Oct. 16, 1928. **1,687,792**

E. M. RAVE

RADIO COMMUNICATION

Filed Oct. 28, 1922

Fig. 1.

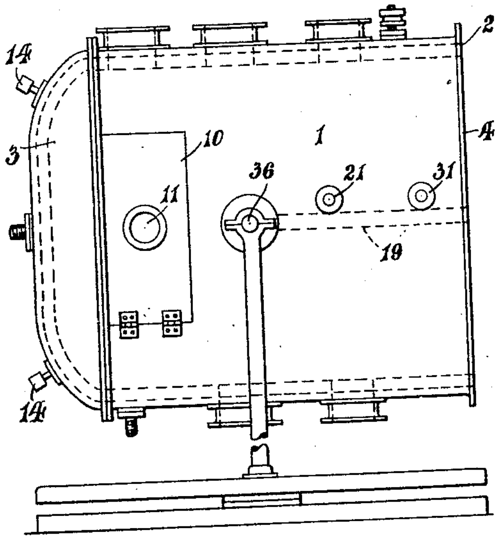


Fig. 2.

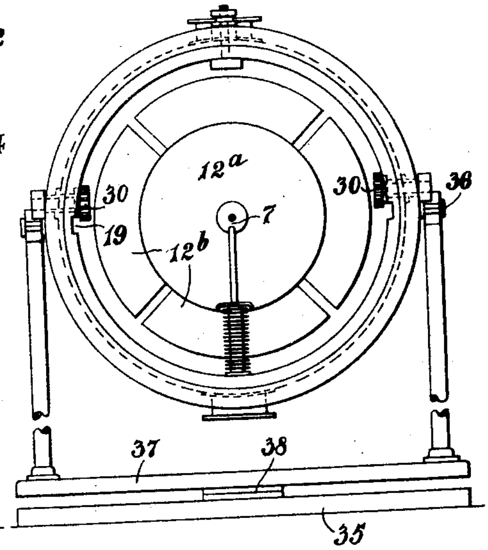


Fig. 3

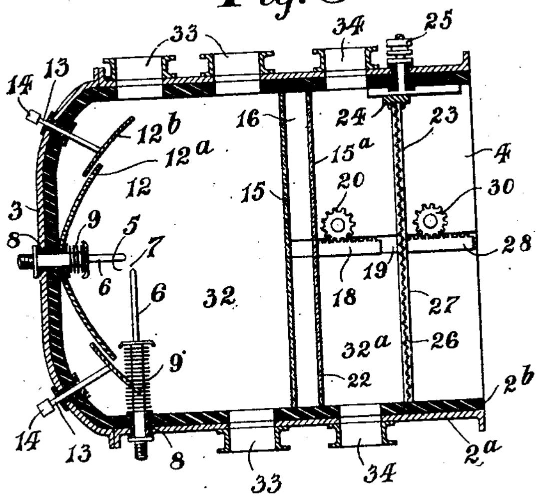
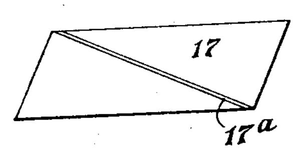


Fig. 4.



Elmer Mathew Rave Inventor

By his Attorneys *Marks & Clerk*

Patented Oct. 16, 1928. 1,687,792

UNITED STATES PATENT OFFICE.

ELMER M. RAVE, OF BROOKLYN, NEW YORK, ASSIGNOR OF ONE-THIRD TO BENTON B. HALE, OF EAST ORANGE, NEW JERSEY, AND ONE-THIRD TO DAVID H. REID, OF BROOKLYN, NEW YORK.

RADIOCOMMUNICATION.

Application filed October 28, 1922. Serial No. 597,508.

This invention relates to radio communication.

An object of the invention is to obviate the necessity for using wire antennæ or aerials for the transmission or reception of signals, messages or electrical energy through space.

Another object of the invention is to provide means and method for so projecting and modulating a beam of light that it may be utilized as a conductor of electricity.

The invention is of particular application in radio communication in which a beam of light is utilized as the aeral or antennæ in either transmission or reception, for conducting high or radio frequency electrical oscillations.

While it has been suggested (U. S. Patent 1,309,031) to utilize a beam of ionized air or atmosphere as an aerial, the air being ionized by the ultra violet rays of a projected beam of light, in the present invention I do not depend for results on such an unstable ionized gaseous medium which is subject to every breeze and other atmospheric disturbance, and which is electrically conductively unstable or variable.

It is my present theory (to which I do not desire to be bound however) that by the apparatus shown in the drawing, and by the method hereinafter described, I am able to effect such change in the characteristic of a beam of light as to render the light itself (as distinguished from ionized atmosphere) conducting, or as I will call it modulated, although there may be slight ionization of the air itself in the neighbourhood of the projected beam. Any gaseous ionization if it exists, due to my apparatus, does not appear to be important. Throughout the following specification and in the claims I will therefore refer to the beam of light, as herein modified as a "modulated beam of light". By "light" is meant, not only those rays that affect the eye and are visible, but also the invisible rays including the infra red, and those visible rays that are near the red end of the spectrum and which have longer wave lengths and are not photoelectric, that is, do not cause appreciable ionization of the atmosphere like the ultra violet rays do.

I have discovered that, if the light ray or beam has the required characteristics as regards color and polarization, as hereinafter explained, that is, is "modulated", such beam can be utilized as a conductor of electricity or as an aerial for conducting electrical oscillations which are projected or radiated into space as electromagnetic waves, or as a receiver of such electro-mgnetic waves, like an ordinary aerial. Nor is such conductivity dependent upon the ionization of the atmosphere through which the beam of light is projected. For in actual experiments conducted with the apparatus illustrated in the drawing excellent results were obtained when the ionizing ultra violet rays were screened out and when the red or infra red in the ray predominated.

In the present invention the light generated or projected or formed is passed through a pair of flat plates of Iceland spar separated by an air space, which arrangement assures a practical operation of the apparatus and secures operative results. The properties of Iceland spar are now well known. Its most characteristic property is that it polarizes light. Light is also polarized when an ordinary ray falls upon a reflecting surface arranged at an angle or at the polarizing angle for maximum polarization. Apparently my apparatus polarizes the light beam or ray, thereby modifying the characteristics or properties of the beam, making it conducting or modulating it.

Again it is to be understood that I do not desire to be bound or limited by any theories of polarization, the invention residing in the apparatus and method herein illustrated and hereinafter more fully described, such theory being propounded merely to make the invention clearer and easier to grasp and understand.

While I have obtained excellent results with the spaced plates of Iceland spar which, it is believed, cause the formation of the ordinary ray and extraordinary ray plane polarized at right angles to each other, yet I do not desire to be limited to the use of this instrumentality for the purpose of "polarizing" the light ray and any equivalent operative instrumentality may be employed, such for instance, as a "Nicol's prism" or a reflecting surface arranged at the polarizing angle.

To reduce the cost of installing and maintaining the towers or antennæ as now used I utilize a beam of light having the characteristics above described to conduct and project or radiate the electrical oscillations as ether waves or to receive such waves, the oscillations being superimposed upon or directed by the modulated beam.

The problem involves the utilization of a conducting medium which is not appreciably affected by atmospheric conditions or by the sun or other sources of light, the latter causing the ionization of the air or atmosphere by reason of their ultra violet rays, and which may be regulated to properly control the electric oscillations and maintain them.

To obtain the desired results my apparatus comprises three elements (1) a source of light, (2) a polarizer, as I call it, and (3) means, such as a metal screen, for imposing and receiving the electrical oscillations upon and from, respectively the polarized or modulated beam and forming a terminal of a local circuit connecting the beam thereto.

The source of light should be adjustable to vary the intensity of the beam according to conditions and to vary the length of the beam and its capability for directing or carrying or radiating and receiving the electrical oscillations.

The screen should be such as not to obstruct the beam and is adjustable with reference to the polarizer to vary its positions in the beam and thereby vary the results obtained, i. e. the distance to which radiation takes place.

It is a matter of everyday experience that rays of light cross each other without interference, the rays however, will be absorbed more or less in the atmosphere depending upon the intensity of the source and upon the nature of the light, that is, upon its wave length. I find from actual observation and experiment that in the use of my apparatus the presence of other beams of light does not influence my projected beam and the electrical oscillations associated therewith.

The degree of modulation of the beam of light or its effectiveness can be controlled either by adjusting the polarizer or the screen or terminal, or both, or wave length, that is the color of the relative quantity of long waves (the waves near the red end or below it) in the beam or any or all. For adjusting the polarizer the plates are so mounted as to be capable of movement towards and away from each other. The adjustment must be delicately controlled as the effectiveness of the beam, which is adjustable, will depend on meteorological conditions, such as whether it is day or night. The beam must be insulated from the earth and surrounding objects.

The actual source of light may be an ordinary electric bulb or a bulb of the concentrated filament type or an arc. In order to get the best results parabolic reflectors may be employed to concentrate the rays and direct them in the desired directions. The reflectors may be made of zinc or silver, as such materials will absorb no more than two or three per cent of the rays, the remainder being reflected. The infra red rays when their use is desirable, may be increased to a marked extent by adding barium chloride to the arc electrodes. At a temperature (at the electrodes) of 3460° C., the energy output has been calculated to be between 15 and 20 kilowatts.

It is to be understood that two or more beams may be utilized in a given installation or system, for instance on an airplane where a second beam is used as a counterpoise.

With this apparatus radio communication in space either transmission or reception between stations wherever located, whether up in the air, under the water, under the ground or on the ground or water, is possible.

In the accompanying drawing I have illustrated one embodiment of the invention in which

Figure 1 is a side elevation of the apparatus.

Figure 2 is an end view, parts being omitted.

Figure 3 is a vertical sectional view, and

Figure 4 is a view of a Nicol's prism.

Apparatus embodying the present invention comprises a projector 1, which resembles an ordinary searchlight, and consists of a cylindrical shell 2, closed at one end 3, and open at the opposite end 4, from which the beam of light is projected. The shell 2 comprises an outer part 2^a of metal, lined with insulation 2^b, whereby the beam and electrical circuits are thoroughly insulated from the ground and surrounding objects.

At the rear of the projector 1, is the source of light 5, which in the embodiment disclosed comprises two electrodes 6, arranged at right angles to each other and forming a gap 7 between them, across which the arc is formed, causing light. The electrodes 6 are mounted in the shell 2 as indicated at 8 and are preferably adjustable relatively to each other to vary or adjust the arc (by means not illustrated). The electrodes 6 may be made of any suitable material, for instance, carbon rods. Metal vanes 9 may be placed upon the electrodes or upon their mountings to radiate heat and for cooling purposes. Access may be made to the interior of the shell 2 to adjust or remove the electrodes 6 through a door 10, having a window 11 therein.

Behind the electrodes 6 within the projector 1, is placed a parabolic reflector 12, which comprises a central reflecting surface 12^a, and reflecting surfaces 12^b, arranged around the edges of the surface 12^a which reflect and direct the light from the arc forwardly through opening 4 projecting it into space. The reflectors 12^b are adjustably mounted in the end 3 of shell 2 (as indicated at 13) being movable in and out by handles 14.

Mounted within the projector 1 between the source 5, of light, and the end 4 of the projector is a pair of transversely arranged parallel plates 15, 15ª of a light polarizing material such as Iceland spar. These plates 15, 15ª are spaced from each other forming an air space 16 between them. For convenience I will call the spaced plates 15, 15ª, a "polarizer". In lieu of the plates 15, 15ª, illustrated in Fig. 3, I may substitute a prism of the character illustrated in Fig. 4 which is an ordinary Nicol's prism comprising a piece of Iceland spar 17 cut on an inclined axis 17ª and cemented together by a thin film of Canadian balsam. A Nicol's prism polarizes light but reflects the ordinary ray allowing the extraordinary ray only to pass through, the latter ray being plane polarized.

The plate 15ª is preferably mounted in the projector 1, for movement towards and away from plate 15, while maintaining the parallelism, varying the thickness of the air space 16, between them. The means for moving plate 15ª comprises racks 18 secured to opposite sides of the plate 15ª and suitably guided in guideways 19 in projector 1. The racks 18 are actuated by pinions 20 which may be manually rotated by the knobs 21 exteriorly arranged upon opposite sides of the projector 1. (The racks 18 may be actuated by a single knob connected to the pinions 20, if so desired.) The arrangement of racks and pinions disclosed however, is a good one for quickly and accurately adjusting the plates 15, 15ª relatively to each other and at the same time for preventing the tilting or binding of the movable plate on the inner sides of the projector 1.

One surface 22 of the plate 15ª is coated with a suitable material, such as a red vegetable coloring material, which will screen or cut off the ultra violet rays and prevent their projection into space in the beam but which will allow the longer waves near the red end of the spectrum and the infra red rays to pass through and form the beam.

In front of the polarizer 15, 15ª within the projector 1 in the path of the beam is mounted a transversely arranged terminal 23 forming part of a local circuit including sliding contacts 24 on the terminal 23 and projector respectively (to allow their relative adjustment while maintaining the circuit) and the insulated binding post 25 on the outside of the projector 1 connected to the contacts 24. This local circuit (which is not illustrated in detail) may comprise any circuit and its adjuncts which is adapted to form or does form part of transmitter or receiver.

The terminal 23 is of such a character that it does not obstruct the passage of the ray or beam or shut it off materially. For this purpose where alternating current is used, a metal screening or gauze 26 embedded in glass 27 has been found satisfactory, the glass allowing the light to pass through and the screening allowing it also by reason of its porous or perforate character, the terminal having however a maximum amount of surface in contact with the light beam, whereby the electrical oscillations or alternating current may be readily conveyed from one to the other, to and from binding post 25.

The glass forms a rigid support for the terminal screen and thoroughly insulates it from the projector and surrounding objects but does not prevent the transfer of the oscillations from and to the terminal to and from the beam.

The terminal 23 is mounted parallel to the plates 15, 15ª and is adjustable towards and away from such plates (while maintaining the parallelism) to vary its position in the beam. For this purpose a pair of racks 28 are secured to the framework of the terminal 23 at the opposite sides and are suitably guided in the ways 19 in the projector 1. Pinions 30 engage the racks and are operated from the outside of the projector 1 by the knobs 31, this actuating mechanism being similar to that for moving or adjusting the plate 15ª. It should be understood that the terminal 23 may be located at any point in the beam even beyond the end 4 of the projector 1 and is only mounted in the projector for convenience.

The arc chamber 32 formed between the end 3 of the projector and plate 15 is provided with openings 33 through the projector 1 to allow a good circulation of air, keeping the chamber 32 cool and preventing ionization of the gases therein and for quickly diffusing such ionized gases. In like manner the chamber 32ª formed between the plate 15ª and terminal 23 is provided with openings 34 to keep the air therein cool, to prevent its ionization and to rapidly diffuse such ionized air.

The projector 1 is mounted for universal movement upon a base 35, which is of insulating material thoroughly insulating the apparatus from ground. For this purpose the projector is mounted upon trunions 36 upon a table 37, in turn rotatable on a vertical axis 38 upon base 35, whereby the projector may be swung vertically and laterally respectively. This mounting allows the beam forming the aerial to be projected vertically, upwardly in all directions at any inclination, horizontally in all directions or downwardly at different angles in all directions according to the requirements or to the location of the projector in space, whether below the surface of the ground or water, up in the air, or on the surface of the ground or water.

The intensity of the beam and its length can be adjusted by varying the amount of power (electrical) applied to the arc electrodes (means for doing this is not illustrated, as such means are well known). In any given apparatus embodying this invention, I find that the distance to which or from which a signal or message can be sent or received depends upon the length and intensity of the beam forming the aerial or antennæ as well as upon the energy (or amplitude) of the electrical oscillations impressed upon the beam from the local circuit when my apparatus is being used as a transmitter or upon the intensity of the received oscillations when acting as a receiver. Hence it is possible to adjust either the power applied to the arc 5, or the power of the electrical oscillations being impressed upon the beam or the condition of the beam (as regards modulation) or any or all in order to transmit most economically. When it is desired to transmit short distances not only the power behind the electrical oscillations but also the power applied to the arc can be materially reduced.

The adjustment of the polarizer, I find, enables me to secure optimum conditions of the beam for optimum transmission or reception for each wave length used. In transmitting or receiving it is preferable to tune the local circuit to the desired wave length in the usual manner by the adjustment of the inductances and capacities of the circuit and also to adjust the polarizer (plates 15, 15^a) and the position of the terminal 23 until the optimum or maximum signal is heard either in the local telephones when the device is being used as a receiver, or as indicated by suitable transmitting indicating devices or instruments, such as a thermocouple or hotwire type ammeter, when used as a transmitter.

While I do not know the ultimate causes of the results obtained by the adjustment of the polarizer (the relative movement of the plates 15, 15^a) and I do not wish to be bound by the theory of operation proposed, yet I believe that the results obtained by such adjustment vary the degree or nature of the polarization of the light ray or beam and the amount of or character of modulation of the ray which must be adjusted according to varying atmospheric or meteorological conditions due, for instance, to sunlight and the resulting ionization of the air around the beam due to the sunlight. In other words this adjustment enables the beam to efficiently carry and radiate and receive electrical oscillations of different wave lengths under different atmospheric conditions.

The adjustment of the terminal 23 along the beam varies the effective length of the beam and hence adjusts the beam for effectively transmitting or receiving oscillations of different wave lengths. Irrespective of the ultimate reasons or theories of operation of these adjustable devices, I find that by adjusting either one or the other, or both of them the apparatus may be adjusted to send or receive a maximum optimum signal observable in the telephones or indicating or measuring instruments. In other words the several devices must be adjusted until optimum results are obtained, as noted in the telephone ear pieces or by such measuring or indicating instruments.

In the use of the apparatus the beam of light is generated or formed and directed into space with the required intensity as above explained. It is then passed through the polarizing plates 15, 15^a these plates being adjustable as above described. Such a beam is electrically conductive, especially of radio frequency oscillations, and such oscillations are then impressed upon the beam or directed along the path of the beam, either through terminal 23 in transmitting or by the action of the electromagnetic waves in space, when receiving, which are transferred through the the terminal 23 to the receiver, the terminal 23 being adjustable.

I claim:—

1. The hereindescribed method which consists in forming a beam of light, polarizing said beam, projecting it into space, and conducting electricity along said beam.

2. The hereindescribed method which consists in forming a ray of light in which the waves at the infra red end of the spectrum predominate, polarizing said ray and imposing electrical oscillations upon said ray.

3. Radio apparatus comprising means for forming a light ray, a polarizer in the path of the ray and a terminal arranged in the path of the ray for connecting said ray in an electric circuit.

4. Radio apparatus comprising means for generating a light ray, spaced plates of light polarizing material arranged in the path of the ray, and a terminal arranged in the path of the ray in front of said plates for connecting said ray in an electric circuit, such terminal being of a form which will allow of the passage therethrough of the ray of light.

5. Radio apparatus comprising means for generating light and projecting it as a beam, a polarizer arranged in the path of said beam and comprising relatively movable plates, means for moving said plates towards and away from each other and a circuit comprising a terminal arranged in the path of said beam in front of said polarizer and movable along said beam to position it at different points, such terminal being of a form which will allow of the passage therethrough of the beam of light.

6. Radio apparatus comprising an insulated projector having an arc chamber and means for ventilating it, spaced plates of Iceland spar arranged in said projector transversely of the projected beam of light, a glass embedded metal terminal arranged transversely of the beam in front of said plates and adapted to be connected to a circuit, such terminal being of a form which will allow of the passage therethrough of the beam of light, and means for causing said beam

to be of substantially one wave-length light.

7. Radio apparatus comprising an insulated projector having a source of light and means for reflecting it forwardly in the form of a beam, a polarizer in the path of the beam and comprising spaced plates of Iceland spar one of which is treated to prevent the projection of the ultra violet rays, a glass embedded metal terminal arranged in the path of said beam in front of said polarizer and adapted to be connected in a circuit, such terminal being of a form which will allow of the passage therethrough of the beam of light and means for adjusting said polarizer and said terminal.

In testimony whereof I affix my signature.

ELMER M. RAVE.