F_1' are of the low-pass type, they will transmit readily frequencies below their cut-off frequencies. Consequently they do not terminate the antenna structure for any other frequency than the particular frequency or band of frequencies for which the antenna between the filters F_1 and F_1' is intended to receive.

The filters F_2 and F_2' have the characteristic represented by the curve *c* in Fig. 5, which shows a cut-off frequency f_2. Accordingly, these filters will serve to terminate the antenna for the frequency f_2, and therefore render the section of the antenna between F_2 and F_2' adapted to receive that frequency or band of frequencies which are above f_2. Other groups of filters having the characteristics represented by *f* and *g* in Fig. 5 could be inserted in the antenna 1, which would serve to terminate the antenna at other points and render the intervening antenna structure suitable for the reception of other frequencies than those shown. Furthermore, the antenna between the terminating resistances R_0 and R_0' would, of course, be adapted to receive still another and different frequency from any heretofore referred to.

The effect, therefore, of inserting the filters as shown in Fig. 1 is to render the antenna structure highly efficient for the reception of three different frequencies. The complete action attained by the structure shown in Fig. 1 may in a sense, be considered equivalent to that which would obtain for three separate antenna structures, each specifically designed to function for a definite wave length range. This is clearly shown in the equivalent circuit diagrams of Fig. 2, where the structure *a* represents the antenna 1, which for frequencies f_1 or greater is effectively terminated by the filters F_1 and F_1'. Similarly, the structure represented by *b* represents the antenna 1 effectively terminated by the filters F_2 and F_2', which is efficient for the reception of frequencies f_2 and greater, and the structure represented by *c* of Fig. 2 represents the antenna 1 as terminated by the resistances R_0 and R_0'.

The arrangement shown in Fig. 3 represents the embodiment of the invention in an inverted L antenna. The filters F_1 and F_2 inserted in the antenna 1 serve to terminate this antenna in the same manner in which they function in connection with the antenna shown in Fig. 1. The effect of introducing these filters is to render the antenna structure of Fig. 3 terminated at the points wherein they are inserted, which, in effect, makes the antenna suitable for the reception of three different wave lengths, as clearly shown by the diagrams in Fig. 4

Although my invention is not limited to the use of any particular type of filter to effect the discontinuity of the antenna structure itself for particular frequencies, I find that the type of network shown diagrammatically in Figs. 1 and 3 which includes resistance elements in its makeup is particularly well suited for this purpose, since it may be designed to possess substantially uniform impedance throughout the entire range of frequencies, and therefore, in effect, serves to terminate the antenna at the point wherein it is inserted by an impedance equal to the characteristic impedance of the antenna for the cut-off frequency of the particular filter. This is clearly shown in Figs. 5 and 6. Thus in Fig. 6 the curves d', e', f' and g' represent characteristic impedance-frequency actions of the normal type of filter, the attenuation-frequency characteristics of which are represented by the curves *d*, *e*, *f* and *g* of Fig. 5, that is to say, in the normal non-dissipative type of filter the impedance would either increase rapidly at the cut-off frequency in like manner, as the attenuation does or would decrease rapidly to approach zero, depending on the particular type of termination employed. In filters of the type represented, for example in Fig. 1, the impedance does not vary as the cut-off frequency is reached, but remains substantially uniform throughout almost any range of frequency. The use of filters of this type, therefore, has the effect of terminating the antenna structure at the point wherein they are inserted by means of an impedance equal to the characteristic impedance of that part of the antenna included between the two filters of the group, which, of course, is highly desirable, since it avoids creating the effect of an open-ended antenna for the particular frequency for which the intervening antenna structure is intended to receive.

For the purpose of making the invention clear and distinct it has been described as embodied in an antenna having receiving apparatus associated therewith. The invention, however, is not limited to a receiving antenna since it is equally well adapted for the purpose of transmitting, and accordingly the apparatus shown and described as receiving apparatus may also be considered as transmitting apparatus.

Although this invention has been disclosed as embodied in a particular form and arrangement of parts, it is to be understood that it is capable of embodiment in other and different forms within the spirit and scope of the appended claims.

What is claimed is:

1. An antenna, comprising a conductor of such length as to efficiently receive waves of predetermined length, and a filter having a fixed cut-off point connected with the said conductor and effectively terminating the conductor at the point of connection of the said filter for frequencies above the cut-off point, the said point of connection being so chosen that the portion of the said antenna between the said point of connection of the filter and point of connection of a terminal circuit will have the optimum length for frequencies above the cut-off frequency of the filter.

2. An antenna, comprising a conductor of such length as to efficiently respond to waves of a predetermined length, and a plurality of filters each connected with the said conductors at different places between the ends thereof, each filter having a fixed cut-off point which, for each filter, is different from that of the others, to effectively terminate the conductor at each of a plurality of points for frequencies above the cut-off point of the filter, each point of connection of the said filters being so chosen that the portion of the antenna between the point of connection of a particular filter and the end adjacent to the terminal circuit will have the optimum length for frequencies above the cut-off frequency of the particular filter.

3. An antenna, comprising a conductor of such length as to efficiently respond to waves of predetermined length, and a plurality of pairs of filters, all of said filters being con-

nected with the said conductor at different places between the terminating point of the antenna and the ends thereof, each filter having a fixed cut-off point and the filters of each group having the same cut-off point which is different from that of the other groups of filters, the filters of each group being symmetrically placed upon opposite sides of the terminating point of the antenna, each point of connection of the said filters being so chosen that the portion of the antenna between two filters of the same group will have the optimum length for frequencies above the cut-off frequency of the filters of that particular group.

4. An antenna comprising a horizontal conductor having a plurality of pairs of filters inserted therein between the terminating point and the outer ends of said antenna, and symmetrically disposed on each side of the said terminating point, the filters more distant from the terminating point having a lower cut-off point than those nearer thereto.

5. An antenna comprising a horizontal conductor having the distant end grounded through resistance simulating the characteristic impedance of the antenna and having a plurality of filters inserted therein at definite intervals between the terminating point and the distant end of the said antenna, the filters more distant from the said terminating point having a lower cut-off point than those nearer thereto.

6. An antenna comprising a horizontal conductor having the distant ends grounded through resistances simulating the characteristic impedance of the antenna and having a plurality of pairs of filters inserted therein between the terminating point and the outer ends of said antenna, and symmetrically disposed on each side of the said terminating point.

7. In a radio signaling system, the combination with an antenna of a plurality of low-pass filters having different cut-off points and a multi-frequency terminal apparatus, the said filters being connected into the said antenna between the point of connection thereto of the said apparatus and the distant end and so disposed that those more distant from the said apparatus have lower cut-off points than those nearer thereto.

8. In a radio signaling system, the combination with an antenna having its outer ends grounded through a resistance simulating the characteristic impedance of the antenna of a plurality of pairs of low-pass filters, the said pairs having different cut-off points, and multi-frequency terminal apparatus connected with the said antenna, the said filters being symmetrically disposed on each side of the point of connection of the said apparatus to said antenna and so arranged that the more distant ones have lower cut-off points than those nearer the said apparatus.

9. A horizontal antenna having a plurality of filters each having a different frequency cut-off point, the said filters being connected therein between the terminating point of said antenna and an outer end thereof, the distance between each of said filters and the terminating point of the antenna being the optimum length of the antenna for the frequency at which the particular filter cuts off.

10. A horizontal antenna having a plurality of pairs of filters, each pair having a different frequency cut-off point, the filters of each pair being connected with the said antenna at points which are upon opposite sides of the terminating point of the said antenna and the length of the antenna between each pair of filters being the optimum length for the frequency at which the particular pair of filters cuts off.

In testimony whereof, I have signed my name to this specification this 23rd day of June 1922.

HERMAN A. AFFEL.