May 28, 1957 R. F. KOLAR ET AL 2,794,184

MULTIPLE RESONANT SLOT ANTENNA

Filed July 21, 1953

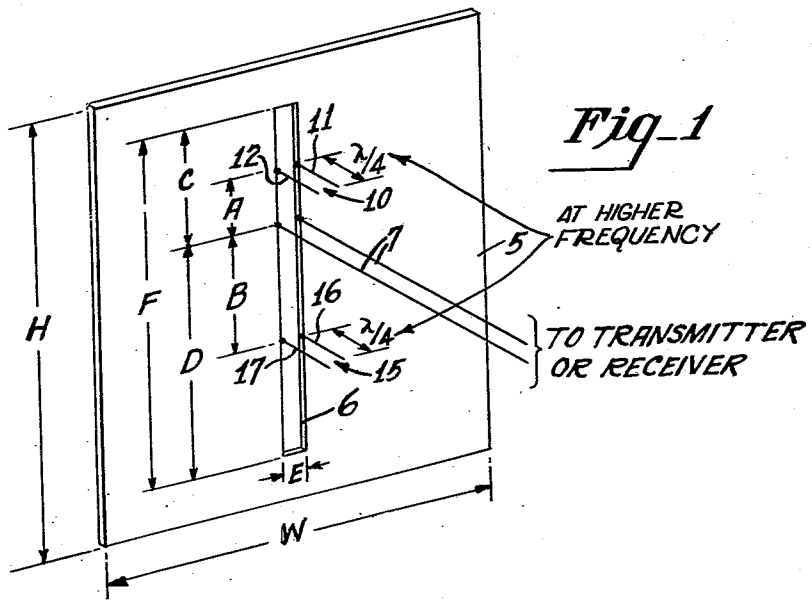


Fig_1

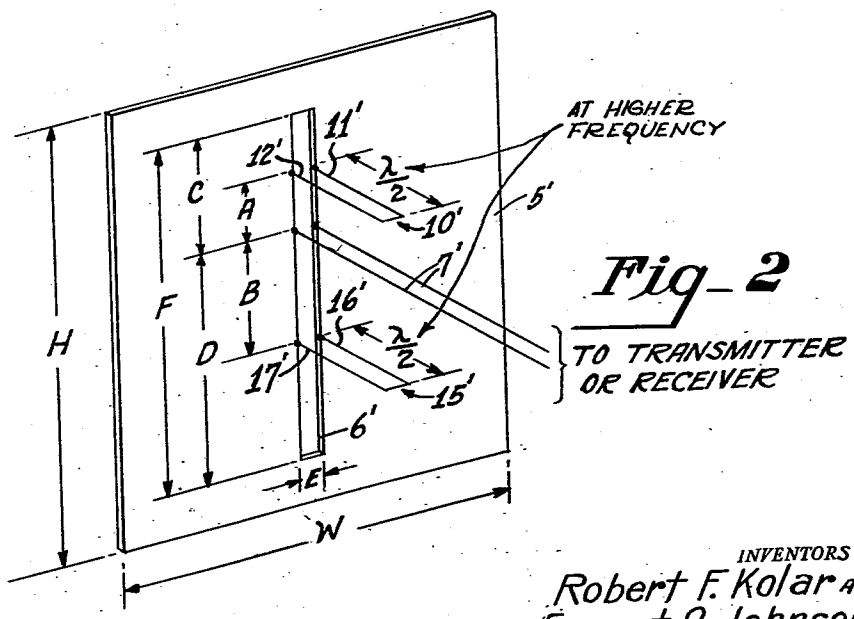


Fig_2

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United States Patent Office 2,794,184 Patented May 28, 1957

2,794,184

MULTIPLE RESONANT SLOT ANTENNA

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Application July 21, 1953, Serial No. 369,348

12 Claims. (Cl. 343—767)

This invention relates to a multiple frequency slot antenna, and more particularly to an antenna having connected thereto a single transmission line, the antenna being resonant at two different frequencies unrelated to each other and also resonant at harmonics of the two frequencies.

In radio communications, it is often desirable to be able to communicate via any one of several different radio frequencies, the choice of frequency being made to select one least affected by disturbing factors such as atmospheric conditions. It is very desirable that such a communication system be capable of shifting between any one of the predetermined frequencies without the necessity for making mechanical modifications or changes to the antenna structure itself. While remotely operated switches or the like may be mounted on an antenna, their use is to be avoided if possible because of the attendant maintenance problems. It is, therefore, a general object of this invention to provide an improved antenna which is inherently resonant at a plurality of different frequencies.

This invention relates to antennas of the type comprising a conductive sheet having an elongated slot therein and including a transmission line connected to opposite edges of the slot. Antennas of this type are usually referred to as slot antennas and they are especially useful at high frequencies. The slot antenna lends itself to use on aircraft where an airfoil of the aircraft serves as the conductive sheet and a slot cut in the airfoil serves as a means to apply or take off radio frequency energy. The slot may be filled with an insulating material to prevent an interruption in the surface of the airfoil. It is often desirable that an aircraft have radio communications equipment which is operable at any one of a number of different frequencies, and it is therefore another object of this invention to provide an improved slot type antenna which is capable, without mechanical adjustment, of operation at different frequencies.

It is a further object to provide an improved multi-frequency slot antenna which may be unobtrusively incorporated into a structure, such as a building.

It is a still further object to provide an improved multi-frequency antenna which is characterized by its simplicity and its economy of manufacture.

In one aspect, the invention comprises a conductive sheet having an elongated rectangular slot therein. The sheet may be a flat sheet of metal, or it may be a conductive sheet formed or bent into any desired shape. The slot in the conductive sheet is made to have a length such that the structure is resonant at the lowest frequency which it is desired to transmit or receive. A transmission line is connected to the slot at a point intermediate the ends of the slot which provides the proper impedance match between the transmission line and the antenna. The antenna, as thus far described, is suitable for the reception of, or transmission of, radio frequency energy at the frequency determined by the length of the slot and at frequencies which are odd harmonics thereof. A stub

is connected to the slot at a point between the point at which the transmission line is connected and one end of the slot, and a second stub is connected to the slot at a point between the point at which the transmission line is connected and the opposite end of the slot. Each stub consists of two conductors, connected to opposite sides of the slot. The two conductors may be a quarter wave in length and open-circuited at the free ends, or may be a half wave in length and shorted together at the free ends. The stubs have lengths in terms of fractional wave lengths at the higher of the two fundamental frequencies which it is desired to transmit or receive. The effect of the stubs is to shorten the effective length of the slot so that the antenna also resonates at the higher frequency. The antenna is therefore operative at either of the two fundamental frequencies which are harmonically unrelated, and at odd harmonics of the two fundamental frequencies.

These and other objects and aspects of the invention will be apparent to those skilled in the art from the following more detailed description taken in conjunction with the drawing, wherein:

Fig. 1 is a perspective view of a multi-frequency slot-in-plane antenna of the invention utilizing quarter wave length transmission line open stubs; and

Fig. 2 is a perspective view of a multi-frequency slot-in-plane antenna of the invention utilizing half wave length transmission line short-circuited stubs.

In Fig. 1, a conductive sheet **5**, having a height H, and a width W, is constructed of sheet metal, or wire mesh, or metallic paint laid upon a supporting structure. The dimensions H and W are selected to provide the desired polar pattern of the antenna. A rectangular slot **6** cut in the conductive sheet **5** has a length F and a width E. The width E of the slot may be any conveniently small dimension, and the length F of the slot is equal to an experimentally determined value which provides resonance at the lowest desired fundamental frequency of operation of the antenna. The slot length F is between one-half wavelength and one wavelength at the lowest desired fundamental frequency. The two conductors of the transmission line feeder **7** are connected to opposite sides of the slot at a distance C from one end of the slot and a distance D from the other end of the slot. The dimensions C and D are determined experimentally to provide the proper impedance match between the transmission line **7** and the antenna. Line **7** extends to suitable radio transmitting or receiving apparatus. The antenna thus far described is operative to radiate or receive radio frequency energy at the lower fundamental frequency determined by the dimensions C and D of the slot and frequencies which are odd harmonics thereof.

An open section of transmission line **10**, referred to as a shorting stub **10** is connected to the slot **6** at a distance A from the point at which the transmission line **7** is connected. The stub **10** consists of two parallel conductors **11** and **12** extending from opposite edges of the slot. Conductors **11** and **12** are a quarter-wave in length at the higher of the two fundamental frequencies which it is desired to transmit or receive. A second similar transmission line stub **15**, consisting of quarter-wave long conductors **16** and **17**, is connected to opposite edges of the slots at a distance B from the point at which the transmission line **7** is connected to the slot. Conductors **16** and **17** are likewise a quarter-wave in length at the higher of the two fundamental frequencies which it is desired to receive or transmit. The distances $A+B$ between stubs **10** and **15** is experimentally determined at a value which makes the antenna resonant at the higher of the two fundamental frequencies, the distance being between one-half wavelength and one wavelength at the higher of the two frequencies which it is desired to re-

ceive or transmit. The relative magnitudes of the distances A and B are adjusted so that the part of the slot **6** between stubs **10** and **15** provides an impedance match with the tranmission line **7** at the higher of the two fundamental frequencies. The quarter-wave open stubs **10** and **15** operate to provide a short circuit across slot **6** at the points on the slot where they are connected. The stubs provide a short circuit only at the higher fundamental frequency and odd harmonics thereof. At this higher fundamenal frequency, and odd harmonics thereof, the antenna acts though the slot **6** has a length equal to $A+B$. At the lower of the fundamental frequencies, the shorting stubs **10** and **15** have very little, if any, practical effect on the operation of the antenna. The stubs **10** and **15** act to add an insignificant amount of capacitance to the slot **6** at the lower fundamental frequency.

It is thus apparent that the antenna of Fig. 1 may be operated at either one of two fundamental frequencies and odd harmonics thereof without the necessity of switching or otherwise mechanically altering the antenna.

Fig. 2 shows an alternative form of the invention similar to that shown in Fig. 1 except that the shorting stubs are in the form of half-wavelength sections of transmission line shorted at the free ends thereof. The same numeral designations used in Fig. 1 have been used in Fig. 2 for corresponding elements except that prime designation have been added. The shorting stub **10'** consists of two conductors **11'** and **12'**, the conductors being a half-wave in length at the higher of the two fundamental frequencies. The free ends of conductors **11'** and **12'** are connected together. The half-wave shorted stub **10'** serves to short circuit the slot at the point at which the stub is connected, so far as frequencies equal to the higher of the two fundamental frequencies and odd harmonics thereof are concerned. The shorting stub **10'** does not short the slot at other frequencies such as those equal to the lower of the two fundamental frequencies. A second half-wave shorted stub **15'** is in all respects similar to the shorting stub **10'**.

The use of the half-wave shorted stubs **10'** and **15'** shown in Fig. 2 may be advantageous where it is desired to use such stubs for the additional purpose of supporting the conductive sheet **5'** from a structure in spaced relationship therewith.

By way of example only, an antenna was constructed according to Fig. 1 with dimensions as follows:

	Inches
A	4.75
B	10.0
C	7.5
D	21.25
E	1
H	42
W	44
Stubs 10 and 15	3

The transmission line **7** has a characteristic impedance of 280 ohms. The dimensions C and D are such as to provide an impedance match to the 280-ohm transmission line **7** at a fundamental frequency of 200 megacycles. The dimensions A and B are such as to provide an impedance match to the 280-ohm transmission line **7** at a higher fundamental frequency of 800 megacycles. The antenna provided an impedance match to the transmission line **7** at frequencies including 200 megacycles, 650 megacycles, and 800 megacycles. The antenna was resonant at 650 megacycles, rather than at 600 megacycles, the third harmonic, because of the capacitance added by the shorting stubs **10** and **15**.

It is apparent that by the use of shorting stubs of the proper length, the effective length of the slot **6** may be altered for certain predetermined frequencies only, and that the antenna may be used for any one of a number

of frequencies without the need for making any mechanical alteration to the antenna structure. It will be understood that the shorting stubs short-circuit the slot **6** at the predetermined frequencies only due their frequency selective properties, in contradistinction with mechanical shorting connections made directly across the slot. A direct mechanical short-circuit across a slot is effective at all frequencies. It will be understood that the invention is not limited to an antenna for use at two predetermined frequencies and odd harmonics thereof, but that additional shorting stubs may be employed to provide for operation at three or more fundamental frequencies and the odd harmonics thereof. It will also be understood that one of the shorting stubs **10**, **15** may be a quarter-wave open stub and the other may be a half-wave shorted stub. Under certain special conditions of frequencies and transmission line impedance, a single shorting stub is sufficient.

What is claimed is:

1. An antenna comprising a conductive sheet having an elongated slot therein, the length of said slot being such as to provide resonance at a first predetermined frequency, means to effectively short-circuit said slot at a second higher predetermined frequency, said means effectively providing a shorter slot resonant at said second predetermined frequency, and a transmission line connected to said slot at a position which provides an impedance match at both of said predetermined frequencies.

2. A multi-frequency antenna comprising a conductive sheet having a slot therein which provides resonance at a first predetermined frequency, and short-circuiting transmission line stub means connected to said slot to effectively shorten said slot and provide resonance at a second higher predetermined frequency.

3. An antenna comprising a conductive sheet having an elongated slot therein, a transmission line connected to the edges of said slot at a point intermediate its ends providing an impedance match at a first predetermined frequency, and short-circuiting stub means connected to said slot to provide an impedance match at a second higher predetermined frequency.

4. A multi-frequency antenna comprising a conductive sheet having an elongated slot therein, said slot having a length which provides resonance at a first predetermined frequency and at least one short-circuiting stub connected to said slot to make said slot resonate at a second higher predetermined frequency, said short-circuiting stub having a length making it operative to short said slot only at said second higher predetermined frequency and odd harmonics thereof.

5. A multi-frequency antenna as defined in claim 4 wherein said shorting stub comprises two parallel conductors connected to opposite edges of said slot and having a length equal to a quarter-wave at said second higher predetermined frequency.

6. A multi-frequency antenna as defined in claim 4 wherein said shorting stub comprises two parallel conductors connected to opposite edges of said slot and having a length equal to a half-wave at said second higher predetermined frequency, and means connecting the remote ends of said conductors.

7. A multi-frequency antenna as defined in claim 4 wherein said shorting stub comprises a quarter-wave open stub at said second higher predetermined frequency.

8. A multi-frequency antenna as defined in claim 4 wherein said shorting stub comprises a half-wave shorted stub at said second higher predetermined frequency.

9. A multi-frequency antenna comprising a conductive sheet having an elongated slot therein, a transmission line including two conductors connected to opposite edges of said slot at a point which provides an impedance match between the transmission line and the slot at a first predetermined frequency at which said slot is resonant, a first shorting stub connected to said slot at a point be-

tween one end of the slot and the point at which the line is connected, and a second shorting stub connected to said slot at a point between the opposite end of the slot and the point at which the line is connected, said shorting stubs being constructed to effectively shorten said slot solely at a second higher predetermined frequency and odd harmonics thereof, whereby said antenna is operative at frequencies equal to said first and second predetermined frequencies and odd harmonics thereof without the necessity of any switching or mechanical change in said antenna.

10. A multi-frequency antenna as defined in claim 9 wherein said shorting stubs are quarter-wave open stubs at said second predetermined frequency.

11. A multi-frequency antenna as defined in claim 9 wherein said shorting stubs are half-wave shorted stubs at said second predetermined frequency.

12. An antenna comprising a conductive sheet having an elongated slot therein, the length of said slot being such as to provide resonance at a first predetermined frequency, and means resonant to a second predetermined frequency higher than said first frequency coupled across said slot to effectively short-circuit said slot at said second frequency, said means effectively providing a shorter slot resonant at said second frequency.

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