Nov. 18, 1924. 1,515,670

L. F. FULLER

RADIOTELEGRAPHY

Filed Sept. 25, 1919 2 Sheets-Sheet 1

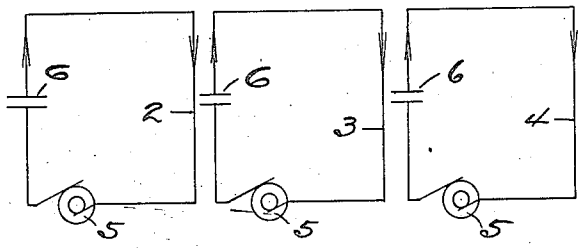

Fig. 1

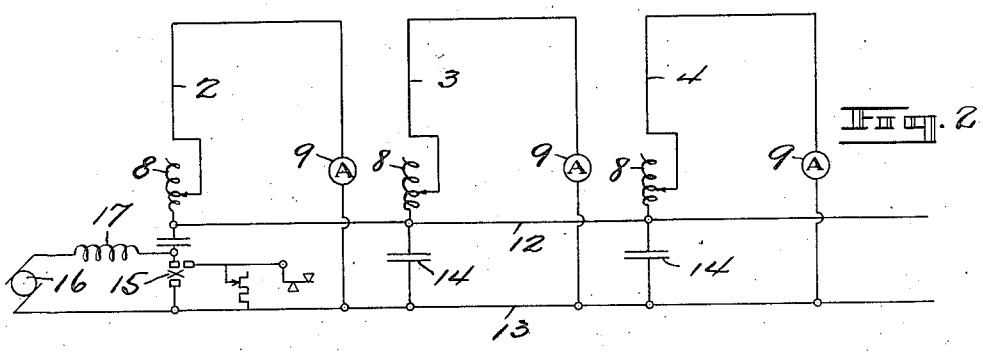

Fig. 2

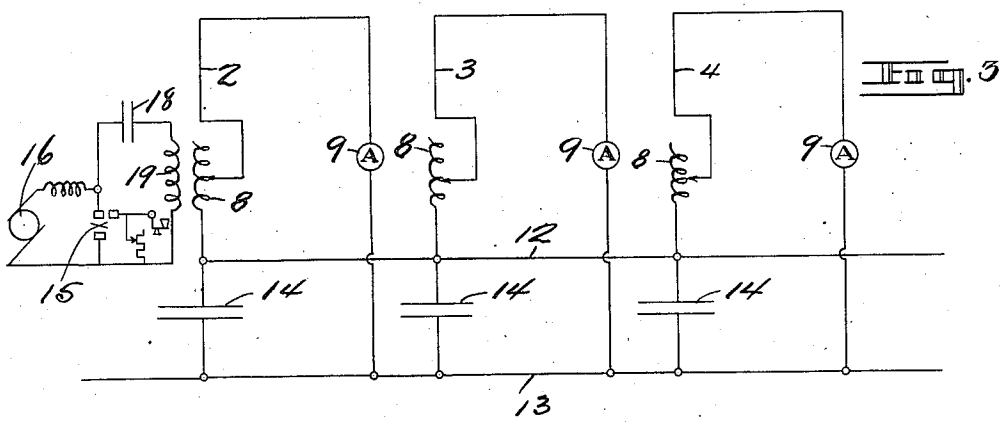

Fig. 3

Witness:
H. A. Sherburne.

INVENTOR.
L. F. FULLER
BY White & Frost
his ATTORNEYS.

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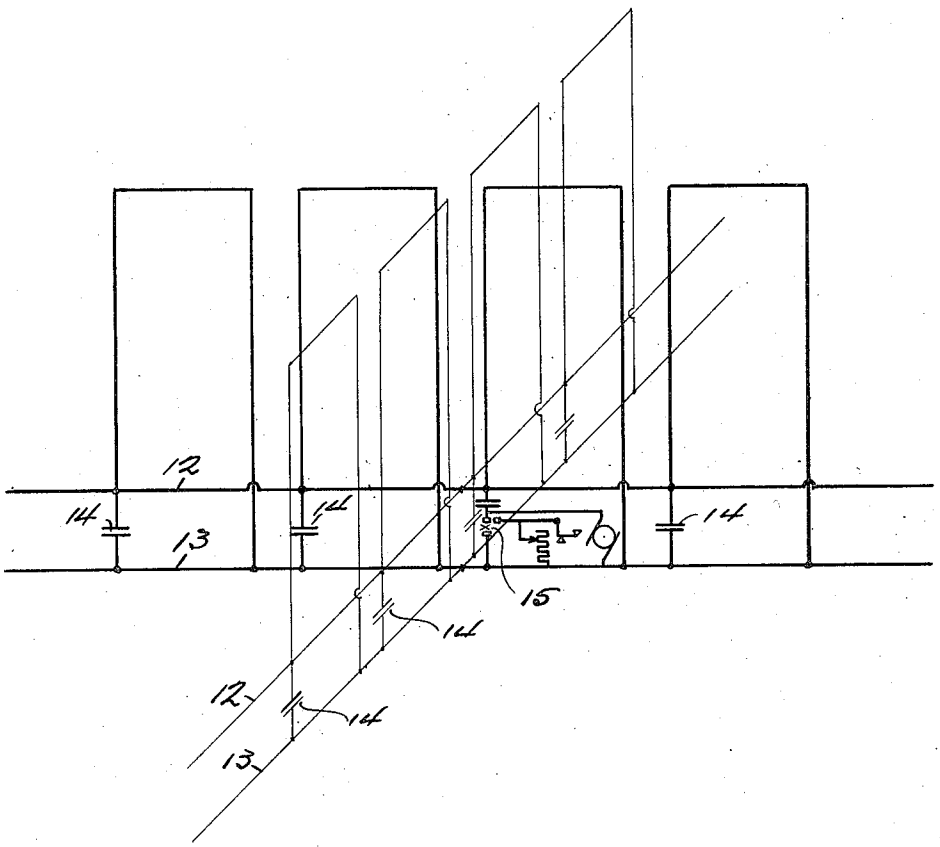
Fig. 4



WITNESS

J. B. Gardner

INVENTOR

L. F. FULLER

BY White & Frost

HIS ATTORNEYS

Patented Nov. 18, 1924. 1,515,670

UNITED STATES PATENT OFFICE.

LEONARD F. FULLER, OF BARBERTON, OHIO, ASSIGNOR, BY MESNE ASSIGNMENTS, TO FEDERAL TELEGRAPH COMPANY, OF SAN FRANCISCO, CALIFORNIA, A CORPORATION OF CALIFORNIA.

RADIOTELEGRAPHY.

Application filed September 25, 1919. Serial No. 326,344.

To all whom it may concern:

Be it known that I, LEONARD F. FULLER, a citizen of the United States, and a resident of Barberton, county of Summit, and State of Ohio, have invented certain new and useful Improvements in Radiotelegraphy, of which the following is a specification.

The invention relates to radio telegraphy and particularly to transmission systems.

Within the last few years, as the art of radio telegraphy has progressed, and as more and more transmission stations of constantly increasing power have been erected, it has been found that the resistance of the ground systems of these stations has presented a very serious problem, since as the antenna currents used in practice has been constantly increased, the I^2R losses have become too large. Furthermore, the ratio of the energy radiated, i. e., I^2r (r=radiation resistance) to I^2R (R=ohmic resistance of station ground system) has been so low, that the overall efficiency of the stations has been below that value which could be considered reasonably satisfactory.

It is an object of my invention, therefore, to reduce the ohmic resistance of the ground system, and raise the overall efficiency of the station.

Another object of my invention is to provide a radiating system which will transmit in a chosen direction instead of throughout 360°, as is now usually the case.

A further object of the invention is to provide an antenna which requires a lesser number of towers for its support than do the high powered antennæ now employed.

The invention possesses other advantageous features, some of which, with the foregoing, will be set forth at length in the following description, where I shall outline in full, that form of the invention which I have selected for illustration in the drawings accompanying and forming part of the present specification. In said drawings I have shown one form of the system of my invention, but it is to be understood that I do not limit myself to such form, since the invention, as expressed in the claims, may be embodied in a plurality of forms.

Referring to said drawings:

Figure 1 is a diagram illustrating the principle of my invention.

Figure 2 is a diagrammatic representation of a modified form of transmission system of my invention.

Figure 3 is a diagrammatic representation of a further modified form of transmission system of my invention.

Figure 4 is a diagrammatic representation in perspective of a system for transmission in different directions, the loop circuits in one plane being shown heavy and the loop circuits in the other plane being shown in light lines, to distinguish them.

The present invention involves the use of loop antenna. Theoretical consideration of the method by which energy is radiated from a loop antenna shows that among other things, the watts radiated from the loop are proportional to the square of the length of the loop and the square of the number of turns. The radiated energy is also proportional to the square of the radio frequency current in the loop. Other conditions remaining constant, it is evident that the watts radiated from the loop will be quadrupled if the number of turns in the loop are doubled. This increase in the number of turns, however, quadruples the reactive voltage drop across the loop when the current is maintained constant. This increase in voltage is objectionable, since the maximum voltage in the loop is rather definitely fixed by the allowable voltage on the condenser in the loop circuit.

The energy radiated, however, may be increased without increasing the voltage on the condenser by using two or more separate loops with currents in phase with each other arranged in the same vertical plane.

In Fig. 1 I have shown this diagrammatically. The radiating system consists of three vertical loops 2, 3 and 4, arranged in the same vertical plane, pointing in the same direction. A radio frequency current is circulated in each loop by a source of radio frequency E. M. F. 5, and it is assumed that by some means the currents are kept in phase. The currents in the adjacent conductors of the successive loops are in phase opposition, and the direction of current flow is the same in all of the loops. The magnetic fields set up by each loop acting as a solenoid are in the same direction, so that there is no flux linking more than one loop, and therefore the inductance of each loop is not increased

by the presence of the adjacent loops. Hence the voltage on each loop is not increased by the presence of adjacent loops. The inductive reactance of each loop is neutralized by a proper capacitance, 6, inserted in each loop, the capacitance acting to tune the circuit.

The plurality of loops may be considered as one loop "N" times the length of a single loop, or as one loop having "N" turns. Since radiated watts are proportional to the square of the length of the loop or to the square of the number of turns of the loop, it follows that in either case the watts radiated are proportional to "N^2".

It is also possible to arrange the loops in various parallel planes with sufficient distance between them to reduce the mutual inductance to a very low value.

In Fig. 1 the sources of radio frequency E. M. F., 5, may be radio freqency alternators connected mechanically, or otherwise, so that the currents in the three loops are in phase. It is not essential that there be a source of radio freqency E. M. F. for each loop, and in Fig. 2 I have shown one source for three loops, this source consisting of a Poulsen arc 15 fed by the D. C. generator 16, through a circuit containing a choke coil 17. In this arrangement, each loop is preferably provided with a variable inductor 8, by which each loop circuit is tuned. The adjustments of each loop are made by varying the inductance in each loop circuit until the radio frequency ammeter 9 reads a maximum in accordance with the well-known method.

The loops are connected to the two buses, 12 and 13. Connected across the buses, alternately with respect to the loops are the condensers 14 and the inductors are so adjusted for each capacitance that there is an inductance of proper value to form a resonant circuit for the radio frequency currents.

There are further methods of supplying energy to the loop radiating system, which may be employed. The Poulsen arc converter 15 may be inductively connected to the inductor 8 in the loop 2, in which arrangement the inductance of each loop must be adjusted so that the period of oscillation of its respective loop is the same as the frequency set up in the closed oscillatory circuit, containing the arc 15, the condenser 18, and the inductor 19. This arrangement is shown in Fig. 3.

Energy from the system of loops is radiated with maximum intensity in the plane of the system, and with minimum intensity normal to said plane, the intensity at any angle with the plane being approximately proportional to the cosine of the angle.

In Fig. 4 I show two loop systems at right angles. If they are excited by different sources of radio frequency E. M. F., two messages may be sent at the same time on the same wave length;—one in the direction of the plane of one loop system and one in the plane of the other system. In this figure I show the two loop systems connected to one source of radio frequency thus permitting transmission of one message throughout 360° instead of in two directions only.

In practice, the condensers 14 are preferably made with air dielectric in order that their losses shall be a minimum. I have found that layers of wire strung from telegraph poles are a means of obtaining a condenser of extremely low resistance and yet capable of withstanding high voltages. Since the capacities used in this antenna system are near the earth, it is necessary that high towers, or masts, be provided only for the support of the loops, so that only one row of towers are required for a station which is constructed to send in one direction.

It has been customary heretofore to put the capacitance as high in the air as possible, thereby throwing the electro-static field a long distance which in turn caused larger earth losses.

Signaling may be accomplished in any well-known or desirable manner, and I do not desire to limit myself in any manner to any particular method or apparatus for signaling. In the drawings I have shown the signaling system disclosed in my United States Letters Patent No. 1,330,254, since this is one form of signaling system which may be employed with this antenna system, although others may be used with equal or greater efficacy.

I claim:

1. In a radio frequency transmission system, an ungrounded radiating circuit comprising a plurality of vertical loops in substantially the same plane, the vertical sides of adjacent loops being near each other, means for supplying current to each loop, of such phase that the currents in these adjacent vertical sides are opposed and substantially nullify each other, whereby the resistance losses in the entire structure may be maintained at a desired low value, and means for individually tuning the loops.

2. A radio telegraphy transmission system comprising a plurality of vertical loops arranged with their planes pointing in the same direction, a pair of conductors to which the opposite end of said loops are connected, a condenser connected across said conductors at each loop, and a source of radio frequency electromotive force connected across said conductors.

3. An antenna comprising two sets of vertical loops arranged at an angle to each other, the loops in each set arranged with their planes pointing in the same direction and so that the mutual inductance between the loops of a set is practically zero.

4. A radio telegraphy transmission system comprising two sets of vertical loops arranged at an angle to each other, the loops in each set arranged with their planes pointing in the same direction and means for impressing a radio frequency electro-motive force on said loops.

In testimony whereof, I have hereunto set my hand at Barberton, Ohio, this 13th day of September, 1919.

LEONARD F. FULLER.

In presence of—
GEO. L. H. ROE,
LUCRETIA STRONG FULLER.