WIRELESS TELEGRAPHY AND TELEPHONY.*

A REVIEW OF ETHEREAL SIGNALING METHODS.

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This paper is a brief review of the art commonly known as "wireless telegraphy"; and deals with only one branch of the general subject, that is, with wireless telegraphy and wireless telephony which employ as the energy transmitted through space from the sending to the receiving station what are commonly known as "Hertzian oscillations" or "Hertzian waves," or "electro-magnetic waves," all being synonymous.

There are other systems of wireless telegraphy and telephony which will not be considered, because, so far as the author knows, they have not come into any

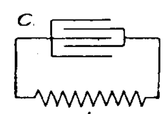

Fig. 1.

extensive commercial or general use; that is, the "earth shunt" and simple "induction" systems.

Had this paper been written ten years ago it might well have gone into greater detail than will be the case now, because at that time the art was quite restricted as compared with the present time.

Fundamentally, wireless telegraphy and telephony depend upon a wave propagation through the ether, the energy having electric and magnetic components, and with a frequency so high as compared with ordinary alternating currents as to denote the energy as "high-frequency waves or oscillation." To give an idea as to the position in the whole category of ether waves of those employed in wireless telegraphy and telephony, the following is submitted:

X-Rays—not visible to human eye; ultra-violet light; frequency 870 trillions to 1,500 trillions per second.
Light—visible to human eye; frequency 430 trillions to 740 trillions per second, less than one octave.

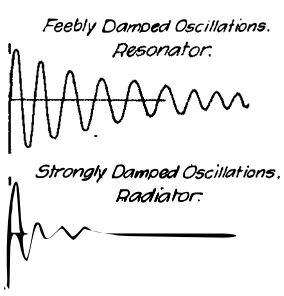

Fig. 2.

Infra red—invisible; frequency 430 trillions down to 300 trillions per second.
Heat—frequency 300 trillions down to 20 trillions per second.
Electro-magnetic waves (Hertzian waves or oscillations)—forty-five octaves lower; frequency of several millions per second down to 100,000 or less per second; used in wireless telegraphy and telephony; 300 feet (or less) to 5,000 feet (or more) in length.
Sound waves (audible to human ear)—frequency of 40,000 per second down to 32 or 16 per pound.

From this table it will be seen that the waves used in wireless telegraphy and telephony have a frequency much lower than light waves, and, indeed, far lower even than heat waves, being just above sound waves in

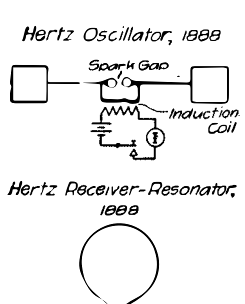

Fig. 3.

the table. And it will be understood that the frequencies under consideration range from about a million per second to one hundred thousand, or less, per second.

The earliest known way of producing high-frequency electric waves, and the way that is in common use, consists in letting loose through a sufficiently low resistance path a charge of electricity, which, when the resistance of the discharge path is sufficiently low, oscillates or swings electrically like a pendulum, there being a decrement in the amplitudes of the successive waves causing them to die out sooner or later, as a pendulum will come to rest after a time.

To consider an elemental case, refer to Fig. 1. Consider the condenser *C* connected in circuit with the inductance *L*. The condenser, as is well known, consists of two conducting plates or armatures separated by a dielectric medium, as air, gas, or what not. The inductance consists of a coil of wire, for example (preferably without iron core for high-frequency work), and is a means for lending magnetic inertia to the circuit. If the condenser *C* has been charged from any suitable source of electricity, it will discharge through the circuit containing itself and the inductance *L*. The charge will swing first one way and then the other, back and forth, at high rate, gradually dying out owing to radiation of energy from the circuit and owing to resistance and other losses in the circuit.

The frequency of the oscillations so produced is dependent upon the capacity of the condenser *C*, the magnitude of the inductance *L*, and the resistance of the circuit. The resistance of the circuit should be

Fig. 4.

made as low as possible consistent with other requirements; and when below a certain critical value oscillations take place, and when the resistance is made low, it may be disregarded as a factor in the determination of the natural frequency of the circuit.

The natural frequency of the circuit may then be expressed as follows:

$$N = \frac{1}{2\pi\sqrt{LC}}$$

N being the number of complete cycles per second, *L* the inductance, and *C* the capacity of the circuit. It is evident that *N* will be greater as either *L* or *C*, or both, is or are smaller. This shows algebraically that for high-frequency work inductances and capacities employed are quite small as compared with those used in ordinary alternating-current commercial work.

The speed or velocity of propagation of the energy of Hertzian or electro-magnetic waves through space is the same as that of light, namely, 186,000 miles per second. Knowing this, and knowing also the frequency, *N*, the wave length is easily computed from the expression

$$V = N\lambda$$

where *V* is the velocity of propagation, *N* the frequency, and λ the wave length.

The high-frequency oscillations may be graphically represented as in Fig. 2. Distances measured horizontally represent time, while those measured vertically represent amplitude or intensity. The upper part of the figure illustrates a slightly damped train of waves or oscillations, and are such as may be produced by what is termed a resonator. In the lower half of the figure is shown a train of strongly damped oscillations which die out very quickly. Such oscillations exist in a good radiator, it being characteristic of a resonator or sustained oscillator that radiation of energy into space may be slight, while in the case of strongly damped oscillations the radiation may be relatively greater; or, to put it another way, when radiation is efficient and great, the oscillations are relatively strongly damped.

In wireless telegraphy, particularly in the spark systems, good radiation is desirable, as also is persistency of the oscillations, so that we have opposed conditions to be met. Persistent oscillations make it easier for "tuning" the distant receiving apparatus, while good radiation means that the energy can penetrate to a greater distance.

Coming now to something more concrete, Fig. 3 represents the Hertz oscillator or transmitter.

Heinrich Hertz was the first to profoundly investigate the subject of high-frequency electric waves or oscillations. In 1888, or thereabout, as professor at the

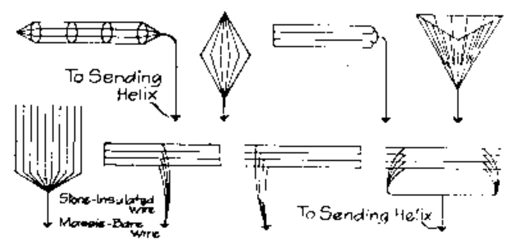

Fig. 6.

University of Bonn, in Germany, he constructed such an oscillator. It consists of two conducting plates, here shown rectangular, each connected to a ball or other spark gap terminal, the balls being separated a short distance to form the spark gap. The secondary winding of an ordinary induction or Ruhmkorff coil has its terminals connected to the spark gap terminals, while in the primary winding of the induction coil is included a battery or other source of energy, suitable interrupter, and a switch or key. The secondary of the coil delivers high-potential current, thus charging one of the capacity areas positively and the other negatively. When their potential rises sufficiently high, a spark leaps across the spark gap, forming an instantaneous circuit closer or bridge over which the electric charge oscillates or vibrates at an extremely high rate. By opening and closing the switch or key the sparking is stopped or started.

His receiver is shown in the lower portion of the figure. It is known as a resonator and consists of a loop of wire having its ends separated by a micrometer spark gap. He chose the product of the capacity and inductance of the loop to conform suitably with the product of the capacity and inductance of the separated plates and their connections in the oscillator, and upon the passage of a spark at the spark gap of the oscillator there was a passage of a minute spark at the micrometer gap of the receiver or resonator.

This was then a complete wireless telegraph apparatus, though in the form shown was not suitable for very long distance work.

Because of the form of the oscillator, having large

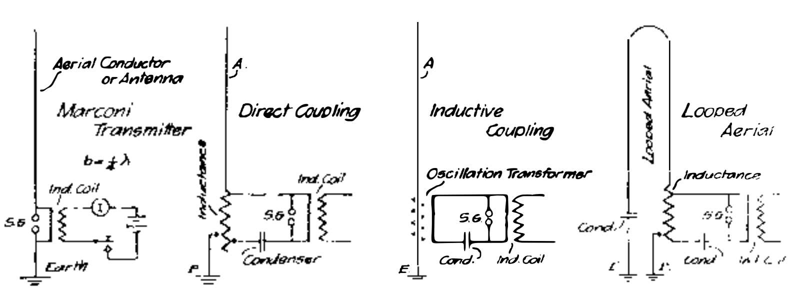

Fig. 5.

separated areas connected by a slender conductor, it has been termed the "dumbbell" oscillator.

So to speak, Hertz set his electric pendulum, the oscillator, into vibration, and his loop or resonator being in electric sympathy with it, tuned to the frequency of his pendulum, his receiver responded efficiently to the frequency of the transmitter and caused the spark at the micrometer gap.

For every impulse of high-potential current from the secondary of the induction coil there was a spark at the gap of the oscillator or transmitter, and for each of those sparks there was generated a "train" or "group" of high-frequency oscillations or waves.

This may be illustrated by Fig. 4.

To represent a "dot" in wireless telegraphy a few wave trains or wave groups succeed each other, while for a "dash" a greater number of wave trains or groups succeed each other, this being determined by the length of time the key or switch in the primary of the induction coil is held closed.

Coming now to the original Marconi transmitter, illustrated in Fig. 5, we have in the left-hand view an aerial conductor on antenna, as it is indifferently called, consisting of a wire or conductor extending upward above the earth's surface and having its lower

* Proceedings of the Engineers' Club.

end connected to a spark gap terminal, the other spark gap terminal connected to earth, the secondary of an induction coil connected to the spark gap terminals and the primary including the source of energy, key, and interrupter. You will at once see that this is precisely the Hertz oscillator of Fig. 3, the aerial conductor or antenna of Fig. 5 representing one of the capacity areas of Hertz's oscillator, while the earth is the other. Here the oscillations are produced in the aerial conductor or antenna and are radiated from it in all directions, as light from a candle. It has been found that where the oscillations are generated in the aerial conductor itself the length of the aerial conductor is equal to one-fourth the length of the wave

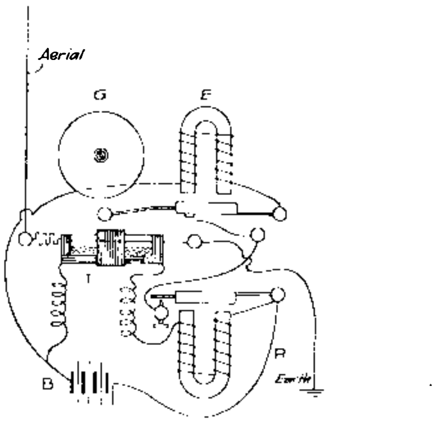

FIG. 7.

generated in it. Thus, if the aerial conductor is 150 feet long, the length of the wave generated in it and radiated from it is 600 feet. Such an aerial conductor, having relatively small inductance, is a good radiator, the oscillations being capable of dying out quite rapidly owing to the radiation of energy into the surrounding medium.

In the next to the right-hand view is shown an inductive coupling, the high-frequency oscillations being produced in a circuit including the spark gap *S G*, the condenser, and the primary of an oscillation transformer, the secondary of the oscillation transformer being connected in series between the aerial conductor and the earth. This makes a very good transmitter; the frequency of the radiated energy may be very closely determined and controlled and the oscillations are not generated or produced in the aerial conductor, but are forced thereon through the medium of the oscillation transformer. So that here the antenna does not entirely determine the frequency or wave length of the radiated energy. However, if the oscillation circuit, including the condenser, spark gap, and primary oscillation transformer, has a natural frequency which is relatively low, and the length of the antenna is far below one-quarter of the wave length corresponding to the oscillations in the condenser circuit, the antenna will not be radiating to the best advantage. This condition of affairs is often met in the matters of contract with the government where, with a given output of the current generator at the transmitter, a great range in wave lengths radiated is required. To store in the condenser the full output of the generating apparatus the condenser must be relatively large. Yet when the condenser is of relatively great capacity it reduces the frequency and, therefore, increases the wave length of the oscillations in the condenser circuit. And this, in turn, means that a given aerial conductor will be too short to efficiently radiate the low-frequency energy, while at the higher

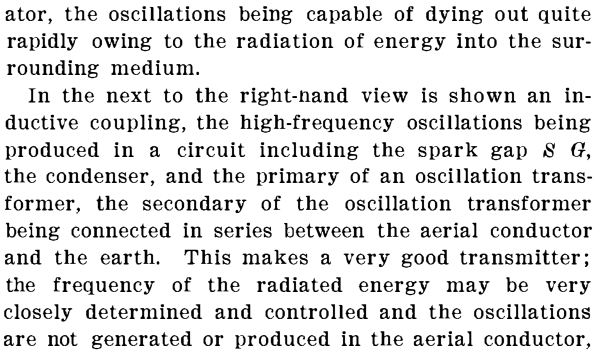

FIG. 8.

frequencies it would efficiently radiate. And if it be attempted to crowd matters by raising voltage, the antenna delivers a brush discharge, the excess energy which it cannot radiate being so dissipated into the immediately surrounding atmosphere.

In the next to the left-hand figure is shown a direct coupling with a closed oscillation circuit. Here the part of the variable inductance connected between the radiating or aerial conductor and earth is also common to the closed oscillation circuit, including the spark gap *S G* and the condenser. This makes an excellent transmitter, and by adjusting the amounts of inductance in the aerial and in the condenser circuit the aerial path may be brought into tune or resonance with the closed oscillation circuit.

In the right-hand view is shown a looped aerial conductor which is not insulated at the top, but has its top connected to earth. The connection between the condenser or oscillation circuit and the aerial conductor is a direct coupling, as in the next to the left-hand view.

These views of Fig. 5 represent elementally some of the better known and more useful transmitters as used to-day, though the early Marconi transmitter is seldom, if ever, used, except perhaps by amateurs or for very short transmissions.

In Fig. 6 are shown elementally different constructions of aerial conductors without regard to the form or type of oscillation producer used in connection therewith.

In the upper left-hand corner is shown a wire cage located at the top of the aerial conductor, either horizontally or in any other position, which gives added capacity at the top of the conductor. The next below shows also a multiple arrangement of wires at the top. The one next shows a plurality of wires extending vertically and having a common connection at the bottom to the sending apparatus. The one in the lower right-hand corner shows a plurality of horizontally disposed wires at the top, connected in parallel with each other and connected together at the bottom to the sending apparatus. There is shown also a spread-out antenna of a plurality of wires in diamond shape; and also an inverted three-sided pyramid arrangement. Next below is a plurality of multiple horizontal wires connected together from their centers to sending apparatus. And there is shown a plurality of horizontal wires at the top having several separated connections coming to a common connection downward to the sending apparatus.

While Fig. 6 illustrates numerous forms of spread-out aerials or antennæ, it has been found good practice also to have the aerial conductor composed of a plurality of wires which are closely bunched instead of being spread out. With a spread-out arrangement, if the spread is any considerable fraction of the wave length, each conductor sends out its wave, and there

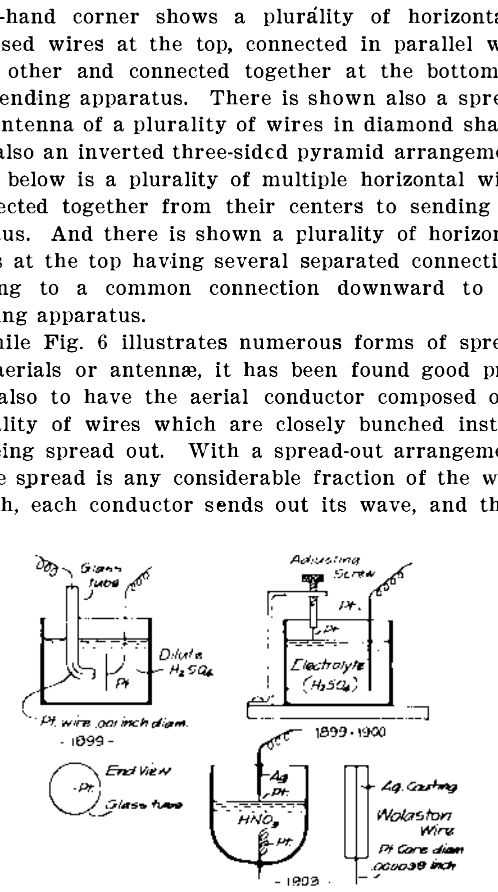

FIG. 9.

results a combination of dephased waves in space, which is a disadvantage in most cases to the receiving apparatus.

Coming now to receiving apparatus, probably the first practical wireless telegraph receiver was devised by Popoff, of the Russian navy, who in 1895 devised the apparatus shown in Fig. 7. This apparatus was for use in recording and predicting lightning storms, some recorded being at such distance that at the location of the recording apparatus it was not otherwise known that a lightning storm existed. The flash of lightning produced became a natural spark gap or natural producer of oscillations, and these oscillations were picked up on an aerial wire whose lower terminal was connected to one terminal of the filings tube or coherer *T*, the other terminal being connected to earth. The coherer or filings tube *T* comprised separated terminals within a glass tube, between and in contact with which was placed a mass of iron or other metal filings. Such a device, as found in 1892 by Branly, was sensitive to electric waves or high-frequency oscillations. The device normally has a very high resistance, but upon high-frequency oscillations traversing the device the filings drop enormously in resistance (the resistance reduction is used to produce the signal) and remain in the condition of low resistance until mechanically shocked, when they again resume the high-resistance state. The action has been explained as one of cohesion, and, therefore, the device has been termed a "coherer." And though detectors or wave-responsive devices coming later in the art did not comprise filings or anything like them, the term "coherer" became for a long period a general one to denote all types of wireless detectors. Popoff connected in series with the filings tube the battery *B* and the relay *R*, the relay controlling also a local circuit including the winding of an electric bell magnet *E*, the hammer being used to strike the tube, to automatically restore the tube to sensitive conditions. Popoff's arrangement was, in fact, a perfectly practical wireless telegraph receiver.

Later, Marconi used almost indentically this arrangement as his receiving apparatus in connection with the transmitting apparatus shown to the left in Fig. 5.

Coming now to later forms of the receiving apparatus, and such as may be taken as fairly representative of types, without going into great detail, Fig. 8 shows in the left-hand figure a non-tuned receiver having an open aerial conductor, between which and earth is connected a detector comprising carbon filaments resting on steel knife edges, and in a local circuit is included a telephone and a battery. At each spark at the distant transmitting apparatus a train of waves is radiated into space, and these waves impinge upon the aerial conductor, setting up therein minute high-frequency currents or oscillations which surge up and down in the conductor through the detector or oscillation-sensitive device, causing it to change its condition suddenly, to thereby cause increased or decreased current through the telephone, producing therein a click, such click corresponding

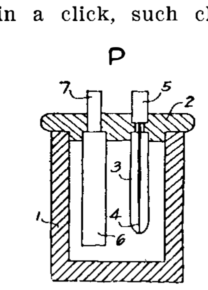

FIG. 10.

with the spark at the distant station. Several clicks coming close together indicate a dot, and a longer series of clicks indicates a dash. This has been called a non-tuned receiver, though it may be roughly tuned to the transmitting apparatus if the dimensions and disposition of the aerial conductor are similar to those of the aerial conductor of the transmitting apparatus.

In the middle sketch is shown a tuned receiver having an aerial conductor, between which and earth are connected the variable inductance and variable condenser. In shunt to the condenser is connected the detector or sensitive device, and in shunt to it is connected a telephone receiver and battery. To get the receiving apparatus into tune the condenser or inductance, or both, is or are suitably varied.

In the right-hand sketch is shown a looped aerial conductor with tuning apparatus, the latter comprising an adjustable inductance and an adjustable condenser.

An important element of each wireless telegraph set is the detector or sensitive device at the receiving station. A good detector, one which is very sensitive yet rugged, and not likely to get out of order, is an important factor in satisfactory wireless telegraphy and telephony. But even with the best of detectors, if the transmitting apparatus is not of the best form or type, or if the receiving circuits independent of the detector are not of the best form or type, successful communication cannot be had.

In Fig. 9 are illustrated several forms of detectors. It will be recalled that the filings coherer had to be tapped to restore it to sensitiveness ready to respond to the next train of received waves or oscillations. It was not, therefore, a self-restoring detector or receiver. The receivers or detectors of Fig. 10 are all self-restoring; that is, immediately after response has been made to a received wave train, it restores itself, or automatically returns to sensitive condition ready to respond to the next train of arriving waves. All the detectors shown in this figure are of the liquid type; that is, they comprise two terminals bridged in one form on another by liquid.

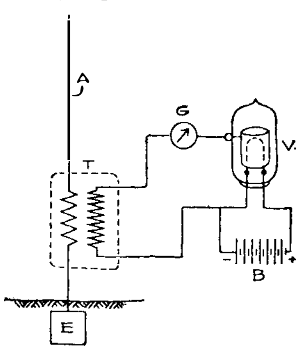

FIG. 11.

In the upper left-hand corner is shown the Pupin detector of 1899, due to Prof. Pupin of Columbia University, who used it to detect Hertzian oscillations, just such oscillations as are used in wireless telegraphy. The action was, as he believed, a rectification of the Hertz waves, more or less complete. The high-frequency alternating currents or Hertzian waves or oscillations were believed to act upon the cell with its adjuncts in such fashion that the oscillations were more or less rectified. But, whatever the action, the result was that an indicating instrument gave a decided indication at each spark of the transmitter, or what is the same thing, for each train of waves generated and received. This detector consists of a mass of dilute sulphuric acid in which dips a terminal of platinum, wire or plate. The other terminal is a platinum wire, 1 mil. (0.001 inch) in diameter, sealed in a glass tube, the platinum wire being polished or ground off flush with the end of the glass so that only the cross-sectional area of the end of the glass is exposed to the solution. This small area is separated in the sulphuric acid from the other and larger platinum terminal. This is, indeed, a sensitive detector, and the author has himself successfully employed it in Philadelphia at the wireless telegraph station on the Bellevue-Stratford Hotel; and without any effort at tuning has received distinct and loud messages from New York and Washington. And with crude tuning apparatus, which is necessary with even the best of detectors, it was possible to pick up messages from very much greater distances. Indeed, so far as the author knows, the Pupin detector is about as good, all matters considered, as exists today.

The Pupin detector, exactly as shown in the figure, has been used with marked success in the United States navy.

At the upper right-hand corner of Fig. 9 is shown a very similar detector due to Capt. Ferrié of the French army. In 1899 and 1900 he successfully used this detector, platinum and platinum in dilute sulphuric acid, in transmitting messages between the different army stations or forts around Paris, as Capt. Ferrié himself told me. Like the previous detector, it is self-restoring, and it is, indeed, the same in principle.

Later, in this country, there was evolved the Wollaston wire form, using one large platinum terminal in nitric acid, and as the other terminal the platinum core of a Wollaston wire projecting into the acid. The platinum core is extremely fine, being only about 0.00004 inch in diameter—a microscopic wire. This produces a very sensitive detector, but is not as rugged as the Pupin form, where the wire is inclosed in glass and is not so easily destroyed. The Pupin arrangement is "fool proof," while the Wollaston wire type is much more delicate and probably more sensitive.

In Fig. 10 is shown still another form of self-restoring detector, consisting of the Pupin glass tube, 3, with the small platinum wire, 4, sealed in and ground off flush with the glass. This dips into dilute sulphuric acid or other cell excitant contained in the jar or vessel, 1, the other element being a plate or bar, 6, of zinc or other metal or conductor other than platinum. This device having dissimilar metals thus constitutes a primary cell, and it is known as the primary cell detector. It is very sensitive and, like the Pupin device, is "fool proof." The telephone is connected directly to the terminals 5 and 7; no local battery is employed.

In Fig. 11 is shown a curious type of detector accredited to Prof. Fleming, of England. It is called a "valve tube," and consists of an exhausted bulb *V* similar to an incandescent lamp bulb, in which is a carbon or other filament, shown in dotted lines. Surrounding this is a metallic cylinder, as of platinum. In circuit with the carbon filament is a source of energy *B* to keep it incandescent. The oscillations delivered from the secondary of the oscillation transformer *T* pass through the indicating instrument *G* to the plate in the vicinity of the heated carbon filament; the heated carbon filament forms the other terminal of the detector. This device is said to be a rectifier, causing the high-frequency current waves or oscillations to be rectified to give an indication in the instrument *G*, which may be a telephone.

A detector resembling the Fleming detector is called the "Audion." Both of these detectors are self-restoring. A carbon filament within an evacuated bulb is kept hot or at incandescence by the source of energy or a battery. The carbon filament forms one terminal of the detector, being connected to earth, while the other terminal within the bulb is of platinum or other suitable material, and connects with the receiving circuit. In the local circuit is a battery and relay, telephone or other instrument. Rectification probably occurs here also. But it is immaterial what the process may be in any detector; the fact is always that the received oscillations produce a change in or by the detector, which change is noted in the telephone and read by the operator. Whether the action of a detector be rectification, resistance change, depolarization, or what not, is a matter of extreme indifference from the commercial and practical standpoint, inasmuch as whichever of these or other processes may occur, the result is the same in that the operator hears a click in his telephone for each spark at the transmitting station.

(To be continued.)

AEROPLANES IN PARIS.—II.*

THE FRENCH SALON.

Concluded from Supplement No. 1820, page 335.

There is obviously considerable hope for the future of aviation when so much intelligent criticism is directed against the machines exhibited at the Paris show. A year ago they were regarded with wonder and admiration, and while this was still the dominant feeling among the huge crowds who flocked to the Grand Palais, there was a general impression among those who are interested more or less in aviation that the construction of the machines fell short of what it should be. There is, indeed, too much of the makeshift about the construction of many of the aeroplanes. While anything may do for experimental appliances, it is expected that a machine which is presented as a settled type will satisfy the mechanical mind; but this is what it fails to do. Wood, wire, and fabric constitute materials which, in many cases, are put together in a haphazard way. The controlling gear of one aeroplane has been aptly described as a "broomstick with string all around it." As an illustration of the want of mechanical knowledge, or perhaps merely thoughtlessness, in the building of aeroplanes, we will take the stays of steel strip which have replaced piano wire on many machines for bracing the under part of monoplanes to the body. These stays work under tension, and have to bear the whole weight and load, as well as the sudden additional strains put upon them when maneuvering. Piano wire may rust and snap at the joints. The steel strip used as a substitute obviously provides an ample margin of safety, but the ends are riveted between a strip bent round a pin held in a lug by bolts. At the point where it is held by the pin, the strip forming the joint, and having a thickness of about 20 wire gage, is narrowed to 4 millimeters. This bears the whole load. On the other hand, there are some machines that are well made and of pleasing design, and the appearance of lightness and finish given to certain of them is distinctly attractive, but in a general way it must be admitted that in the designing of aeroplanes due consideration has not been given to securing the maximum strength.

The general impression of aeroplane progress may be summed up in the suggestion which has been put forward by the Marquis de Dion for a prize to be awarded to the airman who, during 1911, is able to show the greatest difference between his fastest and slowest speeds over a given distance. There is apparently not a machine in existence that will fly slowly. The greatest difference between fastest and slowest speeds at present is not more than 20 per cent. During the year progress has been solely in the direction of increasing speeds, because this is indispensable for the present types of aeroplanes; but a machine that will fly slowly with safety must necessarily represent a considerable advance upon anything done up to the present time. A slow-flying machine must be comparatively independent of ordinary atmospheric perturbations. The proposed competition has been suggested by the idea which is entertained by every thinking man that research work should be diverted from the present line of aeroplane development. Existing types of machines will, of course, be greatly improved, and may satisfactorily fulfill certain conditions of aerial flight; but it is not considered likely that these apparatus will represent a practical class of flying machine. The question therefore arises whether the aeroplane will be able to free itself from the thraldom of speed without relinquishing the propeller, or whether it will have to adopt some other method of propulsion, such as the comparatively slow displacement of large volumes of air. The idea of building machines with flapping wings has always been regarded with more or less contemptuous disapproval, though for what reason it is difficult to say; but there is no doubt that increasing attention is being given in France to this possible solution of the problem. At the Paris show demonstrations were made with a model similar in construction to a large model which has been flying with remarkable success in the open air, but on account of its size this model could not be shown in flight within the restricted precincts of the hall. The behavior of the smaller model, however, appeared fully to justify the claims of the inventor concerning the capabilities of the larger machine. This has a length of about 5 feet, and is, in plan, a copy of the body, tail, and wings of a bird. Each wing is practically a right angle triangle, with the base and perpendicular forming a rigid member, and over this is stretched a flexible fabric. The base is hinged to the body, and the end of the wire constituting the base is bent at right angles to form a level under the horizontal plane for actuating the wing. The lever is connected by a rod with a double horizontal crank, upon which is mounted a pinion. This meshes in a pinion keyed on the motor shaft, which, in the case of the model, is rotated by the twisting of thick rubber. The model is allowed to start from the hand without impulsion, and flies in a straight line so long as the motive power lasts, and then alights gently on the ground. The wings being quite flat, there would, of course, be no advance if they were rigid, but with each upward and downward beat the fabric bends, and thus imparts a waving motion through the air. We do not go so far as to say that this flapping model performs better than models of fixed planes worked by propellers, but it certainly seems to possess greater stability, as well as an easier gliding to earth, while it is also capable of traveling more slowly. Tests with small models may be regarded as of doubtful value, but if comparative trials could be made with large-size models of the fixed plane and moving plane types, some interesting deductions might be drawn therefrom, which would guide makers in the designing of large-size machines.

So long as the present system of fixed planes and propeller is adhered to a somewhat exaggerated importance has to be attached to the engine. In order to gain speed more powerful and lighter engines are required. This raises a problem of specific engine weight which may eventually find a satisfactory solution, but there are obviously mechanical limitations which cannot be exceeded. Every motor builder is induced, by the high prices paid for suitable aviation engines, to produce designs in which weight is cut as finely as possible. These may be divided into four categories—rotary engines, engines with vertical or V-placed cylinders, engines with the cylinders arranged fan fashion, and horizontal engines. The rotary engine undoubtedly enjoys the greatest favor, and this favor is centered upon the Gnome. Its success has naturally been followed by the introduction of other engines, either with revolving cylinders like the Gnome or of the true rotary type. At the show there were no fewer than nine of these engines, of which two, the Beck and the Breton, were exhibited last year. In the Beck the cylinders are constituted by an annular chamber in which the pistons travel through the arc of a circle, and are connected with the crank shaft by levers. If the crank shaft is fixed, the annular chamber is driven round the axis. The Rossel-Peugeot is an improvement of the rotary engine built by Peugeot some years ago. It has seven cylinders, and its special feature is the method of distribution by means of a shuttle traveling in a double cam-shaped groove crossing the path in such a way as to insure contacts at the correct moments. It is claimed that this system offers greater security and certainty than the rollers and cams usually employed on rotary engines. In the Canda engine there are ten cylinders, with the axes at a tangent to the center of rotation. The pistons are fixed so that when the explosion takes place it is the cylinder which must move and this it can only do in a circular direction. This is the principle of most of the so-called rotary engines. The chief reason for the popularity of this type of motor is that it offers the highest air-cooling efficiency, but it also possesses certain drawbacks such as the projection of oil into the explosion chambers which it is not easy to obviate, while the power it develops on an aeroplane is considerably less than on the bench. Being an essentially high-speed engine, it has to be throttled to the maximum number of revolutions allowed for the propeller, and the power developed during flight is not more than two-thirds of what the engine will develop on the bench. It has also been argued that the rotary engine offers a resistance that must be considerable with the high speeds at which aeroplanes travel, and if the rapidly rotating cylinders may be regarded as a solid disk it is obvious that the power absorbed in overcoming this resistance at great speeds must be very high. Probably it is for this reason that in the latest Blériot machines the engines are placed inside the body, which is curved forward to diminish resistance.

If the Gnome engine is so largely adopted on account of its convenience, a good deal of attention is nevertheless being directed to the engine with vertical or V-placed cylinders. It is still an open question

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