M. I. PUPIN AND E. H. ARMSTRONG.

ANTENNA WITH DISTRIBUTED POSITIVE RESISTANCE.

APPLICATION FILED OCT. 1, 1915. RENEWED JUNE 20, 1919.

1,336,378. Patented Apr. 6, 1920.

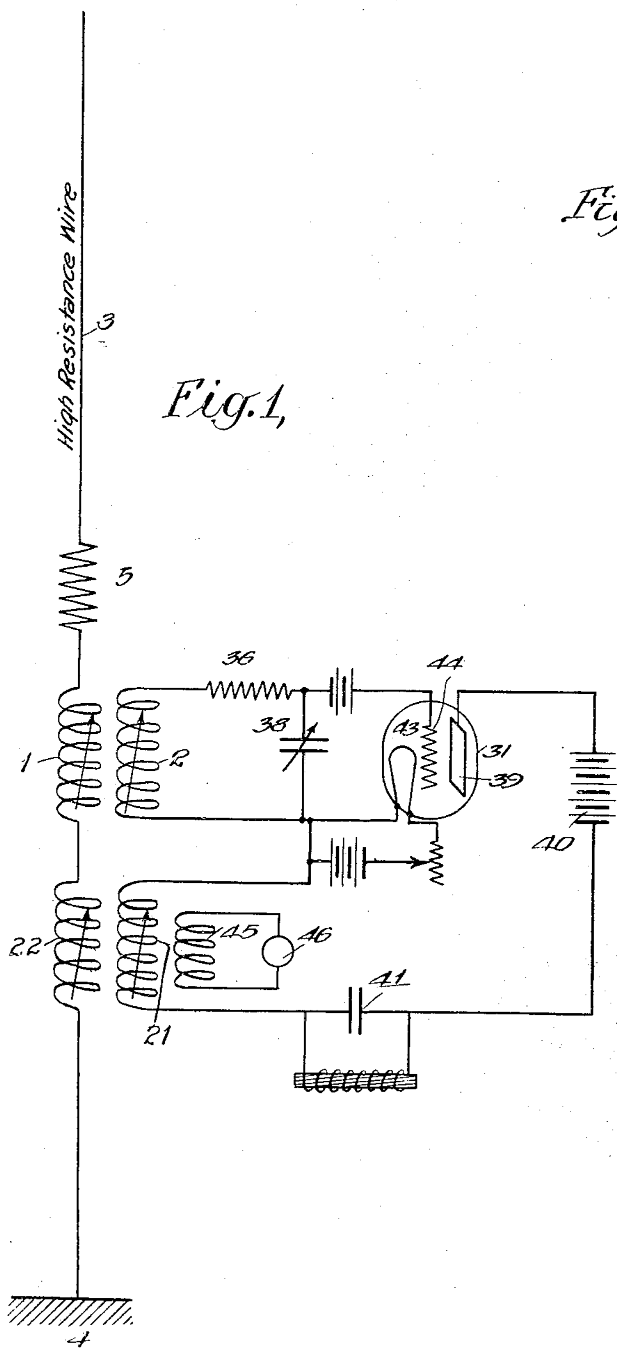

Fig. 1,

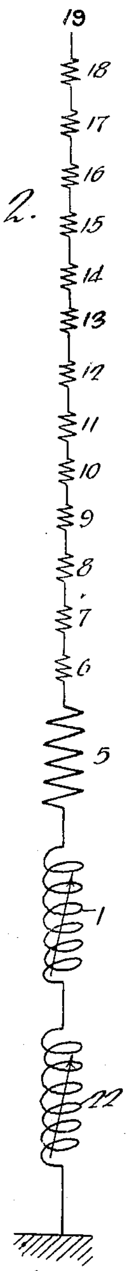

Fig. 2.

INVENTORS
Michael I. Pupin
Edwin H. Armstrong
BY
Pennie, Davis, Marvin
ATTORNEYS

UNITED STATES PATENT OFFICE.

MICHAEL I. PUPIN, OF NORFOLK, CONNECTICUT, AND EDWIN H. ARMSTRONG, OF YONKERS, NEW YORK.

ANTENNA WITH DISTRIBUTED POSITIVE RESISTANCE.

1,336,378. Specification of Letters Patent. **Patented Apr. 6, 1920.**

Application filed October 1, 1915, Serial No. 53,493. Renewed June 20, 1919. Serial No. 305,706.

To all whom it may concern:

Be it known that we, MICHAEL I. PUPIN, a citizen of the United States, residing in Norfolk, county of Litchfield, State of Connecticut, and EDWIN H. ARMSTRONG, a citizen of the United States, residing in Yonkers, county of Westchester, State of New York, have invented certain new and useful Improvements in Antennæ with Distributed Positive Resistance; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The invention relates to receiving wave conductors which are loaded with resistance in order to screen them against the disturbing effects of electrical waves, and particularly those waves which have the character of electrical pulses of short duration, known in the art as "atmospherics" or "strays". A resistance introduced into the receiving conductor, called receiving antenna in wireless transmissions, will diminish the effects of disturbing waves and pulses, but it will also diminish to the same degree the effect of the waves which are to be received, unless the introduced resistance is properly placed. This invention gives definite rules which enable one skilled in the art to distribute the introduced resistance so that it will diminish the effect of disturbing waves more than of the waves which are to be received.

Referring to diagrams of the drawings which form part of this specification,

Figure 1 represents a wireless antenna in which the introduced resistance is uniformly distributed over linear part 3 of the antenna,

Fig. 2 represents a wireless antenna in which the added high resistance is divided into a number of parts, 5, 6, 7, . . . 18 which are placed at approximately equal intervals over the antenna.

Referring to Fig. 1, which represents an antenna in which the resistance is uniformly distributed over its linear part 3, the transformer 1, 2 transmits the electromotive force impressed upon the antenna to the receiving translating devices. The primary 1 of this transformer connects the antenna to ground at 4. We find that in such an antenna the effective resistance for waves to be received is a fractional part only of the total resistance, whereas for electrical pulses of short duration the effective resistance is substantially equal to the total resistance of the antenna. For harmonically varying waves which are not to be received and for which the antenna is not tuned, the effective resistance is also greater than for waves which are to be received. This advantage is particularly valuable when a resistance compensator is employed for the purpose of compensating a large resistance introduced into an antenna. Such a compensator, of the specific type shown in Fig. 3 of our co-pending application Serial No. 51,151, filed September 17, 1915, is here illustrated. This compensator consists of an electrical valve 31 coupled with the antenna on the input side by means of the circuits 2, 36, 38, and on the output side by the circuits 39, 40, 41, 21. The electrical valve illustrated is the well known vacuum tube containing a hot cathode 43 and a cold anode 39, between which a direct current flows, and a third electrode or "grid" 44 between them modifying the normal direct current between the hot cathode and the cold anode. The received oscillations acting in the exciting circuit 2, 36, 38, excite the valve, and release energy in the output circuit 39, 40, 41, 21, and under proper conditions a portion of this released energy is transferred through the transformer 21, 22 into the antenna. This produces in the antenna a negative resistance reaction capable of reducing the resistance of 4, 22, 1, 5, 3, to any predetermined limit for waves of selected frequency. As an illustration, consider a vertical antenna 500 feet high. Let its capacity be 10^{-9} farads. By introducing 3×10^{5} ohms into the antenna, and preferably uniformly distributed over it, its effective resistance for an electromotive force of 3×10^{4} P. P. S. will be only 28×10^{3} ohms. The resistance compensator will have to neutralize less than one tenth of the total resistance of the antenna. The usual detecting arrangement is diagrammatically illustrated by the transformer winding 45 and a detector 46.

In practice it is more convenient to introduce the high resistance in lumps, since a uniform wire of the length of an antenna and having several hundred thousand ohms resistance is difficult to obtain. A wire having a resistance distributed over it in lumps will act like a perfectly uniform wire of the same total resistance, if the lumps are so spaced that there are several per wave length of the waves, the action of which is to be considered. This construction is illustrated in Fig. 2 of the drawings. In this figure the linear antenna 4, 1, 19 carries resistances 5, 6, 7, 8, 9, etc., placed at substantially equidistant intervals, and the length of these intervals is small in comparison with the wave length of the highest frequency, the waves against which the introduced resistance is to act as a screen. Such a wire will act with respect to these waves like a perfectly uniform wire represented in Fig. 1.

The introduction of high resistance into a wave conductor will act as an efficient screen if it not only reduces the amount of electromagnetic energy which a wave can deposit upon the conductor but also diminishes the transmission of the deposited energy from the antenna to the translating devices. This last function is best accomplished by taking a large part, say a quarter, of the total introduced resistance and placing it at the lower terminal of the linear antenna. This is indicated in Fig. 1 and Fig. 2 by the element 5. This represents a large resistance introduced in a single lump at the point where the antenna is connected to the local receiving transformer 1, 2. Its function is to dissipate the electromagnetic energy during its passage from the antenna to the receiving apparatus.

What we claim is:

1. A receiving conductor for wireless wave transmission having a resistance load sufficiently high to screen the system effectively against disturbing electromagnetic waves impressed upon the conductor, the said resistance load being distributed along the conductor with substantial uniformity with respect to the wave lengths developed upon the conductor by the received signals.

2. A receiving conductor for wireless wave transmission having a resistance load sufficiently high to screen the system effectively against disturbing electromagnetic waves impressed upon the conductor, the said resistance load being distributed along the conductor with substantial uniformity with respect to the wave lengths developed upon the conductor by the received signals, and a resistance compensator connected to the conductor and adapted to reduce its effective resistance to any predetermined limit for the received signals.

3. A receiving conductor for wireless wave transmission having a resistance load sufficiently high to screen the system effectively against disturbing electromagnetic waves impressed upon the conductor, the said resistance load being distributed along the conductor with substantial uniformity with respect to the wave lengths developed upon the conductor by the received signals, and a resistance compensator connected to the conductor and adapted to reduce its effective resistance to any predetermined limit for the received signals, and a conductor of high resistance interposed between the receiving conductor and the resistance compensator.

4. A receiving conductor for wireless wave transmission having a resistance load sufficiently high to screen the system effectively against disturbing electromagnetic waves impressed upon the conductor, the said resistance load being distributed in separate units along the conductor at intervals which are small in comparison with the wave units developed upon the loaded conductor by the received signals.

In testimony whereof we affix our signatures.

MICHAEL I. PUPIN.
EDWIN H. ARMSTRONG.