# Pioneer Work In Ether Waves

## By SIR OLIVER LODGE

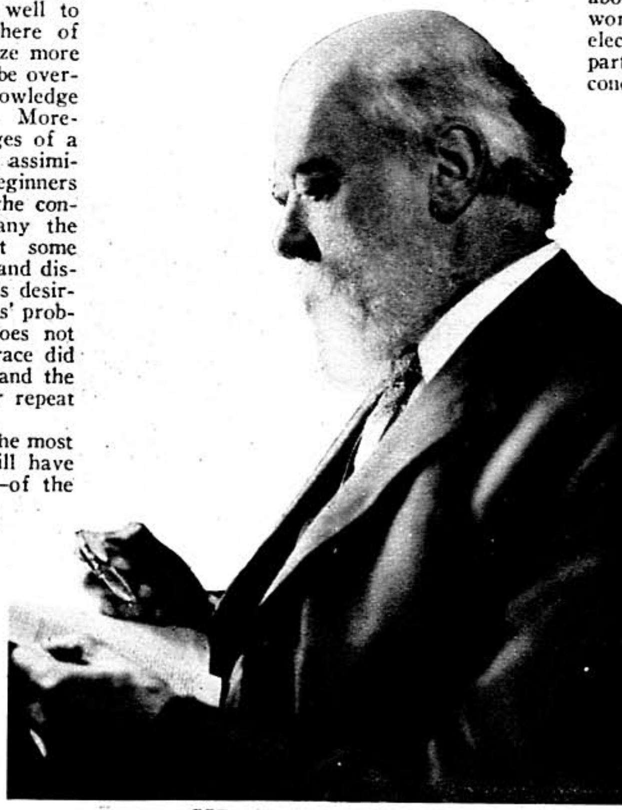
EARLY pioneering work is too often overlooked and forgotten in the rush of a brilliant new generation, and amid the interest of fresh and surprising developments. I often think, however, that the early stages of any discovery have an interest and fascination of their own, and that teachers would do well to immerse themselves in the atmosphere of those earlier times, in order to realize more clearly the difficulties which had to be overcome, and by what steps the new knowledge had to be dovetailed in with the old. Moreover, for beginners, the nascent stages of a discovery are sometimes more easily assimilated than the finished product. Beginners need not indeed be led through all the controversies which naturally accompany the introduction of anything new; but some familiarity with those controversies and discussions on the part of the teacher is desirable if he is to apprehend the students' probable difficulties. For though he does not himself feel them now, the human race did feel them at its first introduction; and the individual is liable to recapitulate, or repeat quickly, the experience of the race.

A large number now interested in the most modern developments of wireless will have but little idea—perhaps none at all—of the early work, in apparently diverse directions, which preceded and made such developments possible. And even those who are high authorities in wireless telegraphy, and know nearly all that can be known about it, can hardly know the early stages quite as well as those who have lived through the nascent and incubating period. Only those who have survived the puzzled and preliminary stages of a discovery can fully appreciate the contrast with subsequent enlightenment. It may suffice to say that the term "inductance" or "self-induction," which we now use so glibly, did not at first exist; and that so late as 1888 Sir William Preece still spoke

JOSEPH HENRY

of it as "a bug-a-boo"; whereas it is the absolute essential to tuning, and even to electric oscillation. Lord Kelvin, who first introduced it as a mathematical coefficient, without any explanation, called it "electrodynamic capacity." The name "self-induction" was given to it by Maxwell, though it was long before it was understood or utilized, and the name "inductance" was a nomenclature of Heaviside. It must be very difficult for some of you who are so familiar with these things now to realize the dense state of ignorance in which your scientific ancestors were.

Silvanus Thompson, well known as an historian of science, wrote in 1911 a care-



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fully drawn up pamphlet about the history of wireless (though it was never published) for use in a trial before Mr. Justice Parker when my patent for tuned or selective wireless came up for extension. This patent, dated May, 1897, was extended in 1911 for seven years, and was then acquired by the Marconi Company from the Lodge-Muirhead Syndicate. Its validity was subsequently contested before Lord Moulton, but was triumphantly upheld, after twelve days trial, as containing the necessary and fundamental principle of all tuned wireless not involving continuous wave transmission.

But my present subject has nothing to do with details of tuning, nor with wireless in its present condition. That all dates after 1896, most of it after 1900; and I wish to say practically nothing about anything later than 1896. What I have to deal with is the early pioneering work apart from practical developments. And let me here say at once, to avoid misunderstanding, that without the energy, ability and enterprise of Signor Marconi, what is now called wireless would not have been established commercially, would not have covered the earth with its radio stations, and that without the valves of Fleming and Lee de Forest it would not have taken the hold it has upon the public imagination. Before 1896 the public knew nothing of its possibilities. And for some time after 1896, in spite of the eloquence of Sir William Preece and the demonstrations by Marconi, the public thought it mysterious and almost incredible; and still knew nothing about the early stages. Indeed, I hardly suppose that Signor Marconi himself really knew very much about them. He had plenty to do with the present; he felt that the future was in his hands; and he could afford to overlook the past without regrets.

It may be doubted whether the younger generation, who are so enthusiastically utilizing and perhaps improving the latest inventions, will care much about the past either; but still they may like to know more about the early incipient and pioneering work, on the production and detection of electric waves in the ether of space. With part of this work it is true I was myself concerned, but I must not hesitate on that account, since it was this early work—the outcome of splendid achievement by Kelvin and Maxwell and Fitzgerald and Hertz—which laid the foundations and made all the present superstructure possible.

### ETHER EXISTS

Incidentally, however, I want to say two things to those who are occupied with the subject today. First, do not hesitate to speak and think of the *ether of space* as the continuous reality which connects us all up, and which welds not only us, but all the planets into a coherent system. Do not be misled by any misapprehensions of the theory of relativity into supposing that that theory dispenses with the ether, merely because it succeeds in ignoring it. You can ignore a thing without putting it out of existence: and the leaders in that theory are well aware that for anything like a physical explanation of light or electricity or magnetism or cohesion or gravitation, the ether is indispensable. The ether has all these functions, and many more. I could suggest some which would astonish you! We are utilizing it every day of our lives; and it would be ungrateful, as well as benighted, if we failed to render due homage to its omnipresent reality and highly efficient properties. It lies at the origin of all electrical developments and forms the basis for this new and broadcast method of communication.

JAMES CLERK-MAXWELL

That is one thing. And the second is to congratulate all those whose wonderful and rapid advances have rendered possible the astonishing feat of, in any sense and by whatever means, carrying the human voice across the Atlantic. When Mr. Marconi succeeded in sending the letter "s" by Morse

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modern limousine one has faith in the persistence of that ever-present class of experimenters who find pleasure in making realities out of dreams.

One can conjure in the imagination the following: a telephone bell ringing in the living room of a country residence. A servant lifts the receiver as is the practice with wired circuits, and answers the call from a distant point. It has come by wire to the telephone exchange of a nearby town, has been transferred to the radio section of the exchange and transmitted into the ether. It is picked up at the residence by a vertical cage antenna; an artistic rigged metal tower erected at the side, or on the roof of the house. The radio equipment proper is located in a room in the basement near the Delco lighting system. Other homes in the neighborhood are similarly radioed, each one having its own wave or party wave, and the wave-lengths are fixed. Each set is in tune with a calling device in the radio section of the telephone exchange. For local purposes communication is by radio, that is a neighbor first calls the exchange and is reconnected by radio to the neighbor called. The connection at the telephone office for this purpose, from one wave to the other, is by remodulation (Arlington time signals on 2500 meters rebroadcast by KDKA on 360 meters.) If the call is from a distance, it is carried by wire to the telephone exchange as mentioned above, shot into the air as it is now being done at Catalina Islands, California, and relayed by radio the rest of the way. Those who can afford it have private waves; others have party waves. There is a conspicuous absence along the country side of ungainly poles. In the winter season when sleet is bearing down wired circuits and the wind comes along and blows them into a tangled mass on the ground, the radio system is enjoying immunity from the storm. This dream is separated from being an actuality merely by the creative genius of the American public. This creative genius has never failed when the proper combinations for accomplishment are present. The gasoline engine made the limousine possible. A radio bell holds the same relation to wireless telephone development.

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signals from Cornwall or Ireland to Newfoundland, it constituted an epoch in human history, on its physical side, and was itself an astonishing and remarkable feat. The present achievement of changing over from Morse signals to ordinary speech, made possible by the valves of Professor Fleming and Dr. Lee de Forest and others, is a natural though still surprising outcome and development of long-distance transmission, and must lead to further advances, of which at present we can probably form but a very imperfect conception.

### EARLY EXPERIMENTS

Well now I must go back to early times. In or about the year 1875 Mr. Edison observed something, which at that time could by no means be understood, about the possibility of drawing sparks from insulated objects in the neighborhood of an electrical discharge. He did not pursue the matter, for the time was not ripe; but he called it "Etheric Force," a name which rather perhaps set our teeth on edge; and none of us thought it of much importance. Silvanus Thompson, however, took the matter up in a half-hearted sort of way, and gave a demonstration to the Physical Society of London in, I believe, June, 1876, a paper which I have had a little difficulty in finding in the proceedings of that society. Nothing much came of it, however, though his argument tended to show that the sparks could be accounted for on known principles. The value of this is merely that it must have rendered Thompson susceptible to methods of detecting real electric waves, when they were discovered later.

It was found afterwards that Joseph Henry, at the Smithsonian Institution in Washington, had observed something of the same kind so early as 1842. And he seems to have had an intuition of the possible importance and far-reaching consequences of his observation. For he speaks as follows: (I quote from a passage cited in my "Modern Views of Electricity," an appended lecture "On the Discharge of a Leyden Jar.")

"It would appear that a single spark is sufficient to disturb perceptibly the electricity of space throughout at least a cube of 400,000 feet of capacity, and . . . it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from flint and steel in the case of light."

That is to say, so early as 1842 Joseph Henry had the genius to surmise—it was only surmise, of course—that there was some similarity between the etherial disturbance caused by the discharge of a conductor and the light emitted from an ordinary high temperature source.

In the light of our modern knowledge, and Clerk Maxwell's Theory, we now know that the similarity is very near akin to identity. Both sources emit ether waves, though prodigiously differing in length.

Subsequent to these early stray observations, an amazingly suggestive observation, of a partially similar kind, was made by that singular genius and brilliant experimenter, David Hughes, the inventor of the microphone or telephone transmitter, and of the Hughes printing telegraph still used in France.

He was a man who "thought with his fingers," and who worked with the simplest home-made apparatus—made of match boxes and bits of wood and metal, stuck together with cobbler's wax and sealing wax. Such a man constantly working is sure to come across phenomena inexplicable by orthodox science. And orthodox science is usually too ready to turn up its nose at phenomena which it does not understand, and so thinks it simplest not to believe in. As a matter of fact Hughes unknowingly was very nearly on the trail of what was subsequently discovered, in a so much more enlightened manner, by Hertz. Hughes, too, got sparks in the course of his experiments, but he also got something very like coherer action too, by means of his microphone detectors.

These spasmodic observations are not exactly and strictly discoveries: they were more akin to vague intuitions. The first and gigantic step in the real discovery was made by Clerk Maxwell, in or about 1865: and he made it in mathematical form, not in experimental actuality, by one of those superhuman achievements which are only possible to our greatest mathematical physicists. He did not discover either the way to generate those ether waves, or to detect them; but he did give their laws: he legislated for them before they were born. He knew the velocity with which they must move, and gave implicitly, though without elaboration, the complete theory of their nature.

Up to this time the nature of light was unknown. All the other theories of light had attempted to explain it on mechanical principles, like the vibrations of an elastic solid. Light was known to consist of transverse waves: the wave-length and the frequency of oscillation could be determined. But no one knew what was oscillating, nor what the mechanism of propagation was. With extraordinary genius Fresnel and MacCullagh had explained the phenomena of light in all detail as regards reflection, refraction, diffraction, interference, and Polarization. But the nature of the waves was unknown; and the elastic solid theory, though fascinating, was felt by those who dived most deeply into it to contain some flaw and to be, strictly speaking, unworkable. Light did not seem explicable on dynamical principles—the principles which were so fruitfully devised by Galileo and Newton for dealing with ordinary matter.

MacCullagh's theory indeed was not dynamical, and in that respect had some advantage. But it was also more vague and less definite on that account; though, being thus indefinite and yet enabling results to be achieved, it was less liable to be upset and replaced by future discovery.

(*To be concluded in the next issue.*)

## The Radio Gun

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put into operation in every modern city, and the crime wave would stop. It would be cheap insurance for us to pay a fee every time we found it necessary to send in a call for help by this means; and by paying such a fee there would be many amateurs on the job at all times, ready to be the first to get the call in to headquarters and receive the reward as recompense.

Of course, the above explanation is only a suggestion, but since wired protective devices are used in most stores there is no reason why radio could not be used for the same purpose.

## Definition of Radio Terms

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in the entire antenna circuit to the square of the effective current at the point of maximum current.

Note: Antenna Resistance includes:
- Radiation Resistance,
- Ground Resistance,
- Radio-frequency resistance of conductors in antenna circuit and equivalent resistance of conductors in the antenna circuit,
- Equivalent resistance due to corona, eddy currents, insulator leakage, dielectric loss, and so on.

**Anti-Resonance** (See parallel resonance).

**Aperiodic Circuit:** An electric circuit in which a voltage impulse will produce transient current in one direction only.

**Arc-Converter:** An electric arc used for the conversion of direct to alternating or pulsating current. Types of current generated are classified as follows:

**Type 1.** That in which the amplitude of the alternating current produced is less than half the direct current through the arc.

**Type 2.** That in which twice the amplitude of the alternating current produced is at least equal to the direct current, but in which the direction of the current through the arc is never reversed.

**Type 3.** That in which the amplitude of the initial portion of the alternating current produced is greater than the direct current passing through

# Pioneer Work in Ether Waves

## By SIR OLIVER LODGE, D. Sc., LLD., F. R. S.

### Part II

TO Clerk Maxwell we owe the epoch-making discovery that light was not a mechanical oscillation at all, that the ordinary mechanical properties of matter did not apply to it, but that it was explicable solely and wholly in terms of electricity and magnetism. It is impossible to sum up his discovery in a few words, but roughly we may say that the most obvious outcome was:

(1) That if electric waves could ever be generated they would travel with the velocity of light.

(2) That light was essentially an electromagnetic and not a mechanical phenomenon.

(3) That the refractive index of a substance was intimately related to its dielectric coefficient.

(4) That conductors of electricity must be opaque to light.

He showed further, though he did not then express it in language of this character, that the ether had two great and characteristic constants of value utterly unknown to this day, though guessed at by a few speculators like myself—one of them the electric constant of Faraday called K; the other, the magnetic constant of Kelvin called $\mu$. It was impossible then, and it is impossible now—though it is not likely always to remain impossible—to determine the value or even the nature of either of these constants. But he did perceive a way of measuring their product; and he was the first to measure it. Their product is known; and it is equal—as Maxwell showed it must be—to the reciprocal of the square of the velocity of light.

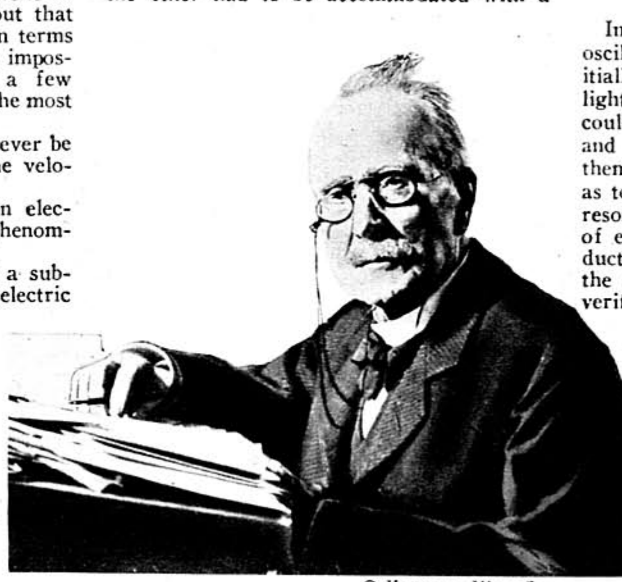
Well, now, this great discovery aroused in us young physicists the greatest enthusiasm. And in the early '70's—I think about 1871 or '72—I remember discussing it with J. A.

SIR WILLIAM CROOKES

Fleming, who at that time was a fellow student with me in Professor Frankland's advanced chemical laboratory at the brand-new College of Science, South Kensington.

A year or two later, at Heidelberg, I studied Maxwell's treatise pretty thoroughly and formed the desire to devote my life, if possible, to the production and detection of Maxwell's electric waves.

Other things supervened. One had to earn a living: we all got immersed in teaching. Some of us got married, and the pursuit of the ether had to be accommodated with a



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EDOUARD BRANLY

few hours of spare time every now and then.

I used to discuss the possibility of producing these waves with my great friend, G. F. FitzGerald, whose acquaintance I made at the meeting of the British Association in Dublin in the year 1878; and he wrote some mathematical papers discussing the possibility of experimentally producing such waves. I myself also spoke at the British Association about them in 1879, 1880, and again in 1882 at the Royal Dublin Society. FitzGerald, as I say, mathematically examined what then seemed the abstruse question of electric wave production; and after some hesitation came to the conclusion that direct artificial generation of waves was really possible on Maxwell's theory, in spite of certain recondite difficulties which at first led him to doubt it. (See "Scientific Writings" of FitzGerald, edited by Larmor, pages 90 to 101.) Indeed, one of his papers on the subject was originally entitled "On the Impossibility of Originating Wave Disturbances in the Ether by Means of Electric Forces." The prefix "im" was subsequently dropped, although his first, or 1897, paper concluded thus:

"However these (displacement currents) may be produced, by any system of fixed or movable conductors charged in any way, and discharging themselves amongst one another, they will never be so distributed as to originate wave-disturbances propagated through space outside the system."

In other words, Hertz's discovery was impossible on Maxwell's theory.

In 1882 he corrected this erroneous conclusion, and referred to some early attempts of mine at producing the waves. ("Scientific Writings," page 100.) I state all this in order to emphasize the difficulty which in those early days surrounded the subject on its theoretical as well as on its practical side.

In 1883, at the Southport meeting of the British Association, FitzGerald took a further step and surmised that one mode of attaining the desired result would be by utilizing the oscillatory discharge of a Leyden jar, if only we had the means of detecting such waves when they were generated.

#### PRODUCTION OF WAVES

In 1887 and 1888 I was working at the oscillatory discharge of Leyden jars (initially in connection with the phenomena of lightning), and I then found that the waves could be not only produced but detected, and the wave-length measured, by getting them to go along guiding wires adjusted so as to be of the right length for sympathetic resonance. Thus I obtained the phenomenon of electric nodes and loops, due to the production of stationary waves by reflection at the distant end, and in my own mind thus verified Maxwell's theory.

Transmission along wires popularly sounds different from transmission in free space, but it was well known to me that the process was the same, and that the waves travel at the same speed, being only guided by the wires, much as sound is guided in a speaking-tube, without the velocity of transmission being to any important extent altered. The theory is given near the end of my paper—an important one as I think, in the Phil. Mag. for August, 1888, where the experimental production of much shorter waves is foreshadowed.

The beginning of my experiments was reported to the Society of Arts in April 1888; they are recorded in the *Philosophical Magazine* for August, 1888, and they were more completely described orally at the British Association at Bath that year. (See *The Electrician*, Vol. 21, pp. 607-8, Sept., 1888.)

In that year, also, I heard for the first time of Hertz's brilliant series of experi-

HEINRICH HERTZ

ments, where, by the use of an open-circuit oscillator, he had obtained waves in free space, and by reflection had also converted them into stationary waves and observed the phenomena of nodes and loops, and measured the wave-length.

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ments were equally successful in demonstrating my claims, a request would be granted for the special automatic sending apparatus I had so long desired in order to incorporate my "Learn While You Sleep" method of instruction here.

### A MATERIAL AID TO THE PRESENT SYSTEM OF INSTRUCTION

It is now proposed to develop my system as a very material aid to the present system.

Our prescribed syllabus of instruction covers a period of twenty-one weeks and the student is required to make a predetermined rate of progress week by week in order to remain in the class. Those students whose rate of progress had been consistently unsatisfactory for some time and who would therefore have been dropped from the class within the week, were told something of my successful experiences with my "Learn While You Sleep" system. Naturally, they jumped at the chance. Seventeen students volunteered for this experiment with the following results next day:

(1) One of the seventeen copied five words faster than he had ever been able to copy previously.

(2) Four copied three words faster and one nearly three words faster.

(3) Four copied two words faster, and one nearly two words faster.

(4) Three copied one word faster and one only half a word faster.

The instructors derive some amusement to compensate for their loss of time and sleep in watching the facial contortions, restlessness and mutterings caused by the induced dreams of the students. Errors and erratic sending cause restlessness and muttered protests. Stoppage of sending when changing operators will arouse them.

The system is now being tried out on officers of the class just started under much more favorable conditions, real beds replacing the wooden benches and tables. Students are no longer confined to last-chance tests.

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These experiments of Hertz were called attention to by FitzGerald in his Presidential Address to Section A of the British Association Meeting at Bath in 1888. And no wonder they interested him; for they showed that his method of utilizing the oscillatory discharge of a Leyden jar was effective; and, to the surprise of all of us, including Hertz himself, that the waves from an opened-out condenser had sufficient power to generate sparks in an insulated conductor upon which they impinged; the detecting conductor, as generally used by Hertz, being in the form of a nearly closed circle with a minute spark gap at which the scintilla appeared. The radiating power of even a small Hertz oscillator was calculated by me in a subsequent paper (*Phil. Mag.* for July, 1889, p. 54), and was found to be 100 horsepower, while it lasted. The duration was excessively short, for at that rate practically all the energy was expended in a single swing (about the 100 millionth of a second), but its power of producing little sparks was explained.

The work of Hertz was splendid. He was then Professor at Carlsruhe, still quite a young man. He had been trained under Helmholtz; and I had made his personal acquaintance in Berlin when I went to call on Helmholtz in 1881, on a tour of the universities of the continent. He was then Helmholtz's demonstrator, and was thought highly of by that great master. He could speak English, and was very friendly. I did not see him again till some time after the publication of his great discovery.

He was not at that time fully acquainted with Maxwell's Theory, though he knew his equations better than any other German except Helmholtz. Maxwell had not then made any serious impression on the Continent. Even Hertz does not seem at first to have realized what he was doing, and did not use the words "Electric Waves." That title was attached to his subsequently translated book at the suggestion of Lord Kelvin. He spoke about the out-spreading of electric force; somewhat as Joseph Henry had done. That was one title of his book. But he worked out the phenomena he observed with extraordinary skill, both experimentally and mathematically, rapidly perceiving that Maxwell's Theory could be applied to it and that it might be elaborated in detail so as to include the whole of his phenomena. He it was who drew those accurate diagrams of the genesis of the waves, showing what is happening near the oscillator at every phase—diagrams which now appear in most textbooks and of which the upper half is represented as scouring across the country. He knew that true waves were not emitted till beyond a quarter-wave length from the source. He knew how they were polarized, and how their intensity differed in the equatorial and polar directions and how it varied with what may be called latitude. In fact he rapidly came to know all about these waves. As to us, we knew not which to admire most—his experimental skill when working with a tiresome and irritating mode of detection; or his mathematical thoroughness in ascertaining the laws of their propagation. A synopsis of his equations will be found clearly cited in Preston's "Theory of Light," as well as in other books. I translated some of his papers into "Nature." And never was there the smallest iota of jealousy between us, or anything but cordial and frank appreciation. Maxwell and Hertz are the essential founders of the whole system of wireless. That is to say, they constructed the foundations solidly and well. Of the super-structure—splendid as it is now—we are as yet far from seeing the completion.

In March, 1889, I lectured to the Royal Institution on "The Oscillatory Discharge of a Leyden Jar," and incidentally exhibited many of the effects of waves, both on wires and in free space, with overflow and recoil effects. But there was nothing akin to *signalling* exhibited in this lecture, as there was in the subsequent 1894 one.

Nevertheless Sir William Crookes, on the strength of these experiments—which he mentions—wrote a brilliant article in the *Fortnightly Review* for February, 1892 (Vol. 51, page 173), in which he foreshadows actual telegraphic accomplishment by that means, and indicates also the possibility of tuning or selective telegraphy, which was not actually born till 1897. He is evidently impressed with the experiments both of Hertz and of myself, and he quotes from my Phil. Mag. Paper of August, 1888, in confirmation and illustration of his prevision. For he says—after speaking of choosing wave-length with which to signal to specific people—"This is no dream of a visionary philosopher. All the requisites needed to bring it within the grasp of daily life are well within the possibility of discovery, and are so reasonably and clearly in the path of researches now being actually prosecuted in every capital of Europe, that we may any day expect to hear they have emerged from the realm of speculation into that of sober fact." And then he goes on: "Even now indeed telegraphy without wires is possible within a restricted radius of a few hundred yards, and some years ago I assisted at experiments where messages were transmitted from one part of a house to another without any intervening wire, by almost the identical means here described."

That article appeared in 1892, and was an inspiration of genius. Too little appreciation is felt today for the brilliant surmises and careful and conscientious observations of a great experimental worker like William Crookes. And on some of it orthodox science still turns its weighty and respectable back.

### OTHER METHODS OF DETECTING WAVES

In 1889 I had come across the effect of cohesion under electric impetus, and employed it to ring a bell under the stimulus of the overflow of a Leyden-jar, as described in my paper to the Institution of Electrical Engineers in 1890.

In 1893 I heard of Branly's filings-tube—an independent discovery of M. Branly, which really constituted an improvement on the first rough coherer idea. I think I heard of it through a lecture and demonstration by Dr. Dawson Turner of Edinburgh. What I had called a coherer was not this, but a needle point arrangement, or the end of a spiral spring touching an aluminum plate, which was and is extremely sensitive, but rather unmanageable.

With a Branly's filings-tube I made many more experiments, developing the subject; and on the untimely death of Hertz I determined to raise a monument to his memory by a lecture at the Royal Institution on these experiments (Friday evening, June 1st, 1894), which I styled "The Work of Hertz,"—meaning that it was a direct outcome and development inspired by that work. I soon found that the title was misleading, so that in the next edition I changed it into "The Work of Hertz and some of his Successors," and subsequently changed it still further into "Signalling across Space without Wires"; for that of course is what was being done all the time. The depression of a key in one place produced a perceptible signal in another—usually the deflection of a spot of light—and, as I showed at Oxford, also in 1894, employing a Thomson marine speaking galvanometer lent me by Alexander Muirhead, a momentary depression of the key would produce a short signal, a continued depression a long signal—thus giving an equivalent for the dots and dashes of the Morse Code—if the filings-tube were associated with an automatic tapper-back. One form of such tapper-back was then and there exhibited—a trembler or vibrator being mounted on the stand of a receiving filings-tube. This was subsequently improved into a rotating steel wheel dipping into oiled mercury. Our aim was to get signals on tape with a siphon recorder, and not be satisfied with mere telephonic detection. We succeeded; but more rapid progress would have been made had we stuck to the telephone, as wiser people did.

### TELEGRAPHY 1894 TO 1896

My Royal Institution (1894) lecture was heard by Dr. Muirhead, who immediately conceived the desire to apply it to practical telegraphy. And when my lecture was published—as it was in *The Electrician,* with diagrams roughly depicting the apparatus shown, drawn (some of them) skilfully but not always quite correctly, by the then editor of *The Electrician,* Mr. W. H. Snell, it excited a good deal of interest; stimulating, to the best of my belief, Captain, now Admiral Sir Henry Jackson, Professor Righi, and Admiral Popoff, to their various experimental successes which have been elsewhere described.

To show that my work of 1894, though published, and therefore unpatentable in this country, was recognized as of value and as patentable for telegraphic purposes in the United States, I appeal to my U. S. Patent (674,846, dated May 21st, 1901—application filed December 20th, 1897), which was granted, after long discussion, on the strength of work recorded in 1894, since it could be proved to have been introduced into the United States in that year—a year mentioned in the Specification, line 100.

I was too busy with teaching work to take up telegraphic or any other development; nor had I the foresight to perceive, what has turned out to be, its extraordinary importance to the navy, the merchant service, and indeed land and war service, too. But fortunately in Italy there was a man of sufficient insight to perceive much of this, and with leisure to devote himself to its practical development.

In 1896 Signor Marconi brought the subject to the notice of the British telegraphic authorities, and the subject began to assume practical and commercial importance. Its further progress during the present century is known to all. My patent of May, 1897, for tuned or selective telegraphy has been legally established by Lord Moulton as the fundamental tuning patent. It was extended in 1911 for another seven years by Lord Justice Parker, and was acquired by the Marconi Company.

*The end*

## I Want to Know

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will be seen, this will open the field of radio to a large number of persons to whom it is now more or less of a mystery.

Another great factor in the advancement of the radio art will be the retransmission of concerts, which have been broadcast by electric-light lines, it being done in a way similar to that discussed in the February issue of RADIO NEWS.

### NOISE IN PHONES

(779) Mr. C. R. Doremus, c/o Ohila Electric Co., 23d & Market Sts., Philadelphia, Pa., writes:

Q. 1. When I use my radio receiving set I get a severe rattle in the phones, which sounds as if there is an open circuit somewhere in the set. However, I have not been able to locate any such condition and should like to know if you can assist me.

A. 1. From your description, we would strongly suspect the phone cords as being the source of your trouble. It may be that there is a broken strand in one of them, which makes contact as the cord is shifted by the movements of the wearer. Since you say that you have checked up all your connections, it would seem that this is the only possible place to look for such trouble.

### ALTERNATING CURRENT ON VACUUM TUBES

(780) Mr. Walter Curtin, 1425 Broad Street, Hartford, Conn., asks:

Q. 1. How can I use alternating current for lighting the filament of my single-tube receiving set?

A. 1. Alternating current used on the filament of a single tube is very seldom satisfactory, due to the hum which will be produced in the receivers of such a set. Circuit diagrams for this circuit, which give a certain amount of satisfaction, have appeared in various past issues of the RADIO NEWS.

### SHIELDING

(781) Mr. Edward E. Craven, 159 Lincoln Park Drive, Youngstown, O., writes:

Q. 1. When the back of the panel of a radio receiving set is covered with tin foil, is any connection made to this covering?

A. 1. The tin foil, when placed in the position you mention, is used to shield the instruments and is connected to the ground. This may be done by connecting it directly to the ground-post on the receiving set.

## Enlarging the Classroom

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### RADIO CANNOT REPLACE THE TEACHER

"Radio can never replace the actual teacher in her class room," said Mr. Burnham, principal of the Haaren High School, "for after all, the most important thing about a teacher is her personality, and this is not obvious to a child who cannot see her. The idea of having pupils come up to the transmitter and talk in a regular class recitation is good, as the others can then hear the questions asked, corrections made, and instruction given."

To this Dr. Gustave Straubenmuller, Associate Superintendent of Schools of New York City, agreed, adding, however, that a