THE REALM OF SCIENCE

WIRELESS TELEGRAHPY AND TIME SIGNALS.

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WHILE wireless telegraphy may justly be called one of the greatest inventions of our day, its use has spread so rapidly and its manipulation is mastered by so many youthful amateurs, that it behooves every educated person to be acquainted with its principles and to understand its most essential instruments The recent installation of a wireless receiving outfit at the University, and its employment in the redetermination of the longitude of the Observatory, are the occasions of the present article.

The general principle of wireless telegraphy may be said to be very simple, although it is beset with many practical difficulties and apparent contradictions. We are all acquainted with the induction coil, the Ruhmkorff coil, as it used to be called. This consists of two coils or spools of insulated wire. The inner one of these is wound about an iron core and has comparatively few layers and few turns of thick wire, and is called the primary coil. The outer one, the secondary, is made up of as many layers and as many turns of fine wire as we can crowd into the space available for it. If now we send an interrupted current into the primary coil, we find that at each make and break of the circuit an induced momentary current is generated in the secondary, and that the voltage, that is, the tension or pressure of the secondary current, is nearly as many times greater than that of the primary as is the ratio of the number of turns of wire in the two coils. For this reason while we can make this ratio as large as we like, we must also insulate the wire as carefully as possible. Let us add that while the voltage may be raised to any desirable height, the amperage, that is, the quantity of the current, is cor-

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respondingly diminished in such a way that the product of volts and amperes called watts, 746 of which make a horsepower, remains the same in both coils, and there is, therefore, no creation of energy.

As the secondary or induced current owes its existence exclusively to the interruptions, strictly the variation, of the primary current, it follows that the more frequently and the more suddenly we interrupt the current the greater will the induction be. The old and classic magnetic interrupter is much too slow for our modern requirements. Electrolytic interrupters may raise the number per second to the thousands, and other contrivances even to the millions. For wireless work the interruptions per second are often produced by a thick zinc wheel with heavy projecting cogs, which is set into rotation by an electric motor. Two sliding rods on opposite sides of the wheel allow the spark to jump through a diameter whenever its projecting cogs come in line with them. The frequency of the interruptions, together with the self-induction of the coils and the capacity of our wires and condensers, produces waves in the ether which have definite length. High power stations generate long waves of several thousand meters. Arlington uses a wave of 2,500 meters, because that length is best received at Paris.

Each station generally adheres to a definite wave length and amateurs are restricted within certain limits. The result of this voluntary or enforced constancy in the wave length is that receiving apparatus may be turned so effectively to one particular sending station that all others using a different wave, even when nearer and louder, may be completely silenced and the desired message received without the destructive interference that brought the hand of the law down upon reckless amateurs. This tuning, however, is not as perfect as inventors would desire, and cannot be relied upon to maintain two or a set of stations in absolutely secret connection. The only sure secret communication is by cypher; that is, ordinary words seem to be transmitted, but their true meaning is known only to be initiated. While I can merely touch upon some of the essentials of wireless telegraph, I must not forget to state that whenever the primary current in an induction coil is started, the induced current in the secondary runs in the direction opposite to that of the primary, and that when the primary current is interrupted and stops the secondary current runs in the same direction as the primary. While the primary current is, therefore, as a rule an interrupted direct current which never changes its direction, but only its intensity or very existence, the secondary current is essentially an alternating one, which changes direction at each make and break of the primary. The rapidity and intensity of these alternations set up violent surgings and to and fro motions in the ether; they push and pull, as it were; they tug and tustle, and must, therefore, set sympathetic bodies in synchronous vibration just as sound waves do.

One end of the high-potential secondary is connected to the ground by a large metallic plate or a water pipe, while the other ascends above the building into the antenna. Waves are, therefore, produced in the earth as well as in the ether. As the energy of the sending coil separates these two sets of waves, which must and will somewhere and somehow reunite, like the lines of force about a magnet, it is the province of the receiving apparatus to offer them an easy and agreeable path through the medium of a copper wire. Hence, copper wires stretched out in the open, high above terrestrial obstacles and reaching out into space like the antennae or feelers of an insect, catch these ether vibrations and lead them back to the ground through appropriate instruments which transform them and make them perceptible to our senses.

The most essential of these receiving instruments is the detector, the successor of the coherer. The coherer used to consist, for example, of metal or other conductive filings thrown loosely together. These filings offered such a very obstructed passage to the current of a small battery, enfeebled in addition by a large resistance, that it could not force its way through. But when the high-potential current from some distant induction coil set the ether in vibration, and had an easy passage to the earth offered it through these filings, it never failed to take the chance, and in doing so seemed to fuse the particles together, to make them cohere, so much so that the low-potential battery current could then readily follow the path opened up for it. The battery current would then continue to flow until by an automatic contrivance like the hammer of an electric bell, the filings were shaken up and made to decohere. The next ether wave would then restore the path as before, the battery current would follow and again shake up the filings.

The next improvement was to use substances which would themselves automatically decohere the moment the ether wave ceased. It was discovered that many crystals found in the ground possessed this property. One of the simplest of these is galena, crystallized lead, which is touched by a thin copper wire, one of the strand that makes up a flexible lamp cord. All these crystals have sensitive as well as dead spots, which must be found by experiment. And a good operator is sure to have several detectors on hand and to develop a predilection for particular kinds.

Next in importance to the detector is the tuning coil. This is practically an induction coil without an iron core and with but one layer of wire on each coil, any desirable fraction of which may be used. The coils may also be separated more or less, and then the instrument is called a loose coupler. Its action is to adjust the inductive action for the best result, because this may be too strong as well as too weak, and the frequency may be out of harmony.

The length of our outside wires, the antenna, is sensitive to only one wave length. More or less self-induction, brought about by an adjustable loading coil, adapts it to various waves. And finally there are fixed and variable condensers, modified Leyden jars, which give capacity.

A receiving station must, therefore, have an antenna above the roof and a loading coil to change its adaptability. It must have a sensitive detector, a tuning transformer or loose coupler, a fixed and a variable condenser, and lastly a pair of very sensitive telephones which can be strapped to the ears by a headband.

While the energy at the sending station may be several horsepower—ten-horsepower, I think, will send signals across 3,000 miles of water—it is astonishing that in spite of the enfeeblement which the law of squares imposes, the signals should be so loud and audible as they are, one, two or even three thousand miles away.

The messages sent and received by wireless telegraphy are the same as those of the ordinary wire telegraph. Letters and numerals are made up of a combination of short and long signals, called dots and dashes. A good memory is required to master the alphabet and to know the many conventional abbreviations of words and phrases. This is quickly acquired by young people, and this is why young operators become so skillful and rapid. Time signals, however, are nothing but a series of dots that follow each other generally at an interval of one second, one or more being omitted each minute for the sake of identification. Those desirous of knowing the time, therefore, need not learn the alphabet at all. And clockmakers are now rapidly availing themselves of the opportunities offered them of regulating their timepieces at the sole expense of installation of receiving apparatus.

Our government has erected several large sending stations, the chief one being at Arlington, just across the Potomac from Washington, and the others at Key West, Panama, San Francisco, Honolulu and Manila, so that all our possesions are at all times in immediate communication. At the request of clockmakers the Arlington station sends out time signals twice every day, at noon and at ten P. M. Eastern time; that is, at eleven A. M. and at nine P. M. in the Central time that we are using in the central part of the United States. These signals last five minutes. They come every second except the twenty-ninth and the last four but one of the minutes, the last nine but one being dropped in the last minute, so that at the full hour there is one long final signal. These signals are exactly on time and no further knowledge is required for their reception. As time is generally known within a few seconds by those desirous of getting it accurately, they need but wait for one one-second or one four-seconds pause. In case the minute is in doubt the final long pause removes that completely.

In the longitude campaign now going on between Arlington and Paris, the time signals are sent on an altogether different scheme. After giving receiving stations two minutes' time to adjust their apparatus to its wave, Paris pauses for a minute and then for seven continuous minutes sends a series of signals which seem to come at intervals of a second, with every sixtieth one omitted. The time interval is, however, ninety-nine hundredths of a second, so that at each succeeding beat the wireless signal gains one hundredth of a second on the home clock. This gain gradually brings about an exact coincidence between the two clocks. The observer must, therefore, note the second of his clock when he judges this coincidence to be perfect. At this moment his own clock shows a full second without any fraction, while the wireless clock shows also a second of its own without any fraction. An error of one in noting the exact second of coincidence entails, therefore, an error of only one hundredth of a second in the comparison of both clocks. An error of two seconds means only an error of two hundredths; that is, one fiftieth of a second in the result, so that all errors are divided by one hundred. This method is the best ever employed which brings in the human element at all and is not automatic. It is superior to the chronograph method, in which the observer presses a key when he hears or sees a certain thing. And the very first time that the writer himself employed this method he was astonished at the close agreement of his results, for amongst four observations in a certain set, the extremes were less than one-tenth of a second apart.

Besides noting the coincidences the observer must also note the pauses, but for these the nearest second will suffice. The purpose of these is to find the so-called radio numbers of his coincidences, and from them to compute the time of the first and last signal.

After Paris has completed its set of seven minutes, there is a pause of three minutes. Then Arlington sends for seven minutes. After three minutes of rest, Paris begins again, and then Arlington. Paris tries once more, and Arlington follows. So that a night's work consists in both stations alternately sending three times a series of signals lasting for seven minutes. At Omaha, of course, we can hear only the Arlington signals.

As these wireless signals gain one second in a hundred, they cannot be used for finding time as the eleven A. M. and nine

P. M. signals, and are therefore of no service except in finding the longitude. American and French astronomers are in Arlington and Paris and observing their coincidences every night. It is only by comparison of the computed times at both places of the first and last radio signal in each set that the longitude can be determined. As these observers in Washington and in Paris are doing this every night to find the difference of longitude between these two places, an exceptional opportunity is offered to all astronomers within receiving distance of either station of determining or verifying their own longitudes without imposing more additional labor on the part of the observers at the Washington and Paris stations than of copying down the times of the few nights asked for by other astronomers and sending them on.

The Creighton University Observatory is one of the fifteen that have so far expressed their intention to enter this longitude campaign. Not to mention the time that must be devoted to adjusting the very delicate receiving apparatus and to the observation of the coincidences, the correction and rate of the home clock must be determined on each successful night by two or more hours of transit observations of stars in the Observatory. The astronomer is then provided with the necessary data with which he may begin his computations. The final outcome of the work of many such nights will result in a much more accurate knowledge of the longitude of the Creighton Observatory. This is now put down as 6 hours 23 minutes 46.96 seconds west of Greenwich, or 1 hour 15 minutes 31.18 seconds west of Washington. It was found as well by a formal exchange of clock signals with Washington over the Western Union Telegraph line on August 5, 6, 7, 1887, as also and more accurately by a triangulation connection with the station of the United States Coast and Geodetic Survey in the High School grounds. The wireless method is far superior in accuracy to the old wire method, excellent as that really is. The present occasion of using the wireless method and thereby making direct connection with the government observatory in Washington, is the very first that has ever presented itself. The method and the occasion are the reasons, therefore, why The Creighton University Observatory has erected its wireless station and has taken such an interest in the matter.

The Aurora Borealis, or Northern Lights, which have so long been an unsolved puzzle to scientific men, are slowly beginning to yield up their secrets. They are so very faint and change so rapidly that it was impossible until late to photograph them. This has now been done and further steps will become less difficult.

The November number of the Astrophysical Journal contains a very interesting article on an auroral expedition in the spring of 1913. Carl Stoermer went to the northern part of Norway, equipped with all modern scientific apparatus. He stationed an assistant, similarly equipped, about sixteen miles away, with whom he was in continuous telephonic communication. Both observers could then direct their cameras to the identical aurora and to any individual part of it, so that by means of this photographic triangulation, so to speak, the distance of the aurora could be determined. This is given in the article only approximately, as the data are not yet fully discussed. It seems to vary between fifty and 160 miles. About 447 pairs of photographs were secured, sometimes more than eighty on the same evening. The observers even attempted the use of the cinematograph; that is, the camera for taking moving pictures. Most of these views, however, turned out to be failures on account of the extreme faintness of the aurora. A few were excellent. The exposure for bright auroras was about one second, and the interval between the pictures was about two seconds. Some of these moving pictures, as well as four pairs of photographs taken simultaneously at both stations, are given with the article in question. They mark a most important turning point in the scientific study of the Northern Lights.