

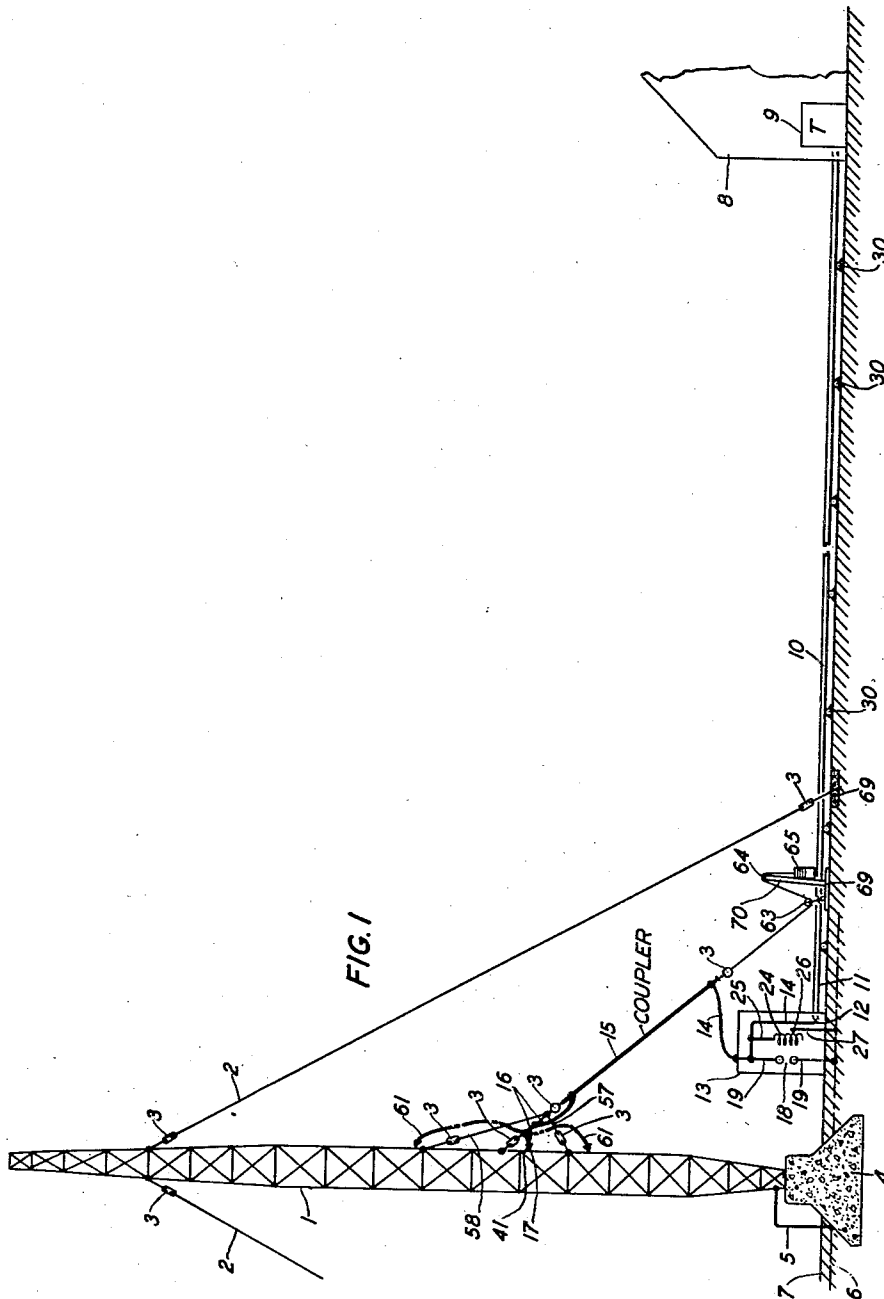
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R. A. CUSHMAN ET AL
ANTENNA COUPLING SYSTEM

2,166,237

Filed June 15, 1938

3 Sheets-Sheet 1



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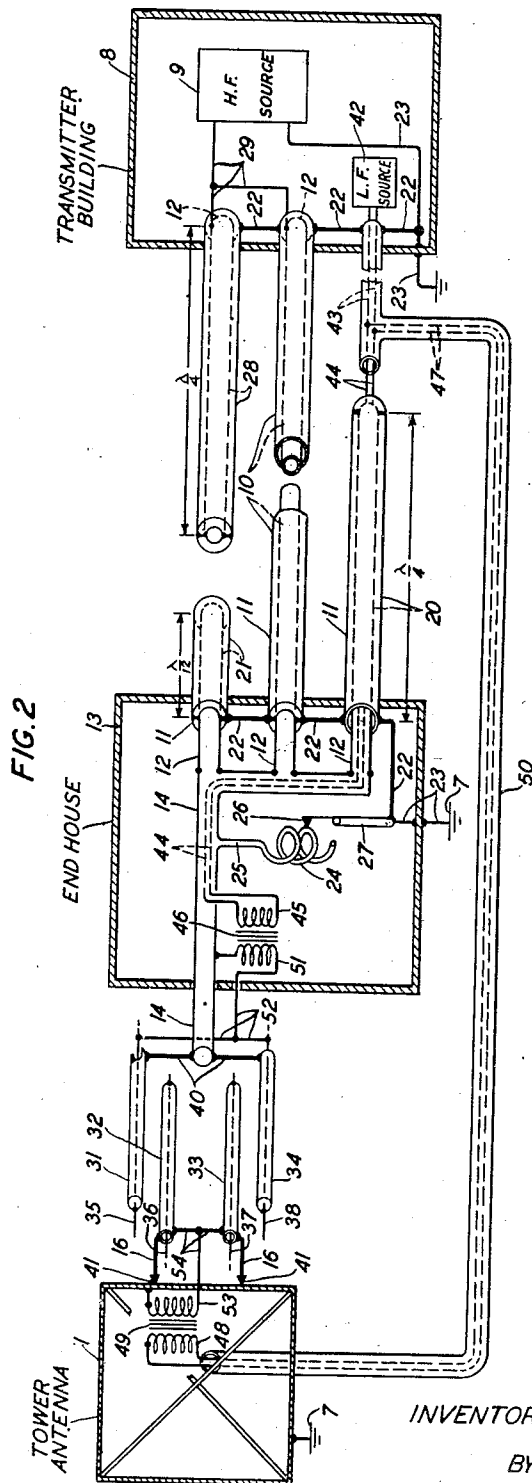
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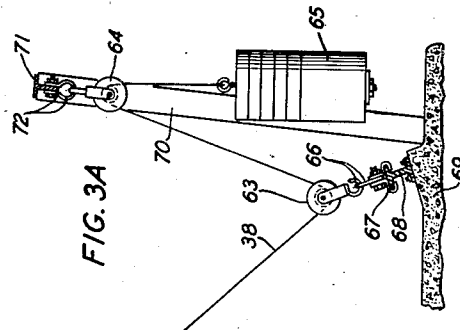
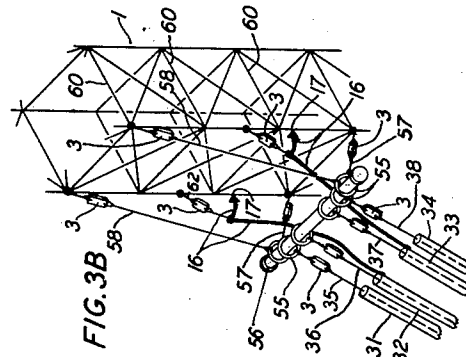
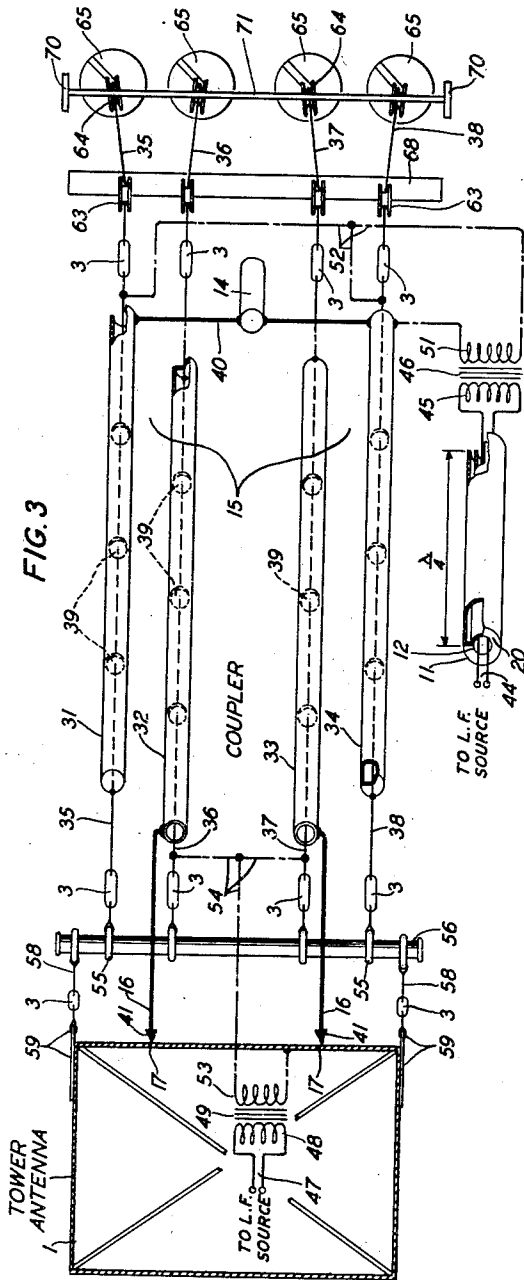
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UNITED STATES PATENT OFFICE

2,166,237

ANTENNA COUPLING SYSTEM

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10 Claims. (Cl. 250—33)

This invention relates to antenna coupling systems and particularly to a capacitive coupling system for connecting a line from a high power transmitter to a tower type antenna.

5 As is well known, base-insulated or series-excited, and base-grounded or shunt-excited, vertical tower antennas are rapidly replacing wire type antennas in the broadcast field. As disclosed in the application of J. F. Morrison, filed on May 9, 1936, and assigned to applicants' assignor, one conductor of the transmission line connecting the transmitter to the shunt-excited tower antenna is preferably connected to a point on the tower antenna through a capacitive coupler or condenser for the purpose of matching the antenna impedance to the line impedance, the coupler being either a conventional condenser comprising plates or a special type condenser comprising a plurality of parallel wires. Generally speaking, it is not practical to employ conventional plate condensers for broadcast installations utilizing a large power output, such as 500 kilowatts, because of the condenser size required and the consequent expensive initial cost and difficult maintenance. Accordingly, it appears desirable to utilize a coupling system comprising light weight linear conductors, the spacing between which may be critically adjusted and constantly maintained irrespective of weather conditions; and to provide structure and facilities for removing sleet from the coupler and for limiting the stresses transferred by the coupling system to the tower antenna.

It is one object of this invention to obtain a satisfactory and inexpensive coupling system for connecting a line from a transmitter of any power output to an antenna.

It is another object of this invention to secure a light-weight linear conductor capacitive coupler in which the spacing between conductors may be easily and accurately adjusted and constantly maintained irrespective of weather conditions.

It is a further object of this invention to minimize in a simple manner the stresses transferred to the tower antenna by the coupling system.

It is still another object of this invention to remove sleet from the conductors or elements constituting the antenna coupling system with a minimum expenditure of heat energy.

According to one embodiment of this invention a capacitive antenna coupling system comprises four inclined lightweight tubular copper conductors arranged substantially parallel and critically

spaced. The inner conductors constitute one condenser plate or element and the outer conductors the other condenser element. The inner conductors may be insulated from each other at their lower ends but at their upper ends are electrically connected together and, by means of flexible conductors, to an intermediate point on the tower antenna. The upper terminals of the outer conductors are insulated from each other and the lower terminals are electrically connected to each other and to one conductor of the line from the transmitter. The diameter of the tubular conductors and the conductor spacing are such as to provide the capacity necessary for matching the antenna impedance to the line impedance, the conductor being large enough in diameter to prevent corona losses. Each tubular conductor is supported by an iron or stainless steel messenger cable included within the conductor and separated therefrom by means of insulators. The four messenger cables are supported at their upper ends by a cross-bar which is attached through strain insulators and a double bridle to the antenna tower. Each supporting cable is individually tensioned at its lower extremity by means of an anchorage comprising a separate pair of pulleys and a counterweight, whereby a uniform tension in the cables is secured, the stresses transferred to the tower by the coupling system considerably lessened, and the capacitance between the tubular conductors stabilized. For the purpose of critically adjusting the spacing and the capacity between the tubular conductors, the four pulleys associated with the four counterweights are supported by a swivel assembly and clamps slidably mounted on an H-beam. Each messenger cable is composed of material having a high electrical resistance and functions as a heater element for the associated tube, each tubular conductor and enclosed supporting cable being connected in series with a source of direct current or low frequency sleet melting current. If desired, the line from the transmitter may be equipped with both odd and even harmonic suppressors of the distributed impedance type.

The invention will be more fully understood from a perusal of the following specification taken in conjunction with the drawings on which like reference characters designate elements of similar function and on which;

Fig. 1 illustrates a side view of a broadcast installation in which the invention is employed;

Fig. 2 illustrates a plan view of a broadcast installation utilizing the invention;

Fig. 3 is a mechanical and electrical schematic illustration of an antenna coupling system constructed in accordance with the invention; and

5 Figs. 3A and 3B illustrate in detail certain mechanical features of the coupling system illustrated by Figs. 1, 2 and 3.

Referring to Figs. 1 and 2 of the drawings, reference numeral 1 designates a mast or steel tower shunt-excited vertical broadcast antenna and numerals 2 and 3 designate, respectively, 10 guy wires and associated insulators for maintaining the tower in a vertical position. The tower antenna is mounted directly on the concrete base 4 and connected by means of the metallic conductor 5 to a screen 6 buried in the ground or earth 7. Reference numeral 8 designates a transmitter building and numeral 9 a transmitter "T" which is located within the 15 building and may have any power output, as, for example, 500 kilowatts. The transmitter 9 is connected to a coaxial line 10 comprising a grounded outer conductor 11 and an inner tubular conductor 12 and terminating in the end house 13. The inner conductor 12 is connected 20 through tubular conductor 14, coupling system 15, flexible leads 16 to electrically similar points 17 on the tower antenna 1. The tower antenna 1 and the coupling system 15 are connected to the earth or ground through conductor 14, lightning arrester 18 and leads 19, the arrester 18 being 25 connected in shunt to the transmission system including the main line 10 whereby the transmission line apparatus is protected from lightning discharges.

Connected across the main coaxial line 10 at a point within the housing 13 are two distributed type harmonic eliminators 20 and 21, each comprising an outer conductor 11 and an inner conductor 12. As shown in Fig. 2, the outer conductors 11 of line 10 and eliminators 20 and 21 35 are connected to the ground 7 through the metallic straps 22 and ground bus-bar or conductor 23. Eliminator or suppressor 20 is one-quarter wave-length long at the antenna operating or fundamental frequency, and is short-circuited at the extremity electrically remote from line 10, whereas eliminator 21 is one-twelfth wave-length long at the fundamental frequency and is open-circuited at the extremity electrically remote 40 from line 10. As is well known, the eliminator 20 constitutes a path of substantially zero impedance for even harmonics of the fundamental frequency and presents an infinite impedance to the fundamental frequency. Eliminator 21 functions as a zero impedance for odd harmonics and in conjunction with tubular coil 24 constitutes a high impedance for the fundamental frequency. The coil 24 is connected across eliminator 21 by 45 means of conductors 14, 25, adjustable contact 26, conductor 27 and straps 22. An additional even harmonic eliminator 28 is bridged across the main line 10 at a point within the transmitter building by straps 22 and conductor 29. Conductor 29 also serves to connect the inner conductor 12 of coaxial line 10 and coaxial line or eliminator 28 to one terminal of transmitter 9, the other terminal of this transmitter being connected to the ground 7 through a conductor 23. 50 Preferably the main coaxial line 10 and the three coaxial line harmonic eliminators 20, 21 and 28 are mounted on roller assemblies 30 (Fig. 1) to allow for expansion and contraction with changes in temperature and are supplied with nitrogen 55 under pressure to prevent water and moisture

from entering the lines. The diameters of the tubular conductors constituting coaxial lines 10, 20, 21 and 28 are in part determined by the transmitter output. Thus, for a 5-kilowatt output, a line having an outside diameter of seven-eighths of an inch and an inner conductor diameter of one-quarter inch; for a 50-kilowatt output, an outside diameter of two and five-eighths inches and an inner conductor diameter of seven-eighths inch, and for a 500-kilowatt output, an outside diameter of six and one-eighth inches and an inner conductor diameter of three and one-eighth inches, appear to be satisfactory.

Referring to Figs. 2 and 3, the antenna coupling system 15 comprises four copper tubes 31, 32, 33 and 34 positioned substantially parallel in an inclined plane and supported, respectively, by steel or iron messenger cables 35, 36, 37 and 38, each of which is insulated from its associated tube by the insulators 39. The outer pair of tubes 31 and 34 are electrically connected at their lower extremities by means of straps 40 and conductor 14 to the inner tubular conductor 12 of the main line 10 and at their upper ends insulated from each other by the air dielectric. The upper end of each inner tube 32 and 33 is electrically connected to one of the points 17 on the tower antenna by a flexible conductor 16 and associated adjustable contact 41, and the lower ends of these conductors are insulated from each other, electrically, by the air dielectric included therebetween. The outer tubular conductors 31 and 34 constitute one condenser element and the inner tubular conductors constitute the other condenser element, and the capacity element so 60 formed functions as a means for canceling the distributed inductance of the antenna tower portion below the points 17. The points 17 are electrically similar and, as an alternative, both of the flexible leads 16 may be connected to a single point on the antenna. The points 17 or the single alternative connecting point is selected, after calculations and adjustment of contacts 41 along tower antenna 1, so that the impedance of the line 10 will be properly matched by the load impedance connected thereto. Initially the length of each of tubes 31, 32, 33 and 34, and spacing therebetween and the tube diameters are chosen as to give the capacity necessary, approximately, to provide the proper match, and at the same time avoid corona loss. The use of two inner conductors results in a low potential gradient as compared to that obtained by using only a single inner conductor. As will be explained later, the messenger cables are supported in accordance with the invention so that a critical adjustment of the capacitance of the coupler may be effected. These supporting or messenger cables are composed of material having a high electrical resistance, as, for example, iron or stainless steel, and serve both as electrical heater elements in the sleet melting circuit illustrated by Figs. 2 and 3 and also as supporting elements for the tubular conductors 31, 32, 33 and 34.

Reference numeral 42 designates a low frequency commercial source of sleet melting current which is connected by means of a switch (not illustrated) and power leads 43 and 44 to the primary winding 45 of a sleet melting transformer 46, and by power leads 43 and 47 to the primary winding 48 of a similar transformer 49, transformer 46 being located within the end house 13 and transformer 49 mounted on the grounded tower antenna 1. The leads 43 and 47 are, wherever practicable, preferably enclosed 75

by a conduit 50. Power leads 44 pass through and are enclosed by the inner tubular conductor 12 of the harmonic eliminator 20, whereby a substantially infinite impedance is presented to the radio frequency energy established in these power conductors by the high potential portions of the radio system including conductor 14 which supplies radio frequency energy from conductor 12 of line 10 to the coupler tubes 31 and 34. As an alternative, the leads may be passed through and enclosed by the tubular conductor forming coil 24 instead of the inner tubular conductor 12 of eliminator 20 since tubular coil 24 and eliminator 21 are anti-resonant at the fundamental frequency. Of course, if the sleet melting transformer 46 is of the radio frequency insulating type it is not necessary to enclose the leads 44 by the inner conductor 11 of eliminator 20 or the conductor forming coil 24. Since the tower is grounded at its base, it is not necessary to include a high frequency impedance in the power leads 47.

One terminal of the secondary winding 51 of transformer 46 is connected through conductor 14 and straps 40 to the lower ends of tubes 31 and 34 and the other terminal is connected by conductor 52 to the messenger cables 35 and 38 at points adjacent the lower ends of tubes 31 and 34. The upper end of tube 31 is conductively connected to the adjacent portion or point of messenger cable 35 and the upper terminal of tube 34 is similarly connected to the adjacent point on cable 38, whereby when the source 42 is connected to conductors 43 sleet melting current flows in series from secondary winding 51 through tube 31 and cable 35 and also flows from the same winding in series through tube 34 and cable 38. Similarly, one terminal of the secondary winding 53 is connected to the tower antenna 1 and therefore through contacts 41 and flexible leads 16 to the upper extremities of tubes 32 and 33, and the other terminal of this winding is connected by conductors 54 to cables 36 and 37, each at a point near the upper extremity of the associated tubular conductor. The lower end of each of tubes 32 and 33 is electrically connected to an adjacent point on the associated supporting cable whereby each of tubes 32 and 33 is connected in series with its supporting cable or heater element and the secondary winding 53 of transformer 49.

Among other advantages, the use of the heater elements 35, 36, 37 and 38 within the radio frequency tubular conductors 31, 32, 33 and 34, respectively, results in a distinct reduction in the amount of low frequency current necessary to melt quickly the sleet and ice that may accumulate on the radio frequency copper tubes. This is believed to be apparent from the fact that each messenger cable has a high resistance and a relatively small cross-sectional area whereas each tubular conductor has a low resistance and a large cross-sectional area. In one practical commercial installation the solid messenger cables each have a diameter of approximately one-quarter inch, whereas the copper tubes each have a diameter of approximately an inch. Moreover, the sleet melting current may be applied during operation of the broadcasting station, that is, simultaneously with the application of the radio frequency power and, because of the high resistance of each cable, without damage of over heating the tubular conductors 31, 32, 33 and 34.

Referring to Figs. 1, 3, 3A and 3B, the mechanical arrangement for the coupling system

will now be described. At the upper end of the coupling system 15 cables 35, 36, 37 and 38 are supported through insulators 3 and collars 55 by a cross-bar or pipe 56 which in turn is supported by a double bridle 57, 58. The double bridle is connected through insulators 3 and plate assemblies 59 (Fig. 3) to the tower antenna 1, the lower bridle 57 and the upper bridle 58 being connected to points on the tower at which horizontal bracing members 60 are located. Along the tower the bridles are preferably spaced so as to fall outside of the predetermined tower section in which the flexible conductors 16 and associated contacts 41 are to be connected to the tower antenna 1. Since the antenna and line are actually matched after the erection of the tower and coupler, the flexible conductors 16 are preferably made sufficiently long so that, if necessary, the connection point or points may be outside of the aforementioned section, as indicated by the dotted lines 61 on Fig. 1. The flexible conductors 16 are supported by guy wires 62 and associated insulators 3.

Referring to the lower end of the coupling system 15 and the same drawing figures, each of the messenger cables extends through a strain insulator 3 over individual pulleys 63 and 64 to an individual counterweight member 65. The pulleys 63 are each attached through a hook swivel assembly 66 to a clamp 67 which is movable along the H-beam 68, the beam 68 being embedded in a concrete base 69. Pulleys 64 and counterweights 65 are supported by a structure comprising upright members 70 and a horizontal member 71, the pulleys 64 being attached to the horizontal member 71 through an individual swivel assembly 72. Pulleys 63 and 65, by virtue of the swivel feature, may turn and slightly rotate upon movement of the associated clamp 67.

It is therefore believed to be apparent that in accordance with the invention the spacing between the cables and therefore between the tubes 31, 32, 33 and 34, and the capacitance of the coupler may be varied and critically adjusted by proper adjustment of clamps 67. The counterweights may be adjusted so as to limit the stress applied to the tower under storm conditions and so as to maintain a uniform tension on the messenger cables 35, 36, 37 and 38 and a constant spacing and capacity between the tubes 31, 32, 33 and 34.

Although the invention has been described in connection with a particular embodiment, it is to be understood that it is not to be limited to such embodiment; that it may be utilized with other types of antennas, as, for example, a base-insulated antenna, and that other arrangements and elements may be successfully employed without exceeding the scope of the invention.

What is claimed is:

1. In combination, a substantially linear tubular conductor having a low resistance, a solid conductor having a high electrical resistance and positioned within and electrically insulated from said tubular conductor, a source of radio frequency energy electrically connected to said tubular conductor, and a source of heating current connected in series with said conductors.

2. An antenna coupling system consisting of a capacity element comprising inclined feed conductors electrically insulated from each other and supporting means for holding the conductors in taut position to stabilize the capacitance therebetween, one of said conductors having a terminal for connection to an antenna and the

other having a terminal for connection to a transmission line for exciting the antenna.

3. An antenna coupling system comprising substantially parallel tubular conductors electrically insulated from each other, the terminal of one of said conductors being connected to an antenna and the opposite terminal of the other conductor being connected to a transmission line for exciting the antenna, and means at one end of said system for adjusting the spacing between said conductors.

4. In combination, a tower antenna, a transmitter and a coupling system comprising four spaced parallel conductors, the outer pair being connected together and to the transmitter, and the inner pair being connected together and to the tower antenna.

5. An antenna coupler comprising a plurality of tubular feed conductors electrically insulated from each other and supporting means for holding the conductors in taut position to stabilize the capacitance therebetween, one of said conductors having a terminal for connection to an antenna and the other having a terminal for connection to a transmission line for exciting the antenna, said means comprising individual cables included within said tubular conductors, each cable being attached to a fixed support at one end and to an individual counterweight at the other end.

6. An antenna coupling system comprising a plurality of tubular feed conductors electrically insulated from each other and supporting means for holding the conductors taut to stabilize the capacitance therebetween, one of said conductors having a terminal for connection to an antenna and the other having a terminal for connection to a transmission line for exciting the antenna, said means comprising individual cables included within said tubular conductors, each cable being attached to a fixed support at one end and an individual counterweight at the other end, and means for adjusting the spacing of the cables and associated tubular conductors so as to vary the capacity therebetween.

7. An antenna coupling system comprising four light-weight tubular feed conductors arranged substantially parallel in the same plane, the two inner conductors being connected together and constituting a capacity element and the two outer conductors being connected together and constituting the other capacity element, the spacing between the inner conductors being greater than the spacing between each inner conductor and the outer conductor, and each conductor

having a diameter related to the spacing between the inner and outer conductors and sufficiently large to prevent corona losses.

8. In combination, a vertical antenna connected electrically to ground at its lower end, a radio transmitter, a pair of transmission line conductors electrically connected to the output terminals of the transmitter and extending to the base of the antenna, the terminal of one of said conductors being connected to ground, and a capacity coupling means connecting the terminal of the other conductor to a point on the antenna to excite the antenna, said coupling means comprising a plurality of inclined lines separated laterally and insulated from each other, one of the lines being electrically connected to the antenna and another being connected to the transmission line conductor, and means for holding the inclined lines taut to preserve their spacings.

9. In combination, a transmission line conductor, a vertical antenna grounded at its lower end, a pair of inclined feed condensers insulated from each other, means electrically connecting one feed conductor to a point on the vertical antenna considerably above the ground terminals whereby the antenna may be shunt-excited, means electrically connecting the other feed conductor to the transmission line conductor whereby electrical energy may be supplied from the transmission line conductor to the antenna over the capacitance between the inclined feed conductors, and means for holding the feed conductors taut to prevent casual variations of the capacitance.

10. In combination, a tower antenna, a transmitter and a capacitive coupling system for connecting said transmitter and tower antenna, said system comprising at least four tubular feed conductors arranged substantially parallel in an inclined plane, the two inner conductors being connected together and to the tower antenna at the upper ends and the two outer conductors being connected together and to the transmitter at their lower ends and means for holding the conductors taut comprising individual cables included within said conductors, a double bridle included between the upper terminals of the cables and the tower antenna, a cross-member positioned below said tubular conductors, a plurality of pulleys movably attached thereto each supporting a different cable, and a plurality of counterweights each attached to a different cable.

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