April 7, 1942. W. BUSCHBECK 2,278,531

ANTENNA COUPLING WITH A COAXIAL LINE

Filed March 28, 1941

Fig. 1

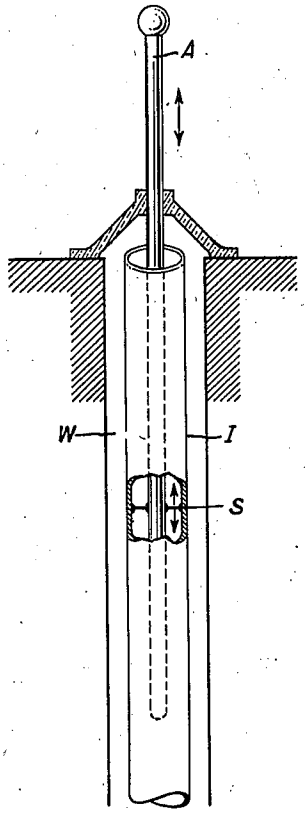



Fig. 2

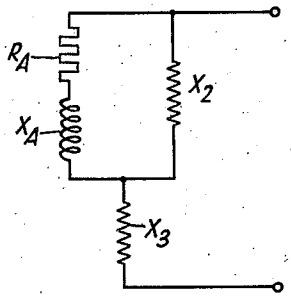
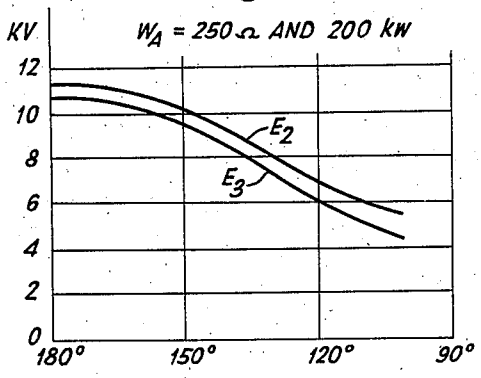



Fig. 3



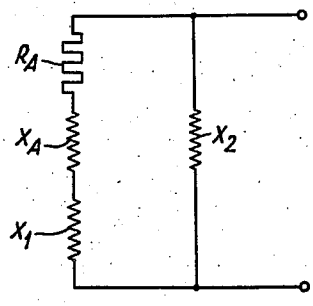




Fig. 4

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## ANTENNA COUPLING WITH A COAXIAL LINE

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Application March 28, 1941, Serial No. 385,584
In Germany September 19, 1939

4 Claims. (Cl. 250—33)

In United States Patent #2,169,377, issued August 15, 1939, it has been proposed already to produce variable short wave antennas with matching to a cable wave resistance which is higher than the bottom point resistance of the $\lambda/4$ antenna, by extending the antenna beyond the $\lambda/4$ length until the effective component of the bottom point impedance calculated for the parallel connection corresponds with the wave resistance, while the remaining inductive wattless parallel resistance is converted into a blocking circuit by a capacity placed between the bottom point of the antenna and ground, or counterweight thus rendering said wattless resistance impotent. This arrangement was found to be useful but it has the drawback that the parallel capacity represents an additional element of the circuit.

In accordance with the present invention there is utilized for the antenna tuning and antenna matching the wattless resistance presented by the antenna proper which is inserted into the inner conductor of the energy line.

Figure 1 shows a mode of construction according to the idea of the present invention, while Figure 2 shows the equivalent circuit diagram corresponding to the structure of Figure 1; Figure 3 illustrates by means of curves the operation of the device and Figure 4 shows a modification of Figure 2.

The antenna A of Figure 1 is drawn from the tubular inner conductor I until its length is such that the effective series component of the impedance of the bottom point of the antenna has reached the value W of the cable wave resistance. The length of the radiator is, in this case, greater than in the proposed case of matching through a parallel wattless resistance since the transformation of the resistance value is dispensed with. Thus, for example, in the case of an antenna of a wave resistance of 250 ohm and matching with a 60 ohm cable the electric length of the radiator is, in the case of the parallel matching, about 95° as compared with about 110° in the case of the series tuning. It is presumed that this series impedance has in no case a stray capacity with respect to ground, since otherwise a new transformation of the resistance values in the bottom point would result. Hence, as wattless series resistance there is employed the input impedance of the conductor piece formed by the antenna conductor which is immersed into the inner conductor of the energy line with the said antenna conductor being shorted at a suitable place by a movable slide in contact with the said conductor piece. In this manner any stray capacity with respect to ground is avoided. The wattless series resistance can be inductive or capacitive which depends on whether the slide S is distanced from the upper end by more than $\lambda/4$ or less.

While, in the present arrangement for matching with a cable of 36 ohm wave resistance, the natural length of the antenna must always be above $\lambda/4$ just as in the already mentioned arrangement with wattless parallel resistance, the simultaneous use of both methods affords an extended effective resistance transformation for simultaneous wattless resistance compensation so that for obtaining longer waves, for instance, the antenna can have a shorter length which assures substantial advantages as regards cost and construction. In the case of wave ranges that are not particularly wide in this method even an antenna having a constant length may be employed. In the interest of a suitable vertical diagram it is not desirable that the length of the antenna be extended substantially beyond $\lambda/2$ wherefore the case will next be investigated in which the antenna can be excited in $\lambda/2$ on the shortest operating wave.

In this case the ohmic component of the impedance of the bottom point of the antenna is substantially greater within a wide range than W and the wattless part is inductive so that the substitution scheme according to Figure 2 is obtained. If $X_2$ fulfills the condition

$$X_2=\frac{WX}{R_A-W}=\pm\sqrt{\left(\frac{WX_A}{R_A-W}\right)^2+\frac{W(R_A^2+X_A^2)}{R_A-W}}$$

the ohmic component will be transformed to the value W. The remaining wattless series resistance will be compensated by $X_3$ if $X_3$ fulfills the condition

$$X_3=-X_2\frac{R_A^2+X_A(X_A+X_2)}{R_A^2+(X_A+X_2)^2}$$

It is seen that matching is obtained for an inductive as well as capacitive $X_2$. In both cases the voltages appearing at $X_2$ and $X_3$ are identical. A more favorable condition exists by rendering $X_2$ inductive and thus $X_3$ capacitive, since in this latter case the wattless power in $X_2$ is much lower.

Figure 3 shows the theoretically to be expected voltage curve in the case of an antenna having a wave resistance of 250 ohms at a power of 200 kilowatts. It can be seen that even at this high power the encountered voltages remain still within controllable order values. If the antenna resistance is lower than W the wattless parallel

resistance $X_2$ is to be placed at the cable end instead of at the bottom point of the antenna, as shown in Figure 4. The transformation to the correct ohmic value will be fulfilled if there is rendered:

$$X_1 = \mp R_A \sqrt{\frac{W}{R_A} - 1 - X_A}$$

while the elimination of the wattless component is carried out by a wattless parallel resistance $X_2$ which fulfills the condition

$$X_2 = \mp \frac{W}{\sqrt{\frac{W}{R_A} - 1}}$$

In the case of the matching of a $\lambda/4$ antenna to a 60 ohm line there would thus be at 200 kilowatts:

$$X_1 = \pm 29.3 \text{ ohms}, \quad X_2 = \mp 73.8 \text{ ohms}$$

or

$$\epsilon_1 = 2190 \text{ volts and } \epsilon_2 = 3460 \text{ volts.}$$

It is seen that the region can be well extended beyond $\lambda/4$ without obtaining inadmissible voltages in the tuning structures. The limit is apparently determined by the peak voltage of the radiator proper which, therefore, is to be maintained as low as possible by employing conductor parts having a low wave resistance (thick tubes, or cone antennas, or loop).

In order to simplify the servicing, values of the series tuning and parallel tuning pertaining to one another are mechanically or electrically coupled.

I claim:

1. Arrangement for coupling an antenna with a coaxial cable having an inner conductor and an outer shell, characterized by the fact that the antenna is formed by a conductor immersed in a tubular end portion of said inner conductor of said cable and which protrudes to such an extent beyond the end of the cable that the ohmic series component of the antenna impedance at the entrance of the cable is equal to the wave resistance of the cable, while the energy line formed by the inner conductor and the part of the antenna conductor which is immersed in said inner conductor is tuned by means of a movable connection to such a length that the wattless component of the antenna impedance is compensated.

2. In combination, a coaxial feeder cable having an inner conductor and an outer shell, said inner conductor being hollow for at least a portion of its length, an antenna coupled to said feeder cable by being inserted within said hollow inner conductor, said antenna having such length extending out of said inner conductor that the series component of antenna impedance at the end of said cable is equal to the wave resistance of said cable, and a connection within said inner conductor to said antenna, said connection being shiftable within said conductor.

3. In combination, a coaxial feeder cable having an inner conductor and an outer shell, said inner conductor being hollow for at least a portion of its length, an antenna coupled to said feeder cable by being inserted within said hollow inner conductor, said antenna having such length extending out of said inner conductor that the series component of antenna impedance at the end of said cable is equal to the wave resistance of said cable, and a connection within said inner conductor to said antenna, said connection being shiftable within said conductor to such point that the wattless component of antenna impedance is compensated.

4. In combination, a coaxial feeder cable having an inner conductor and an outer shell, said inner conductor being hollow for at least a portion of its length, an antenna coupled to said feeder cable by being inserted within said hollow inner conductor, said antenna extending out of said inner conductor a distance of the order of a quarter of the operating wavelength such that the series component of antenna impedance at the end of said cable is equal to the wave resistance of said cable, and a connection within said inner conductor to said antenna, said connection being shiftable within said conductor to such point that the wattless component of antenna impedance is compensated.

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