rection of Mr. Milan Nedelkovitch, has recently issued the first five numbers, January to May, 1902, inclusive, of the Bulletin Mensuel de l'Observatoire de Belgrade, which, with the Annales, to be published at the close of 1902, will constitute the regular publications of the observatory.

From the introduction to the first number of the Bulletin Mensuel and the circular letter accompanying it, we learn that the Annales will contain, in addition to the record of the work for the year, full information regarding the Observatory of Belgrade and its system of meteorological stations, including the history of the meteorological service.

The present meteorological service of Servia appears from the Bulletin Mensuel to have had its beginning in an observatory of a somewhat provisional nature establised in Belgrade in 1887 by its present director, in connection with the chair of astronomy and meteorology of the faculty of sciences. The modest appropriation of but $400 per year sufficed for its maintenance at that time. This observatory has passed through certain crises which greatly retarded its growth. However, governmental recognition was at length received in 1889, and authority granted by the state for the organization of a system of meteorological stations of the second order. In the succeeding years, stations of the third and fourth order were added.

In May, 1891, the Central Observatory of Belgrade was established as the permanent successor of the provisional institution. It occupies a building especially constructed for it, near its temporary predecessor, in a large park of more than 2 hectares (about 5 acres) in the southwestern part of the city.

The work of the Servian Meteorological Service unfortunately suffered a serious interruption for several years through the illness of its director. At the present time, the personnel of the service is: A director, a chief assistant, two subassistants, three observers, six computers, and one telegraph operator. The stations are in number: 18 of the second order (4 of which are equipped with self-registering barometers, thermometers, and hygrometers), 44 of the third order, and 117 of the fourth order, making a total of 179 stations. The ordinary annual appropriation from the state is about $5600 for all expenses. It is interesting to note that in many, if not all places, the instructors in the primary schools and the employees in the grape nurseries act as meteorological observers and without extra compensation.

The Bulletin Mensuel is a valuable addition to climatological and meteorological records and to the increasing literature on those subjects.

AN EXPLANATION OF WIRELESS TELEGRAPHY.

By ALFRED H. THIESSEN, Local Forecast Official, dated December 24, 1902.

In this article wireless telegraphy means that method of telegraphy which has been recently built up from the researches of Maxwell and Hertz. In this kind of telegraphy a sending station is equipped with an apparatus for generating and transmitting electric waves and a receiving station is equipped with apparatus which will enable it to detect these waves. The phenomenon to be considered then has to do primarily with wave motion. *The essential feature of wave motion is that the disturbance in the medium is communicated from one part to adjacent parts periodically.* There is no actual transference of matter or of the medium, but of energy. To illustrate this last: Throw a chip on water agitated by waves; it will be observed that the chip will stay in one position while wave upon wave rolls under it. Thus, it is seen that it is the condition that is being promulgated and not the medium through which the transference of energy is effected.

A stone thrown into still water causes ripples that succeed each other in expanding circles; this succession of ripples constitutes a wave motion. When the clapper strikes the lip of a bell it starts the lip into vibrations which in turn cause waves in the air. In the first example the medium communicating the ripples or waves is the water; in the last example the medium is the air. When a lamp is lit, light radiates from it in all directions in a wave motion. Light is transmitted through space by means of some rarer medium, which is called the æther, and this is also the medium which transmits electric waves. This æther evidently fills all space and the interstices of all kinds of matter, but its physical properties are made known by reasoning upon the phenomena of light and electricity.

It is necessary to presuppose the existence of some such medium; for when energy is transmitted with finite velocity we can think of its transference in only two ways; first, by the actual transference of matter, as when a ball is thrown through the air; secondly, by the propagation of energy from point to point through a medium which fills the space between the two bodies. The body sending out energy disturbs the medium contiguous to it, which disturbance is communicated to adjacent parts of the medium, and so the movement is propagated outward from the sending body through the medium until some other body is affected.

When we say that energy is transmitted in a wave motion, then we predicate certain characteristics of the phenomenon. For instance, we know from observing wave motion in water that the wave may be reflected; also that when a crest meets a trough the phenomenon of interference occurs, and a calm results. It is so with sound, light, and heat; they may be reflected and refracted, and the phenomenon of interference may also be observed in each. We now know that there is an intimate relation between electricity and light; indeed, waves of electricity are of the nature of light waves, differing primarily as to wave length and frequency. Electric waves are propagated through the same æther as light waves and can be reflected, refracted, and be made to interfere with each other just as light waves do.

The simplest example of wave motion which is accessible for study is the pendulum. The pendulum, in fig. 1, when at rest assumes position a, but when set in motion it oscillates between positions b and c. When the arc of oscillation is small we have a close approximation to a simple harmonic motion which is the simplest form of wave motion. To show this motion graphically suppose that x, in fig. 2, moves around the circumference of a circle with uniform velocity, and that the line xy always remains perpendicular to the fixed line bc, then the movement of the intersection of xy with bc represents the motion of a pendulum or any other vibrating body having simple harmonic motion. Referring again to fig. 1, suppose the pen-

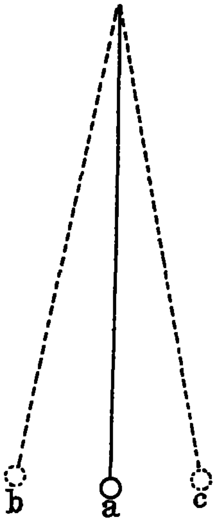

FIG. 1.

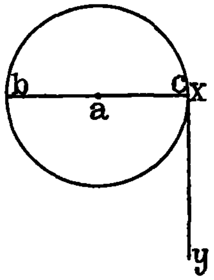

FIG. 2.

dulum bob is displaced to position *b* and set swinging, every time that it assumes the position *b* or *c* it is momentarily at rest; its motion or lack of motion in these positions corresponds to the motion of the intersections of *xy* with the line *bc* at the points *b* or *c* in fig. 2; for when *xy* is perpendicular to *bc* at *b* or *c* then the point of intersection is at rest momentarily; the moment of greatest velocity is at *a*, figs. 1 and 2. When the pendulum, fig. 1, makes a complete excursion *c* to *b* and back again to *c*, or in general when *x*, in fig. 2, makes a complete revolution, the time consumed is said to be the period of the vibrating body or particle. The number of vibrations occurring in a second of time is called the frequency; the greatest displacement of the pendulum from its position of rest is its amplitude.

It is commonly observed that a vibrating body sets up vibrations in another body, as for instance when one tuning fork responds to the vibrations of another when the tuning forks have the same note, or are in tune. The transmission of messages by wireless telegraphy is effected in much the same way. The apparatus at the sending station sends out waves of a certain period through the æther, and these waves are detected at the receiving station by apparatus attuned to this wave length or period.

To show how the vibrations of one body may set up vibrations in another at a distance, a simple apparatus will be described which the reader may readily set up for his own study. In fig. 3 *ab* and *cd* are two pendulums of exactly the same dimensions, about four feet is a convenient length; *ac* is a light stick of wood fastened to the top of a door frame by the cords *ma* and *nc*, each about three inches long. Bring both pendulums to rest. Suppose *ab* is the sending station. Start *ab* vibrating by giving it an impulse with the hand; *cd*, the receiving station, will then be seen to take up these vibrations. The medium in the above instance, transmitting the impulse, is the stick *ac*.

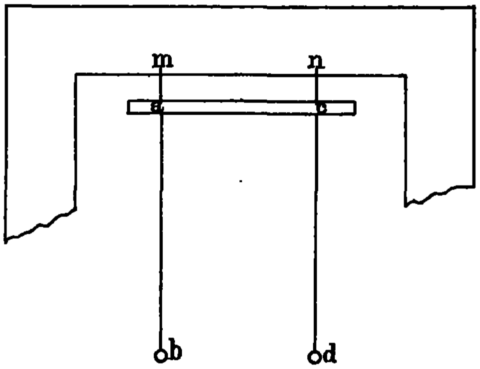

FIG. 3.

If a sound wave is started by disturbing the equilibrium of a sounding body as, for instance, when a guitar string is struck; then the resulting vibration of the string of the guitar agitates the air, this agitation or disturbance is passed on from one portion of the medium to the adjacent portion and so on until the disturbance reaches the ear drum. In general, in order to produce sound, the equilibrium of a sounding body must be disturbed, this in turn disturbs the equilibrium of the air which is the medium that transmits the energy to the drum of the ear.

In an analogous way electric waves are produced. Let *A*, fig. 4, be an insulated plate of some conducting material. Charge it with electricity by connecting it with some electrical machine. Now if another plate, *B*, figs. 5 and 6, which may or may not be connected to the ground, is made to approach *A*, then the intensity of the charge on *A* is increased, and *B* is oppositely charged, that is, if *A* is positively charged then *B* is negatively charged. An instrument in this form is called a capacity or plate condenser; it determines the capacity and is briefly called *the capacity*. If a plate of glass, *G*, in fig. 7, is placed between these two plates then the intensity of the charge is increased. Instead of the plate condenser, as shown in fig. 7, a form which is convenient is shown in fig. 8. It consists of a wide-necked bottle or jar, coated inside and out with tinfoil to within a few inches of the top. This form of condenser is called a Leyden jar, and may be charged the same as the plate condenser, by connecting one coating to an electrical machine and the other to the ground. The jar may be discharged by connecting both coatings with a piece of wire, as shown in fig. 9. *H* is a handle made of some insulating material to save the experimenter from a shock.

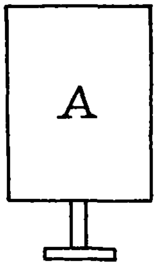

FIG. 4.

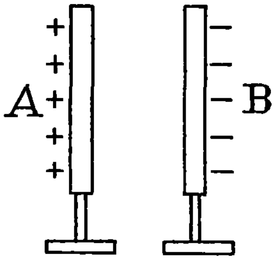

FIG. 5.

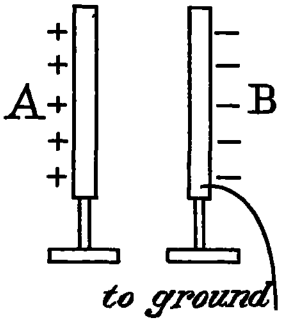

FIG. 6.

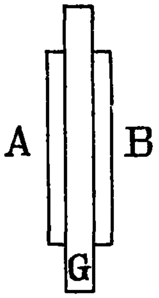

FIG. 7.

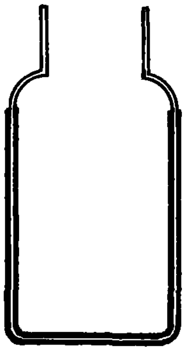

FIG. 8.

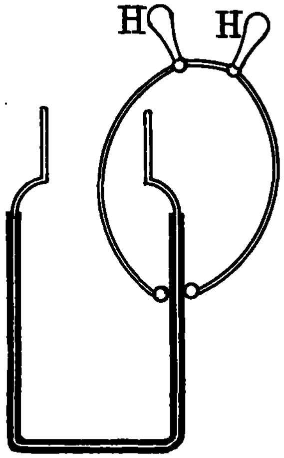

FIG. 9.

The discharge of the jar is oscillatory in character; that is there is no simple union of negative and positive electricity. What occurs is that the positive electricity rushes to the negatively charged coating and the negative electricity rushes to the positively charged coating, and these reversals rapidly follow one another, the intensity becoming less and less at each reversal, until finally electrical rest is reached, just as the amplitude of a pendulum at each swing becomes less and less until it attains mechanical rest. The oscillations in the jar are damped or gradually lessened on account of the electrical resistance in the circuit; the vibrations of the pendulum are also damped on account of the resistance to its motion by the friction at the point of suspension and the resistance of the air.

Since the discharge of the Leyden jar is vibratory, it has a certain time limit of vibration, that is, a definite periodicity called the tune, depending on the electrical constants of its circuit just as the periodicity of a guitar string depends upon its mechanical constants.

If T be the time of vibration of a stretched string, then:

$$T = 2rl\sqrt{\frac{\pi d}{tg}} \qquad (1)$$

where, r = radius of string.
l = length of string.
π = ratio of circumference to the diameter of a circle = 3.14159.
d = density of string.
t = tension or pull that stretches the string.
g = acceleration of gravity.

In the case of a Leyden jar the length of time required for an electrical vibration depends on three electrical constants of its circuit: First, resistance or that which resists the flow of the current and which depends on the dimensions and material of the conductor; it is more accurately defined as the ratio of the electro-motive force, namely, the force which causes the current, to the strength of the current; secondly, capacity, namely, that quality of a conductor by which it may accumulate electricity when in connection with an electric machine; thirdly, inductance or self-induction of the circuit; that is, when a current flows along a circuit, it sets up a magnectic field in the surrounding medium, which field generates an electro-motive force opposing the current; this is inductance and increases with the number of reversals of the current per second.

If T is the period of vibration in an electrical circuit, then:

$$T = 2\pi\sqrt{LS}. \qquad (2)$$

Where L is self-induction and S is the capacity. In this approximate equation the resistance has been omitted because in wireless telegraphy it is small compared to the capacity and and self-induction, and therefore is negligible. The capacity has its mechanical analogue in the reciprocal of the tension of the string, and the self-induction in the inertia of the string. By referring to equation (1) we see that to increase the period of the string, we may increase r, l, and d and so add to the inertia of the string, which is analogous to increasing L or self-induction in equation (2). Again we may increase the period of the string by increasing the reciprocal of the tension, t, which is analogous to increasing the capacity, or S in the equation (2). It is thus seen that by suitably varying the electrical constants the tune of an electrical circuit may be changed at will.

As the discharge of the Leyden jar is oscillatory, it may be compared to the vibrations of any body capable of oscillating, as to a guitar string for example.

When the guitar string is drawn to one side it is equivalent to charging the jar; letting it go, to discharging the jar. The string alternately assumes positions on either side of its position of equilibrium, just as the opposite coatings of the jar alternately become oppositely charged.

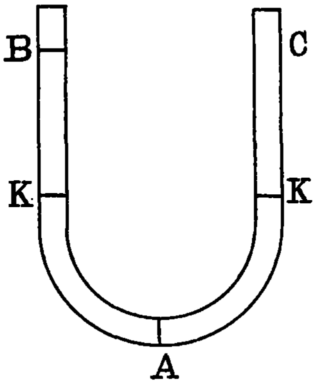

Fig. 10.

The diagram of another mechanical analogy is shown in fig. 10. BAC is a U-shaped tube with a stopcock at A. Close the stopcock, pour in water at one end, and let its level be at B; this may be likened to charging the jar. The B end of the tube may be considered the positively charged coating and the C end of the tube the negatively charged coating. Open the stopcock A, this may be likened to discharging the jar, and the water will flow into the C end of the tube; it will not at first assume equal levels in both legs of the U, but the inertia of the water will cause it to flow past K, the position of rest, and tend to fill up the C leg of the tube and empty the B leg. It will soon stop and flow back again. These reversals will continue until the friction of the walls of the tube, the internal friction of the water, and the resistance offered by the air in the tube cause the water to finally come to rest just as the pendulum comes to rest.

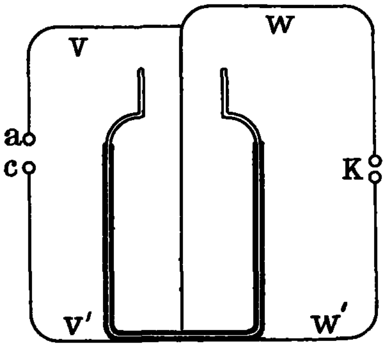

Fig. 11.—Transmitter.

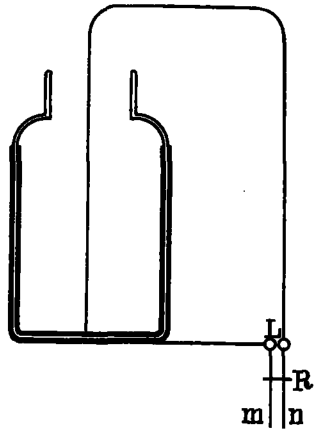

Fig. 12.—Receiver.

Now if the discharge of a Leyden jar be made through the wires W W' and the short spark gap K, as in fig. 11, then electric waves will be emitted to the surrounding medium. To the terminals a and c of other wires V V' may be connected an electrical machine for charging the jar, this constitutes a transmitter. If another jar with dimensions similar to those of the transmitter, fig. 12, be placed near, this constitutes a receiver; then the waves sent out by the transmitter may be detected by observing the sparks as they jump across spark gap L. This is a system devised by Lodge and one in which it is very necessary to obtain accurate tuning. Tuning may be obtained by sliding the short bit of wire on the so-called rider, R, along the conductors m and n. A change in position of R changes the time or value of T in equation (2).

The electrical machine used in producing the spark in wireless telegraphy and attached to the terminals ac, fig. 11, is called a Ruhmkorff or induction coil. It is shown schematically in fig. 13. M is a large piece of cylindrical iron or a bundle of iron wires called the core. On M is coiled a layer of thick wire of only a few turns in all. This wire is called the primary coil. It is connected in series with the battery B, a key K, and a vibrator V. V consists of a steel spring clamped at R with a small magnet m at its free end, which magnet is directly opposite the large iron core M. A coil of fine wire consisting of many turns is coiled around the primary, and is called the secondary coil; it has its terminals at a and c. When the key K is depressed the current from the battery causes M to become a magnet and attracts m, this breaks the circuit at p

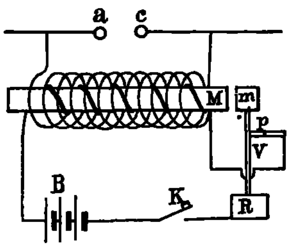

Fig. 13.

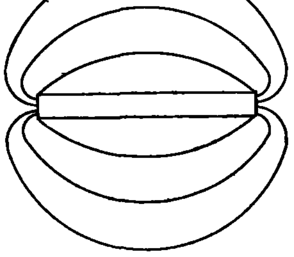

Fig. 14.

and the vibrator springs back to again make a contact, and so the breaking and making the circuit at *p* continues as long as the key is depressed. When the current is made then *M* becomes a magnet and a magnetic field is set up in its neighborhood, whose lines of force have the form shown in cross section in fig. 14.[1] When the current is made a magnetic field builds up around the core, and when the current is broken the field collapses. Every time the magnetic field is built up or is broken down, a current is induced in the secondary coil. This is why the primary current must be constantly interrupted at *p* by the vibrator. At each alternate make and break of the primary current, the current induced in the secondary coil is reversed. The potential is very large at the terminals *ac* of the secondary, and is larger than the potential in the primary in proportion as the number of turns in the secondary is larger than the number of turns in the primary.

In fig. 15 is shown diagrammatically the induction coil as it will be exhibited in the figures following. *S* is the secondary, *P* the primary, *B* the battery, *V* the vibrator or interrupter, and *K* the key.

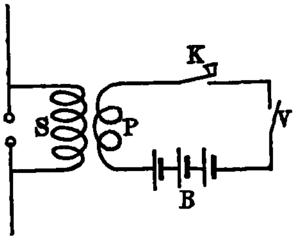

FIG. 15.

Instead of a Leyden jar referred to in fig. 11 let there be substituted two spheres *S* and *T* sliding on rods, as in fig. 16, and let the two rods be connected to the terminals of the secondary circuit of an induction coil. When the spheres are charged above the sparking potential of the air gap then sparking occurs and electric waves are sent out. The spheres are as the two coatings of a Leyden jar or as the plates of condenser shown in fig. 5. In the present case they are separated by air instead of by glass. The Leyden jar in this form is capable of having its capacity altered by sliding the spheres along the rods, the nearer they are together the greater the capacity, and the farther apart they are the smaller the capacity, and thus the electrical tune may be changed. This style of transmitter is called a Hertz oscillator.

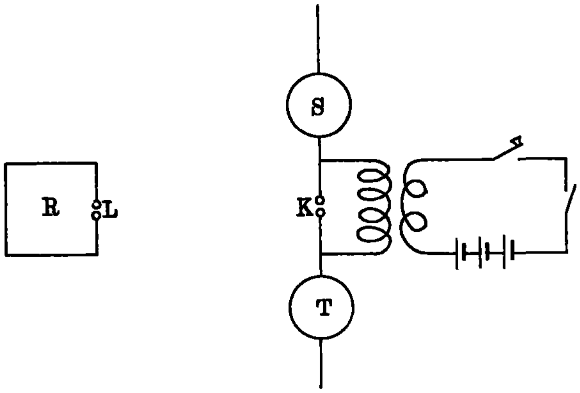

FIG. 16.

Hertz received the waves by the simplest kind of a receiver, as shown at the left of fig. 16; it consisted of a piece of wire bent into a square or circle. When sparking takes place at *K*, sparking will also occur at *L*, provided the spheres are properly adjusted so as to be electrically in tune with *R*. In actual practise the spark gap is 2 millimeters. The receiver was placed about 30 centimeters or more from the sending system. The more sensitive the receiver the farther could it be placed from the sender and still receive signals.

For the sphere *S*, in fig. 16, substitute a vertical wire; for the sphere *T* substitute the ground; that is to say, connect one secondary terminal to a large plate of copper in the ground; we shall then have the simplest form of sending system as used in commercial wireless telegraphy to-day, see fig. 17. The vertical wire applied to both sending and receiving apparatus is one of Marconi's great improvements.

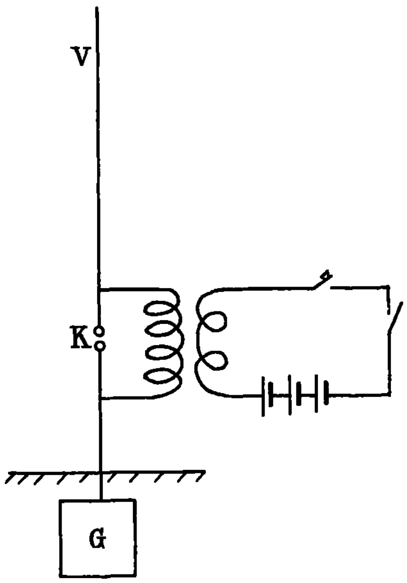

FIG. 17.—The transmitter.

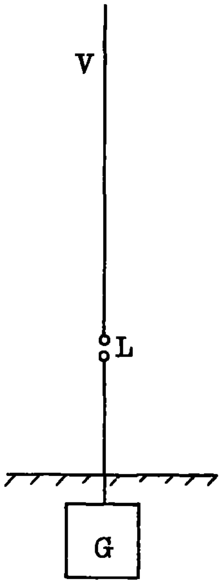

FIG. 18.—The receiver.

The simplest form of the receiving system is shown in fig. 18. *V* is the vertical wire, *G* the ground, and *L* the spark gap. When a wave is sent out from the sending station, as in fig. 17, sparking will take place at *L*, at the receiving station, fig. 18, if the intensity of the wave on arrival at the receiver is great enough to produce a spark that will jump over this small gap. In the ring receiver of Hertz the experimenter relies on his sight to detect the minute sparks which jump across the spark gap *L*. It is evident that with the same sending apparatus, but a more sensitive detector of the waves greater distances could be signaled over.

FIG. 19.—The coherer.

The coherer has been found to be quite a sensitive form of detector. It is shown full size in fig. 19. It consists of a glass or rubber tube with a bore of about one-eighth of an inch in diameter. Fitted very snugly in the tube are two plugs, *PP*, preferably of silver or platinum, about one sixteenth of an inch apart, leading out from which are two wires, *TT*. The space between the two plugs contains metallic filings; almost any metal will give results.

In fig. 20 is represented a receiving system showing the manner of inserting and connecting the coherer. The vertical wire *V* from a tall mast is connected to one terminal T_1 of the coherer, while the other terminal T_2 is connected to the ground; that is to say the spark gap *L*, in fig. 18, is replaced by the coherer. The terminals T_1 and T_2 are also connected to a sensitive relay, *R*, through a cell, B_1. The filings, when lying loosely between the plugs, have an infinite or very high resistance, the resistance depending on how tightly they are packed, so that by adjusting the plugs *PP* the resistance can be chosen so high that the cell B_1 can not work the relay *R*. Now, when an electric wave strikes the vertical wire *V* an oscillatory current is set up in this wire through the coherer to

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[1] See any text-book on physics.

the ground *G;* this current lowers the resistance in the coherer and thus permits the cell B_1 to work the relay *R.* The resistance of the filings in the coherer remains low even after the sparking at the sending end ceases, but it may be brought back to its original state of high resistance by simply tapping the coherer, and this is what is done in actual practise by the magnetic tapper m_1, which strikes the coherer tube from underneath, and so restores the filings to the original state of high resistance. This tapper is driven by the battery B_2, which works whenever the relay *R* brings its armature down so as to complete the connection at *A.* The relay *R* may also be made to work an ordinary telegraphic sounder or a Morse recording instrument, so that signals may be received either by sound or by written dots and dashes. In order to send signals the key (*K*, fig. 13) of the induction coil is depressed a very short time for the length of a dot and a little longer for a dash.

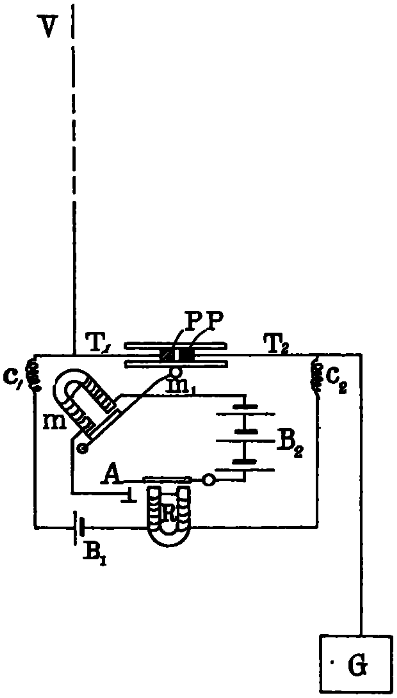


FIG. 20.—The receiver with coherer.

TUNING.

When the operator presses the key *K* in fig. 13, the vibrator of the induction coil begins to make and break the primary circuit rapidly. Each make or break starts oscillations in the secondary circuit which may be considered as dying out rapidly. These oscillations run up and down the vertical wire and from it analogous waves spread to the æther. These waves are shown in fig. 21 at $a\ b\ c\ d$ . . . ., $a'\ b'\ c'\ d'$ . . . ., $a''\ b''\ c''\ d''$ . . . . The distance apart of a, a', a'' corresponds to the intervals between the makes and breaks of the vibrator, while the time period of the electrical oscillations $a\ b\ c\ d$ . . . ., etc., within the vertical wire are of the order of a millionth of a second.

The waves sent by such a transmitter, as shown in fig. 17, are exhibited graphically in fig. 21.

Let time be measured on line *OT* and the intensity of the wave transmitted on the line *OI.* The ordinates of a, a', a'' show the intensity of the oscillations at each successive make and break of the induction coil. It is seen that within four or five oscillations the intensity rapidly dies out and become inappreciable long before the vibrator can make another make or break, especially if the vibrator of the induction coil makes only a few vibrations per second. These vibrations die out rapidly because of the high resistance of the spark gap and the small capacity of the vertical wire, and also because a vertical wire is a good radiator and gives up its energy freely.

The corresponding vibrations set up in the receiving system, fig. 20, are shown in fig. 22. The scale of time is the same as in fig. 21, but the scale of intensity is increased many times in order to show the minute waves as they arrive at the receiving station. The vibrations in the receiving system also die out rapidly, and electrical rest is attained long before the waves sent out by the next break or make at the sending end can reach the receiving end.

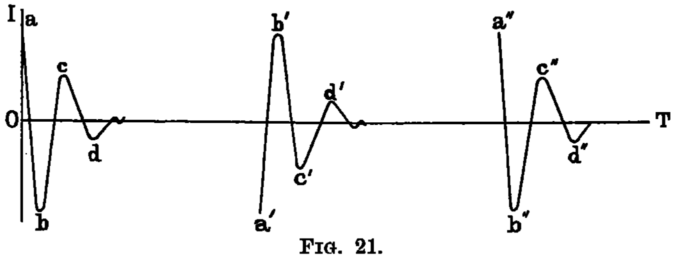


FIG. 21.

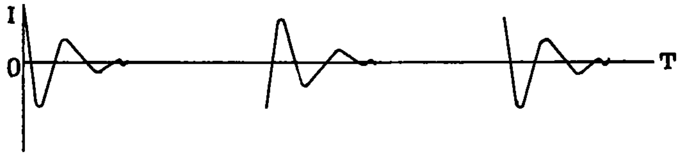


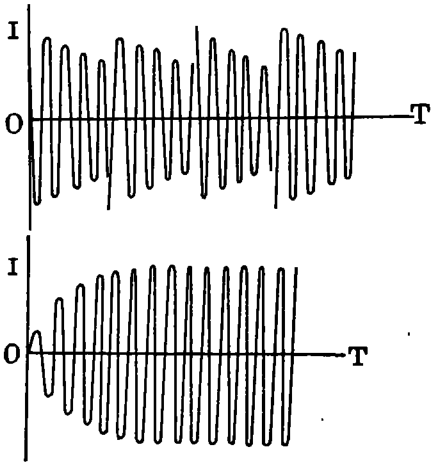
FIG. 22.

The systems just described are called "rapidly damped systems," that is to say, their oscillations die out very quickly. The mechanical analogue is a bell with a finger placed on its lip; when hit with a clapper the bell gives a large initial vibration, but the subsequent ones are feeble. It may be compared to a pendulum swung in a liquid.

It may now be seen that with this kind of a system it is not necessary to have accurate tuning, for by tuning is meant that the natural oscillations of the sending wire be the same as those of the receiving wire so that the oscillations of the latter may be strengthened, before they die out, by rapidly succeeding impulses sent out by the former. By a tuned sending and receiving system is also meant a system the receiver of which will not respond to waves of some other frequency, and the sender of which will not cause a receiver of different tune to respond.

To have accurate tuning one must employ a sending system which is a persistent oscillator, and also a very rapid break and make device so that the trains of waves succeed each other very rapidly. The receiving system must also be a persistent oscillator so that before the oscillations set up in it by a preceeding train of waves die out, they may be increased by the succeeding trains of waves.

The conditions of oscillations to be satisfied in a tuned system are shown graphically in the following figures:



FIGS. 23 and 24.

Fig. 23 represents the vibrations in the transmitting system and the waves sent out will have, of course, the same character. It is seen that before the oscillations completely die out another impulse is given, and that the several trains of waves succeed each other rapidly.

Fig. 24 represents the vibrations induced in the receiving system, it shows the additive effect of all the separate waves which build up the oscillations in the receiving system until they finally break down the resistance in the coherer and a signal is heard.

In fig. 11 the transmitter has persistent oscillations, and it is therefore one adapted for a tuned system, but it is a feeble radiator. In fig. 17 the system shown is a good radiator, but is almost "dead beat"; that is, very rapidly damped. If wires, *V* and *U*, be bent and connected up to a condenser, as shown in fig. 25, it forms a persistent oscillator but a feeble radiator, and is of exactly the same construction as shown in fig. 11. As this construction is a feeble radiator, then a similar construction at the receiving station would also be a feeble absorber, and the system would not be adapted for long distances.

If near the rectangle *VU*, fig. 25, a vertical wire be placed, as in fig. 26, the oscillations of that system would be induced in the vertical wire and then the desirable features of both methods would be combined. To further improve this a Tesla coil may be used by connecting the terminals of its secondary *S* to vertical and to ground, and inserting its primary *P* in the closed condenser circuit, as shown in fig. 27. It is understood that the turns of *S* are wound around *P*, just as the secondary of an induction coil is wound around its primary, and that the Tesla coil is a kind of transformer.

It is necessary to have the two circuits in tune; that is to say, the oscillations in the system vertical—*S*—ground must harmonize with oscillations in the closed condenser circuit *P-D-U-V*.

To tune these two systems a construction somewhat the same as that shown in fig. 28 is used by Signor Marconi. It was shown above that to alter the tune of an electrical circuit either the capacity or self-induction or both must be changed. To this end, a capacity *C* and a few turns of wire terminate the vertical wire. One terminal of the secondary of the Tesla coil may be moved up and down cutting in or out as many turns as is necessary to sufficiently alter self-induction; the capacity *C* is also made variable. The tune of the closed circuit may be changed by altering the variable capacity *D* of its circuit.

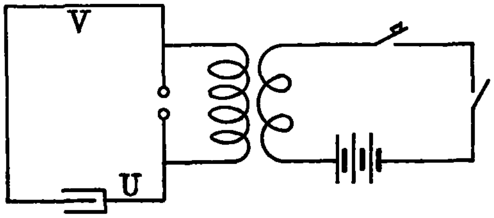


Fig. 25.

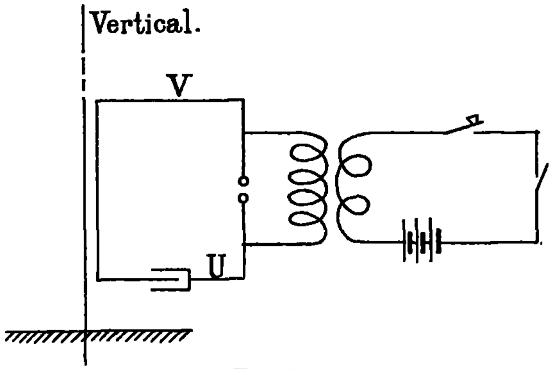


Fig. 26.

In fig. 29 the connections for the receiving apparatus are shown. The vertical *V* is terminated with a few turns of wire so that its induction may be changed. It is connected to one terminal of a transformer, *T* the other terminal of the primary *P* being grounded. The terminals of the secondary *SS* are connected to terminals of the coherer which has a variable capacity *D*, which is connected in parallel to the coherer. Any inductance or capacity may be added to the terminals *a* and *b* of the secondary coil. It is seen that a receiving system similar in construction to the sending system in fig. 27 is given. It is a good absorber, a persistent oscillator, and capable of having its tune altered at will.

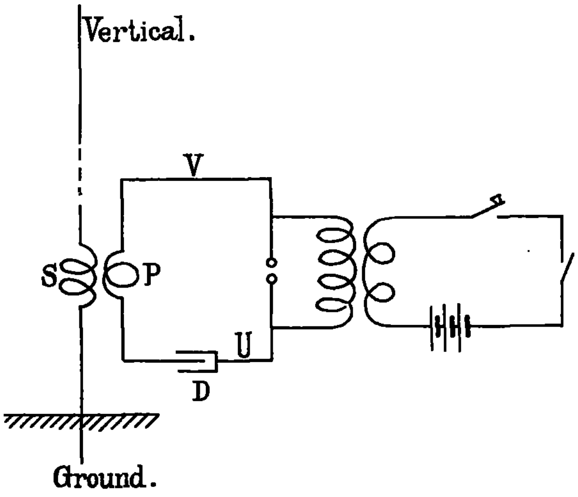


Fig. 27.

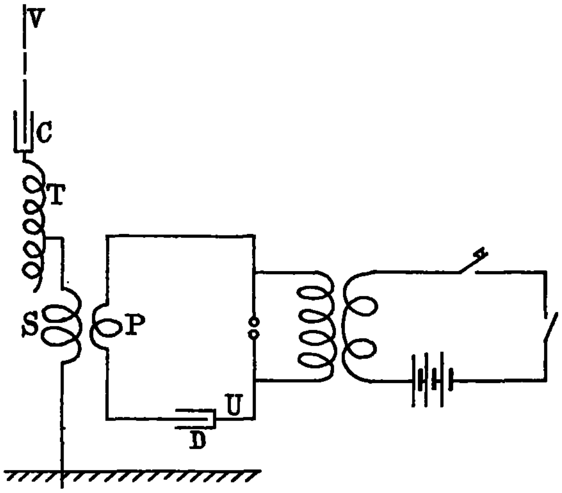


Fig. 28.

A duplex system may be arranged with the system just described by connecting differently tuned transmitters to verticals through different inductances at the sending station; and by connecting a suitably tuned receiver the same way to the receiving vertical. The connections for the transmitter are shown in fig. 30.

In general we may speak of two kinds of telegraphic systems; namely, tuned and untuned.

It is evident that with a perfectly tuned system of transmitters and receivers the number of stations may be multiplied and placed at will, connecting points far and near.

A system that is not arranged for tuning is called an open system, as in fig. 17, and with such an open system, the selection of stations can not be done arbitrarily. To illustrate: Suppose we wish to connect two points *A* and *B*, fig. 31. Set up instruments of the open system at each point; assume that the waves sent out after having traveled a distance *A B* are just strong enough to work the receiving instruments. Now circumscribe both stations with circles having a radius equal to the distance *A B*. It may be seen that no other two independent stations can be worked within these two circles without confusion unless they have receivers which can not be affected by the feeble waves from *A* and *B*. For example; two independent stations may be erected at *C* and *D* with less sensitive receivers and weaker transmitters than those at *A* and *B*. The waves sent out by the transmitters at *A* or *B* can not affect the less sensitive receiver at *C* and *D*, and the waves sent out by less powerful transmitters at *C* and *D* will affect receivers at these points, but on arrival at *A* and *B* they will be so weak that the receivers at these points will not be affected. Thus, stations properly placed, with instruments properly selected as to power and sensitiveness, may be worked "open" simultaneously and without confusion.

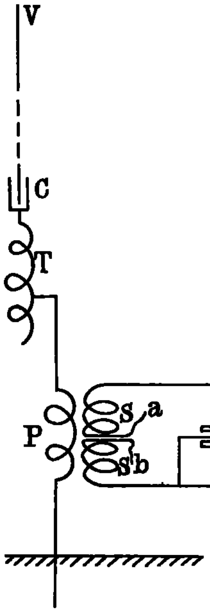


FIG. 29.

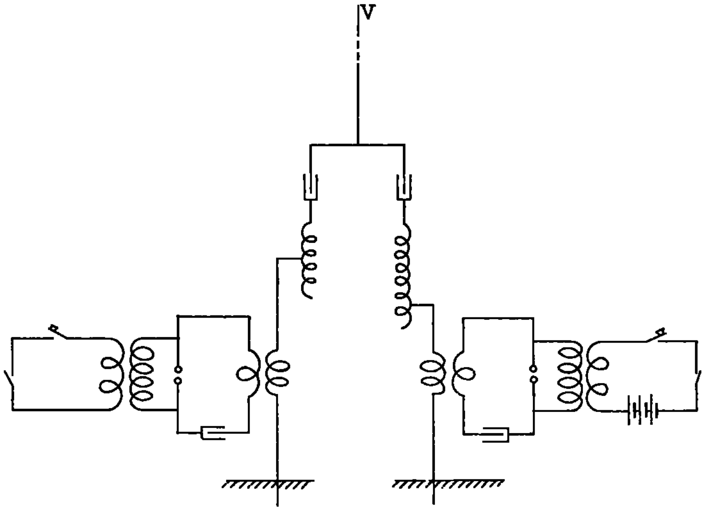


FIG. 30.

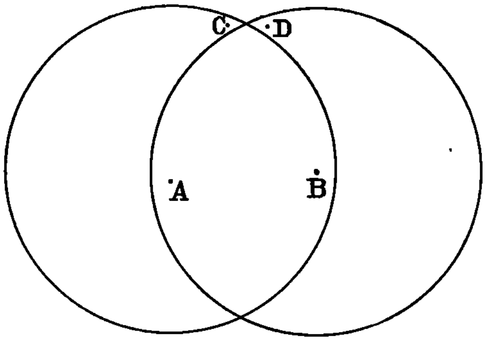


FIG. 31.

RADIOACTIVITY OF FRESHLY FALLEN SNOW.[1]

By S. J. ALLAN, M. Sc., dated McGill University, Montreal, January 27, 1903.

C. T. R. Wilson has shown that freshly fallen rain is radioactive, decaying with time. The author was led to believe that snow freshly fallen would also show this property. So during the first snowstorm a quantity of snow was gathered from a thin layer on the surface. This was then quickly evaporated down to dryness in a shallow tin vessel. This vessel which before filling with snow was tested and found to contain no trace of radioactivity, was now quite radioactive and was able to ionize the air in its immediate vicinity quite readily.

The apparatus used to test the presence of radioactivity consisted of two parallel zinc plates, insulated, a certain distance apart. The upper one was connected to one pair of quadrants of a sensitive electrometer, the other pair being earthed. This electrometer, when the needle was charged to 300 volts potential, gave about 500 divisions per volt, the distance between scale and mirror being about two meters. The lower plate was connected to one pole of a battery of accumulators, from which any voltage up to 300 could be taken. The other pole of the battery was earthed. The radioactive vessel was placed on this lower plate. There was always a slight ionization in the apparatus due to the natural ionization of air. As this only amounted to one-tenth of a division per second any increase could easily be detected. The ionization current as shown by the rate of movement of the electrometer gave a measure of the radioactivity present on the tin vessel. A standard specimen of uranium was kept as a means of standardizing the apparatus.

A great many tests were made extending over about six weeks and taking in four or five snowstorms. The snow was always collected from a thin sheet on the surface so as to get that which had recently fallen. It generally took from twenty to thirty minutes to evaporate down to dryness and test, so that the radioactivity had fallen a good deal in value during that time.

Two of the best methods of distinguishing between the various types of radioactive bodies were tried, viz, the rate of decay, and the penetrating power. Numerous tests made on the rate of decay showed that this radioactivity followed very closely a geometrical progression, falling to half value in about thirty minutes. The rate of decay was never found to decay though taken on different days and under different weather conditions. Three of these results are plotted in the accompanying curves, fig. 1. Curves *a* and *b* are results taken on the same day, *a* from one liter of snow and *b* from one-half liter. The fall of snow on this day was very heavy and damp. This was the greatest amount obtained on any day. Curve *c* shows a curve taken on another day, when there was a much smaller fall of snow, and is the amount from one liter. All of these curves show that the radioactivity falls to half value in about thirty-two minutes. Curve *d* shows the rate of decay of the radioactivity produced on a copper wire charged to a high negative potential in the open air. This is plotted on the same scale for sake of comparison. This falls to half value in about forty-eight minutes. The two rates of decay are thus distinctly different.

Tests were made on the penetrating power, and it was found

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[1] Read before American Physical Society, January 3, 1903.