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ROTATING COUPLING DEVICE FOR RADIO FREQUENCY CURRENTS, ESPECIALLY FOR ULTRA-HIGH FREQUENCY CURRENTS

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Fig. 2.

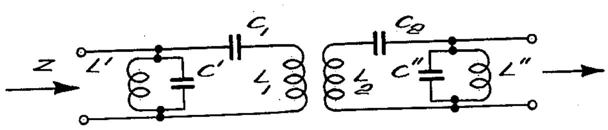


Fig. 3.

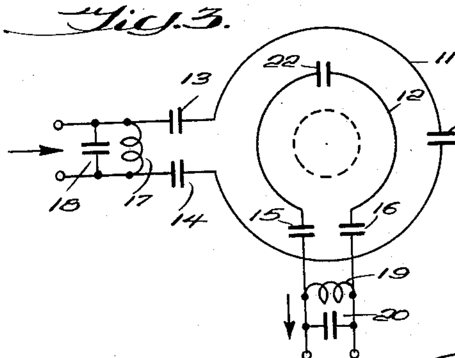


Fig. 1.

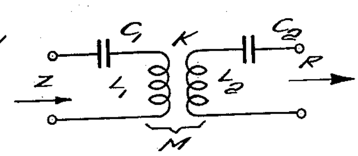


Fig. 4.

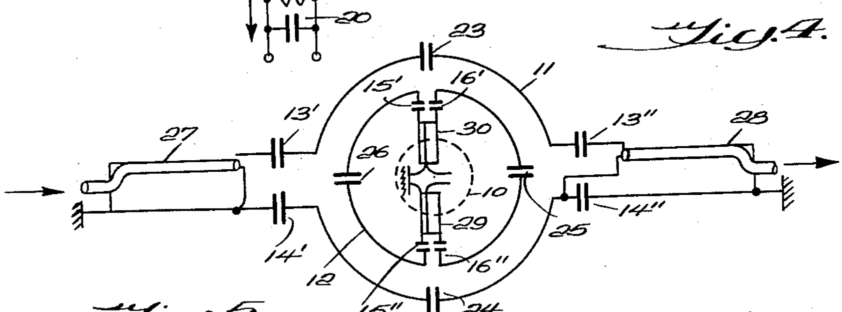
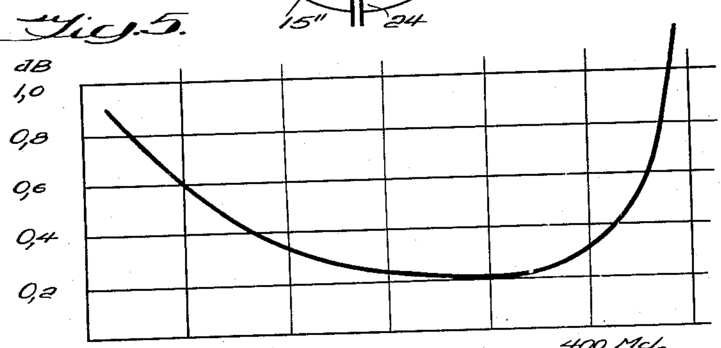


Fig. 5.



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ROTATING COUPLING DEVICE FOR RADIO FREQUENCY CURRENTS, ESPECIALLY FOR ULTRA-HIGH FREQUENCY CURRENTS

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6 Claims. (Cl. 333—24)

The present invention relates to a rotating coupling device for radio frequency currents, especially ultra high frequency currents. Such coupling devices are used in many fields within the radio technics. As an example the transfer of high frequency currents received by an antenna to a radio receiver may be mentioned, or the transfer of such currents from a radio transmitter to an antenna, when the antenna is rotating. This is, for instance, the case in different kinds of direction finding apparatus and also for so called rotating radio beacons, especially the so-called speaking radio beacons, and in radar equipment.

In earlier devices for this purpose two different kinds of rotating coupling devices have been used, for example coupling devices with tuned loops, coupled to each other, and resonators, such as coaxial pipes of a quarter of a wave-length.

When using tuned loops, said loops were coaxially arranged about the rotational shaft carrying the antenna. Due to the tuning a low coupling factor could be used, having the advantage that the capacitive coupling was not too strongly emphasized and did not dominate over the inductive coupling. A rather constant voltage transfer factor during the rotation was therefore obtained. Due to loops being tuned, however, the band width which could be transferred was very narrow, and the arrangement could not be used for the transfer of widely different frequencies.

Some advantage was gained by the use of resonators, meaning coaxial pipes of a quarter of a wave-length. These no longer had such a narrow frequency band, but nevertheless they had a rather constant voltage transfer factor. The disadvantage with them is, however, that they are space robbing, and their mounting is difficult. It should be remembered that the length of these coaxial pipes may be essential, and that they should be stably mounted, but not mounted with means which could disturb their capacitive relations to ground. Further, the resonator pipes should be mechanically stable. In practice it has proved very difficult to satisfy these demands.

The present invention refers to a rotating coupling by means of which all of the abovementioned disadvantages are avoided. According to the invention coaxial, circular rings are used for the rotating coupling device for causing inductive transfer of the electrical radio frequency energy from a fixed system to a rotating system, and the rings are divided into segments separated by means of capacity elements and feeding points so that each segment is less than one quarter of the mean wave-length within the transferred frequency band.

Further details of the invention will be evident from the following description of one form of execution in connection with the attached drawing, in which FIGS. 1 and 2 show a pair of electrical wiring diagrams for explaining the principal of the invention, FIG. 3 and FIG. 4 show a pair of different forms of execution of the arrangement according to the invention and FIG. 5 shows a diagram of the attenuation in an arrangement according to the invention.

FIG. 1 shows the general arrangement of a coupling circuit in schematic form. The circuit consists in two

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coils L_1 and L_2, coupled to each other, with a coupling factor K for the dynamic coupling. In series with each of said coils there is a condenser C_1 and C_2, respectively. It is assumed in the present case that the two coils L_1 and L_2 have an inductance L, and that the two condensers C_1 and C_2 have a capacity C. The impedance transferred to the input side of the circuit is indicated by Z, and the system is assumed to be loaded at its output side by means of the resistor R. The frequency of the transferred alternating currents is w. In this case the following equation is obtained:

$$Z=\frac{w^2 \cdot M^2}{R}=\frac{w^2 K^2 \cdot L^2}{R}$$

In this formula M indicates the mutual inductance between the coils L_1 and L_2, which causes the coupling between said coils. In the formula, the Q-value of the coils is introduced:

$$Q=\frac{w \cdot L}{R}$$

whereby this formula will give the result:

$$\frac{Z}{R}=Q^2 \cdot K^2$$

The most advantageous voltage transfer is obviously obtained if

$$\frac{Z}{R}=1$$

which means the same as $K \cdot Q=1$. Usually one cannot calculate with the possibility of achieving more advantageous values for the coupling factor K in an arrangement comprising concentrical rings, than 0.5 or 0.7, which would, according to the above mentioned formula, give Q-values between 1.5 and 2. A low Q-value is desirable in order that the band-width shall be as large as possible.

From the above-indicated formulas it will be seen that the relation impedance: resistance or Z/R will vary with the square of the frequency. Furthermore, the impedance-resistance-relation will be capacitive for frequencies below the resonance frequency and inductive for frequencies above the resonance frequency. The disadvantage of this, however, can be done away with by introducing a pair of parallel resonance circuits in the manner shown in FIG. 2.

In this figure the same elements are present as in FIG. 1, with the addition of a parallel resonance circuit on the primary side and one on the secondary side. The parallel resonance circuit of the primary side consists of the inductance coil L′ and the condenser C′, whereas the corresponding circuit on the secondary side consists of the inductance coil L″ and the condenser C″. The magnitude of L′ and L″, respectively, as well as C′ and C″, respectively, is suitably chosen in such a way that each circuit is in resonance at a frequency which could be indicated as the mean frequency of the transferred frequency band. The division between capacity and inductance in the said resonance circuits is thereby determined by the combined reactance of the series resonance circuit and the parallel resonance circuit being as closely equal to zero as possible at the limit frequencies for the transfer frequency band.

All of the inductance should normally exist in the coils, and no capacitive coupling should, if possible, exist between them. These conditions are satisfied to a rather high degree if the coils are made according to this invention, that is as circular bands which surround a rotating pole or the like, on which is mounted an antenna or the like.

The arrangement according to the present inevntion is shown in FIGS. 3 and 4.

In FIG. 3 the pole about which the rotating coupling device is disposed is indicated by **10**. The coils of the coupling device, corresponding to the coils L_1 and L_2 in FIGS. 1 and 2, are formed by a pair of coaxial bands **11** and **12**, respectively. The series condensers C_1 and C_2 respectively, are in the practical arrangement according to FIG. 3 divided into two condensers **13** and **14** as well as **15** and **16**. The input parallel resonance circuit L′C′ connected to the receiver when the antenna is used as a receiver antenna, or connected to the transmitter when the antenna is used as a transmitter antenna, consists of the coil **17** and the condenser **18**, whereas the output parallel resonance circuit L″C″ for the side of the coupling device connected to the antenna or the receiver, respectively, is formed by the coil **19** and the condenser **20**.

An arrangement according to FIG. 3 would be possible to use, but it is not ideal, because it is unavoidable that there is some capacitive coupling between the bands **11** and **12** and this capacitive coupling will vary with the mutual position of the bands during the rotation. This capacitive coupling, however, can easily be decreased, if the potential is divided more evenly along the length of the bands. This, for instance, can be done by connecting a part of the effective series capacity C_1 and C_2 (see FIG. 1 and 2) into the bands themselves, which would correspond to each of the coils L_1 and L_2 being divided into two equal half parts, and one part of the capacity being connected directly between the two coil half parts. For this purpose a condenser **21** is connected into one branch of the coupling and a condenser **22** connected into the other branch of the coupling. The three condensers thus connected in series **13**, **14** and **21** or **15**, **16** and **22**, respectively, of course are calculated as to their magnitude in such a way that the resulting capacity will correspond to the capacity of the condenser C_1 or C_2, respectively, in the arrangement according to FIG. 1 or 2.

If the pole carrying the rotating antenna system is very thick the capacitive coupling between the bands may assume a disturbing order of magnitude. In this case the capacitive coupling can be further decreased by providing more than one condenser between different parts of the band **11** or **12**, respectively, corresponding to the condensers **21** and **22**. However parts of the band would then be without any feed of voltage, unless the number of feeding places for the voltage to the bands is increased to a corresponding degree.

FIG. 4 shows a modification of the arrangement according to FIG. 3, in which feeding of the bands takes place in two diametrically opposite points, which makes the connection of two series condensers possible, corresponding to the series condensers **21** and **22** of FIG. 3. The two condensers connected on the apparatus' side corresponding to the condenser **21** of FIG. 3 are formed by the condensers **23** and **24**, and the two condensers on the antenna side of the coupling, corresponding to the condenser **22** of FIG. 3, are formed by the condenser **25** and **26**.

In FIG. 4, the two parallel resonance circuits **17**, **18** as well as **19**, **20** have been replaced by resonators, consisting of a radiation pipe of a mechanical length of one quarter of a wavelength. The two resonators arranged on the apparatus' side of the coupling device are indicated by **27** and **28**, respectively, and the two resonators on the antenna side by **29** and **30**, respectively. The feeder lines are carried through these resonators in the form of conduits in screened mantels in a known manner, whereby the conductor and the screening mantel function as a coaxial cable in which the screens are connected to ground potential.

In this way the two band-formed coils can be divided into a suitable number of sectors, connecting a suitable number of feeding points to them. When deciding the number of such sectors, each sector under all circumstances should be less than one quarter of the mean wave-length of the transferred wave-length band, and the best result is obtained if the length of the sector is about equal to one eighth of the mean wave-length of the transferred frequency band. The band width is determined by the coupling degree between the two bands **11** and **12** forming the coils. The less the distance between them, the stronger the coupling will be, and the bigger the band width will be. However, the band width cannot be increased to much in this way, because of the small distance between the bands **11** and **12** there would be danger for electrical spark formation occurring. In such case each of the bands could be divided into a number of sectors with a separate feed, but then there will be a decrease in the effectivity of the coupling device due to each sector being less than one eighth of the mean wave-length of the band.

An investigation of the electrical properties of a coupling device according to the invention has proven that by means of the same a typical band filter can be obtained with very sharp limits and undesired signals excluded, said band filter having a rather closely constant transmission degree within the band of the filter. Thus, there will be no difficulty in providing a coupling device according to the invention with a relation between the limit frequencies of 1:2 or even 1:3 with a maximum loss of less than 1 decibel and a variation of the loss figure of less than ± 0.1 decibel. FIG. 5 shows a diagram for the variation of the loss figure with the tuning frequency of the signal to be transferred in a coupling device according to the invention, as calculated for transferring a frequency band between 215 and 430 mc./s. It will be seen that the biggest loss figures exist at the limit frequencies, and that the loss figure at the lower frequency is 0.85 decibel and at the upper limit frequency 0.80 decibel. Within a broad range extended from about 285 to 407 mc./s. the loss figure is practically constant and is between 0.2 and 0.3 decibel.

The invention, of course, is not limited to the above described forms of execution thereof, also shown in the drawing, but different modifications may occur within the frame of the invention.

What is claimed is:

1. A coupling device for transfer of high frequency currents between a rotating means and a fixed means comprising substantially circular concentric rings coaxially disposed about said rotating means, at least one of said rings being fixed and at least another of said rings being rotatable with said rotating means condensers dividing each of said rings into sectors of less than one quarter of the mean wave length within the frequency band intended to be transferred, and means for feeding current to each of said sectors.

2. A coupling device according to claim 1 including one or more condensers connected in series between said sectors and said feeding means.

3. A coupling device according to claim 1 wherein said feeding means includes resonance means adapted to compensate for reactances present in the series circuits.

4. A coupling device according to claim 3 wherein said resonance means comprise tuned circuits connected in parallel with said feeding means.

5. A coupling device according to claim 3 wherein said resonance means comprise a resonator of a length of one quarter of the wave length intended to be transferred connected in parallel with said feeding means.

6. A coupling device according to claim 5 wherein said feeding means include a coaxial conductor.

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