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STATION FOR THE TRANSMISSION AND RECEPTION OF ELECTROMAGNETIC WAVE ENERGY.
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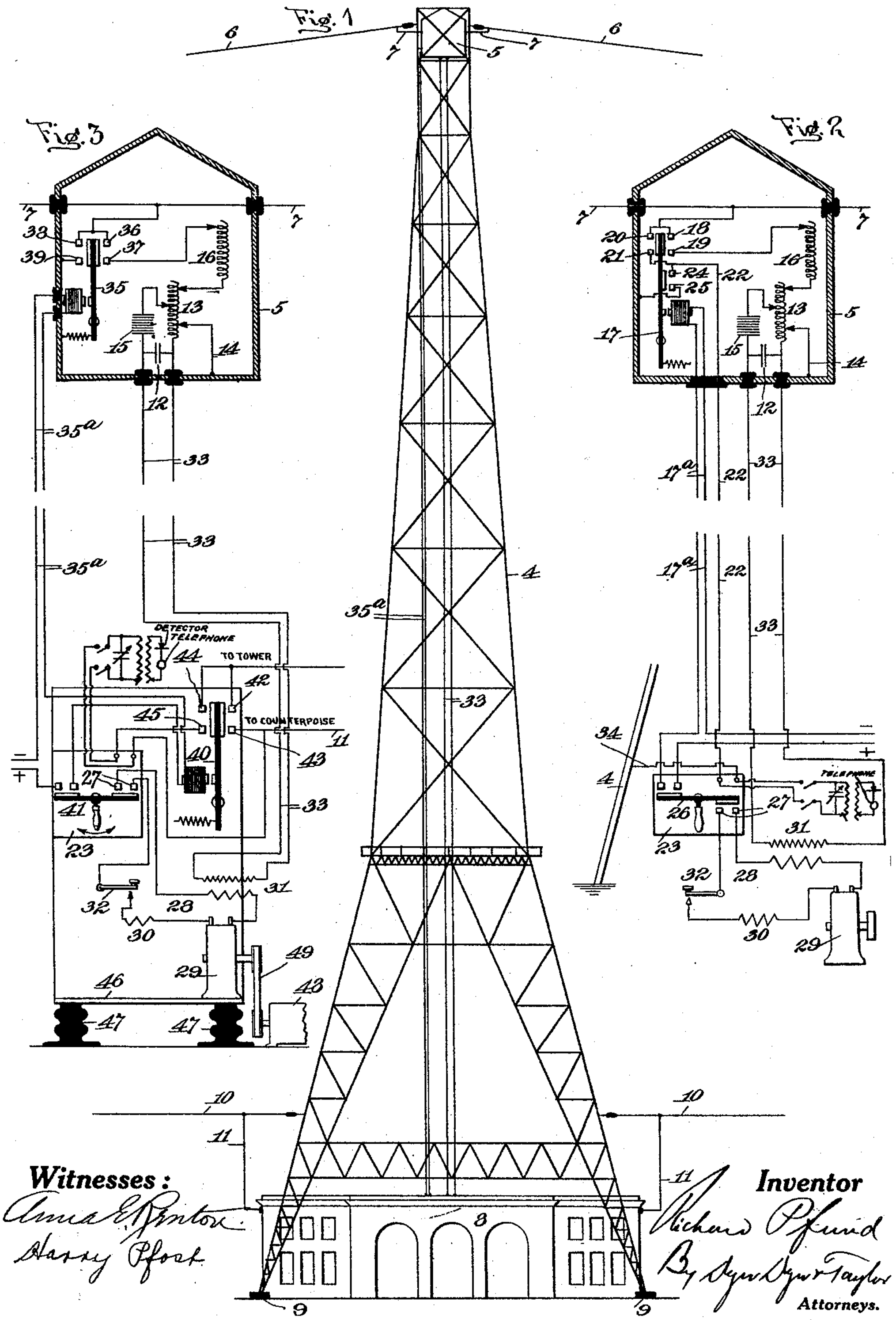

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UNITED STATES PATENT OFFICE.

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STATION FOR THE TRANSMISSION AND RECEPTION OF ELECTROMAGNETIC-WAVE ENERGY.

1,116,111. Specification of Letters Patent. **Patented Nov. 3, 1914.**

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To all whom it may concern:

Be it known that I, Richard Pfund, a citizen of the United States, and a resident of the city and State of New York, have invented a certain new and useful Improvemen in Stations for the Transmission and Reception of Electromagnetic-Wave Energy, of which the following is a specification.

My invention relates to stations for the transmission and reception of electromagnetic wave energy and more particularly to the arrangement of the transmitter proper with reference to the antenna and the ground; and has for its object to effect a decided increase in efficiency of transmission, by eliminating the heretofore unavoidable losses, in the leads between the transmitter proper and the antenna and the ground, and the losses between the antenna, and the leads to the antenna, and the ground.

For best efficiency in transmitting, an antenna should not only be as far away from the earth as possible but it should also, for a given transmitter capacity, have the largest possible electrostatic capacity, with the shortest possible natural period and smallest possible resistance. As however the natural period of an antenna rapidly increases with its height above the earth, on account of the inductance of the leads, and as the losses due to resistance in these leads also rapidly increase with their length, a limit as to height for a given transmitter capacity is soon reached beyond which limit the efficiency, notwithstanding the increased height above the earth, rapidly decreases on account of the natural period of the antenna as a whole, being due more to its inductance than to its electrostatic capacity and therefore being unable to most efficiently absorb and radiate the energy supplied to it by the transmitter. It is of course possible to reduce the inductance and the resistance of the leads, by increasing their number and also by properly spacing them with that end in view, but such an arrangement adds very little to the efficiency and if carried too far will actually decrease it, because the greater the number of leads and the more their spacing approaches or exceeds that of the antenna proper, the more such an arrangement becomes practically equivalent to bringing the entire antenna nearer the ground. This, although it may reduce the inductance and the resistance and increases the electrostatic capacity, at the same time greatly reduces the efficiency of the antenna as a radiator, because, looking upon the antenna and the ground underneath as two surfaces of a condenser connected to the terminals of the transmitter, the closer these two surfaces are to each other the greater will be the capacity, but at the same time the greater will also be the tendency of the oscillating charges to confine themselves to this condenser circuit, made up of the transmitter and the antenna and the ground underneath and the air dielectric between them, and the less will be the tendency of the antenna end of this condenser circuit to radiate its charge into space.

In carrying out the purpose of my invention, I propose to support the antenna, if of the umbrella type, from the top of a substantial metallic tower, of ample cross-section and surface and with the different sections carefully bonded so as to reduce both the inductance and the resistance to a minimum, and to insulate the antenna from this tower and to then locate the transmitter proper at the top or very near the top of the tower with one end connected to the antenna and the other end connected to the tower itself. In order to still further improve the conductivity and reduce the other losses in the tower, a number of copper or other wires or leads may be added to and connected in parallel with it from top to bottom, as will be understood. If local conditions are favorable, the tower may be grounded direct in the most approved manner, while if the conditions are such as to make direct grounding impracticable the tower is carefully insulated from the ground and a counterpoise or capacity earth is employed. In the latter case the conductivity of the tower structure itself may also be still further improved by means of copper or other leads connected in parallel with it as explained above. With a flat-top or other type of antenna, requiring two or more supports, I propose to make at least one of them in the form of a substantial metallic tower of the same general construction as that proposed for an umbrella antenna, and to locate this particular support at that point at which it is intended to make connection with the antenna and to then arrange the transmitter at the top or very near the top of this tower and connect it with the antenna and the tower itself in a similar manner as with the umbrella type antenna described above. The antenna in this case to be also insulated from all its supports including the one containing the transmitter.

In order to make it possible to also receive, it is of course necessary to so arrange the transmitter that it can be rapidly disconnected from the antenna and ground or counterpoise and the antenna and ground or counterpoise then connected with the receiver. To accomplish this with a directly grounded tower, I provide an electrically operated transfer switch located at the top of the tower and automatically operated by the receiver switch in the operating room near the base of the tower. The object of this electrically operated transfer switch at the top of the tower is to connect the transmitter to the antenna and tower, when sending, and to disconnect the transmitter from the antenna and to connect the antenna to a lead or leads extending to the operating room, when receiving. When the switch at the top of the tower is in the sending position it also automatically connects the leads used for receiving to the tower structure at their upper end, in order to prevent any harmful effect from induced currents in these leads.

With an insulated tower, and with either a direct ground or counterpoise, two electrically operated transfer switches, automatically operated in unison, are required. One of these switches is located at the transmitter near the top of the tower and the other at the receiver near the base of the tower. The switch at the transmitter is arranged to connect the transmitter to the antenna and tower, when sending, and to disconnect the transmitter from the antenna and to connect the latter to the tower direct, when receiving; while the switch at the receiver is arranged to connect the tower structure direct to the ground or counterpoise, when sending, and at the same time to disconnect the receiver and to break this direct connection between the tower and the ground or counterpoise, and cut in the receiver in series with the tower and the ground or counterpoise, when receiving. The same switches, as will be understood, are also arranged to open and close various circuits in both the transmitter and the receiver in order to make it impossible to send except when the switches and everything they control is in the sending position and to protect the receiver circuits while transmitting. At stations where a counterpoise or capacity of earth is used, the generators supplying the transmitter must be carefully insulated from the ground; and in order to accomplish this, I propose mounting such generators on a platform near the ground, but insulated from it with insulation equal to that between the tower and the ground, and to then drive these generators by means of a belt from an electric or other prime mover located on a suitable foundation on the ground. This belt to be of sufficient length and of such material as will insure proper insulation, and in practice either ordinary rubber or leather belting will be found to be sufficient. The operator and all regulating and other apparatus required to operate the transmitter and also the receiver, and all apparatus connected with it, must of course also be located on the same or a similar insulated platform or be capable of being operated from it without impairing the insulation or endangering the operator. This is easily arranged and need not be gone into here except that it might be mentioned that in case an electric motor is employed to drive the generator and it is desired to vary the speed of this motor by means of a rheostat from the insulated platform, this may be done with perfect safety by connecting for instance a toothed wheel on the rheostat, located on the ground with the motor, with a similar toothed wheel, located on the insulated platform, by means of a perforated leather or rubber belt of sufficient length to insure the proper amount of insulation. With ordinary systems, *i. e.*, those in which a special high-frequency machine directly connected to the antenna is not employed, I propose to also locate the transformer on the insulated platform near the ground with the generator, and to then simply extend the high potential secondary leads from this transformer to the transmitter proper at the top of the tower. Under ordinary conditions it would of course be desirable to locate both the generator and the transformer as close to the rest of the transmitter as possible, but with high powers it is not practicable or desirable to locate the heavy generators required at the top of high towers, and it is therefore preferable to locate the generators and transformers near the ground as described above and to only put the transmitter proper at the top of the tower.

In cases where a special high-frequency generator for directly producing undamped or feebly damped oscillations is employed, it will of course be necessary with my system to locate such generators at or near the top of the tower and to then control and operate them, by means of either direct or alternating current produced by an ordinary generator, located on the insulated platform referred to above and driven in a similar manner, and in such cases the tower will of course have to be constructed with that end in view. Where a direct ground can be obtained, and a counterpoise or capacity earth is unnecessary, the insulated platform for the generator and transformer and other apparatus is of course also unnecessary and all this apparatus may be installed directly on the ground with only the usual insulation and the usual high-frequency protection.

In the drawing, Figure 1 is an elevation illustrating a suitable form of tower for supporting the antenna. Fig. 2 is a diagram showing apparatus embodying my invention as arranged in connection with a grounded tower; and Fig. 3 is a view similar to Fig. 2 of an apparatus embodying my invention arranged in connection with an insulated tower.

In Fig. 1, 4 is the tower, preferably of metal construction and of any suitable form, having at its top the compartment 5, in which the transmitter proper is located. The branches 6 of the antenna are supported at the top of the tower, but insulated therefrom, and have leads 7 extending into the transmitter compartment 5. At the base of the tower is the operating room 8. The tower in Fig. 1 is shown as insulated from the earth by suitable insulating supports 9, and a counterpoise or capacity earth is illustrated, consisting of the wires 10 connected to but insulated from the tower, and having branches 11 which extend into the operating room.

In Fig. 2, which shows my apparatus arranged in connection with a grounded tower, a portion of the tower is shown by 4, at the left of this figure, and the transmitter compartment 5 at the top of the figure. The transmitter shown in diagram in the compartment 5 is illustrated, for the sake of simplicity, as of the ordinary type, consisting of the capacity 12, self-induction 13, with a variable connection 14, permanently connected with the tower through the metal shell of the compartment 5, spark gap 15 and variable loading coils 16. In this compartment is also located the electrically operated switch 17 for connecting the transmitter through the loading coils 16 to the antenna by means of the contacts 18, 19, when it is desired to send, and for breaking this connection and connecting the antenna through contacts 20, 21 to leads 22 extending to the receiver 23 in the operating room at or near the base of the tower, when it is desired to receive. At 24 and 25, on the switch 17, are contacts by means of which the leads 22 are connected to the tower when sending. At 26 in the operating room is a switch on the receiver 23, by means of which the switch 17 in the transmitter compartment is controlled, *i. e.*, when the switch 26 is thrown into the sending position it closes the direct-current circuit 17^a and automatically throws the switch 17 into such a position that the antenna is connected to the transmitter through the loading coils 16 by means of the contacts 18, 19, and at the same time the leads 22 are connected with the tower by the contacts 24, 25; while when the switch 26 is thrown into the receiving position the circuit 17^a is opened and the antenna is connected to the leads 22 by the contacts 20, 21. When the switch 26 is thrown into the receiving position, it also opens the break 27 in the sending key circuit 28. This break 27 is closed when the switch 26 is put in the sending position. Various other circuits in the receiver and the low frequency side of the transmitter are also automatically controlled by switch 26, as will be well understood, but for the sake of clearness of illustration, these are omitted from the drawing. At 29 is shown the generator, which may be one of 500 cycles, as usually employed at the present time; 30 is the primary choke coil, 31 the transformer and 32 the sending key of the sending key circuit 28. The secondary high potential leads 33 of the transformer 31 extend to the top of the tower into the transmitter compartment 5 and are there connected to the capacity 12 of the transmitter. The leads 22 extending downwardly from the transmitter compartment are connected to one side of the receiver 23, while the other side of the receiver has a connection 34 with the grounded tower 4. It will be seen that in the arrangement illustrated in Fig. 2, the transmitter proper, located in the compartment at the top of the tower is, in sending, connected directly between the antenna and the tower, and through the tower, with the ground; while in receiving, the transmitter is disconnected from the antenna and the receiver is connected between the antenna and the grounded tower.

In Fig. 3 is shown a station arranged according to my invention and used in connection with an insulated tower and a counterpoise or capacity earth, as illustrated in Fig. 1. In Fig. 3, the transmitter compartment 5 is similar to the corresponding compartment in Fig. 2, and has similar antenna connections 7 entering it. The transmitter proper, located in the compartment 5, is likewise, for simplicity of illustration, shown as one of the ordinary type, having the same elements as in the transmitter proper of Fig. 2, namely, the capacity 12, self-induction 13, with a variable connection 14 permanently connected to the tower, spark gap 15 and variable loading coils 16. In the compartment 5 is located the electrically operated switch 35 for connecting the transmitter with the antenna through the loading coils 16 by means of the contacts 36, 37, when it is desired to send, and for breaking this connection and connecting the antenna through contacts 38, 39 to the tower structure, when it is desired to receive. In the operating room near the base of the tower is an electrically operated switch 40 somewhat similar to the switch 35 in the transmitter compartment at the top of the tower. These two switches 35 and 40 are electrically connected together in the same operating circuit 35^{a} so as to operate in unison and both are controlled by a hand switch 41 on the receiver 23 in the operating room. Switch 40 is so arranged that when the switch 35 in the transmitter compartment is in the sending position, the tower structure is connected with the ground direct or with the so-called counterpoise or capacity earth by means of contacts 42, 43, while when the switch 35 is in the receiving position the direct connection between the tower and the ground or counterpoise is broken and the receiver 23 is cut in in series with and between the tower structure and the ground or counterpoise by means of contacts 44, 45. Switch 41 is also so arranged that when it throws switches 35 and 40 into the sending position, it at the same time closes the break 27 in the sending key circuit, while when it throws switches 35 and 40 into the receiving position, this break 27 is open. In Fig. 3 is also illustrated the sending key circuit 28, its generator 29, primary choke coil 30, transformer 31 and sending key 32, while the secondary high potential leads 33 from the transformer 31 extend to the top of the tower and are connected with the capacity 12 of the transmitter proper the same as illustrated in Fig. 2. In the case of the arrangement shown in Fig. 3, all the apparatus in the operating room near the base of the tower is located on the platform 46, which is insulated from the ground by means of insulation 47, which should be at least equal electrically to that employed to insulate the tower from the ground. At 48 is shown the prime mover for driving the generator 29 through a leather or rubber belt 49.

It will be seen that in the case of the apparatus of Fig. 3, owing to the fact that the tower is insulated and differing in this respect from the arrangement in Fig. 2, an additional switch is employed to connect the tower to the ground or counterpoise when the antenna is connected through the transmitter to the tower in sending, and in receiving to connect the antenna directly with the tower and to connect the receiver in series between the tower and the ground or counterpoise.

It is, of course, obvious that, without departing from my invention, in its broader aspect, the operating room of either Fig. 2 or Fig. 3, instead of being located at or near the base of the tower, could also and perhaps with some advantage electrically, be located at or near the top of the tower close to the transmitter compartment, and the generating machinery near the base of the tower could be controlled from this elevated operating room, but such location would no doubt be found to be inconvenient in practice, and any gain electrically would very likely be outweighed by other disadvantages. It is also obvious that, without departing from my invention in its broader aspect, a tower or elevated structure of wood, masonry or other insulating material might be employed, in which case the conductivity afforded by the metal of a metallic tower would be replaced by suitable metal conductors.

I claim:

1. A station for the transmission and reception of electromagnetic wave energy wherein are combined an elevated structure or tower, an antenna supported by the tower, a transmitter located at or near the top of the tower, a receiver located at or near the base of the tower and means controlled at or near the receiver for alternately connecting the transmitter immediately with the antenna and for disconnecting the transmitter from the antenna and connecting the receiver therewith, substantially as set forth.

2. A station for the transmission and reception of electromagnetic wave energy wherein are combined an elevated metallic structure or tower, an antenna supported by the metal tower but insulated therefrom, a transmitter located at or near the top of the tower and permanently connected therewith, a receiver located at or near the base of the tower and means controlled at or near the receiver for alternately connecting the transmitter immediately with the antenna and for disconnecting the transmitter from the antenna and connecting the receiver therewith, substantially as set forth.

3. A station for the transmission and reception of electromagnetic wave energy wherein are combined an elevated structure or tower, an antenna supported by the tower, a transmitter located at or near the top of the tower, an operating station located at or near the base of the tower, a sending-key controlled generator circuit located at the operating station and connected with the elevated transmitter, a receiver also located at the operating station and means controlled at the operating station for alternately connecting the transmitter and receiver with the antenna, substantially as set forth.

4. A station for the transmission and reception of electromagnetic wave energy wherein are combined an elevated metallic structure or tower insulated from the ground, an antenna supported by the metal tower but insulated therefrom, a capacity earth or counterpoise near the base of said metallic structure but insulated from it and the ground, a transmitter located at or near the top of the tower, a receiver and means

for connecting the transmitter immediately between the antenna and the tower and simultaneously connecting the tower and the capacity earth or counterpoise, and for alternately connecting the antenna and tower and connecting the receiver in series between the tower and the capacity earth or counterpoise, substantially as set forth.

5. A station for the transmission and reception of electromagnetic wave energy wherein are combined an elevated metallic structure or tower insulated from the ground, an antenna supported by the metal tower but insulated therefrom, a capacity earth or counterpoise near the base of said metallic structure but insulated from it and the ground, a transmitter located at or near the top of the tower, an operating station located at or near the base of the tower, a sending-key controlled generator circuit located at the operating station and connected with the elevated transmitter, a receiver also located at the operating station and means controlled at the operating station for connecting the transmitter immediately between the antenna and the tower and simultaneously connecting the tower and capacity earth or counterpoise and for alternately connecting the antenna and tower and connecting the receiver in series between the tower and the capacity earth and counterpoise, substantially as set forth.

6. A station for the transmission and reception of electromagnetic wave energy wherein are combined an elevated metallic structure or tower insulated from the ground, an antenna supported by said metallic structure but insulated from it, a capacity earth or counterpoise near the base of said metallic structure but insulated from it and the ground, generating machinery located near the base of said metallic structure but insulated from it and the ground, a transmitter located near the top and a receiver located near the base of said metallic structure, means for connecting the antenna and the metallic structure to the transmitter near the top of said structure and at the same time connecting the said structure to the capacity earth or counterpoise near the base of said structure, means for operating and controlling and connecting the generating machinery located near the base of said structure with the transmitter located near the top of said structure when it is desired to transmit, and means for breaking these connections and connecting the antenna direct to the metallic structure near the top of said structure and cutting in the receiver in series with the metallic structure and the capacity earth or counterpoise near the base of said metallic structure and for disconnecting the generating machinery located at the base of said structure, when it is desired to receive, substantially as set forth.

This specification signed and witnessed this thirty-first day of October, 1913.

RICHARD PFUND.

Witnesses:

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