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TELEGRAPHING WITHOUT WIRES.

A POSSIBILITY OF ELECTRICAL SCIENCE.

By H. J. W. Dam.

I.

THE MYSTERIES OF THE ETHER.—AN INTERVIEW WITH DR. BOSE.

A YEAR has elapsed since Röntgen gave us the new photography. To-day, on the same general lines, we are confronted with something more wonderful, more important, and more revolutionary still—the new telegraphy. Two gentlemen have come to London at the same time from different countries to tell the same story, namely, that telegraphy needs no wires, and that through walls, through houses, through towns, through mountains, and, it may possibly happen, even through the earth, we can send dispatches to any distance with no other apparatus than a sender and a receiver, the communication taking place by means of electric waves in the ether.

The English language uses the word "ether" in two totally different senses. The first is as the name of a colorless liquid, easily vaporized, the vapor of which is used to allay pain. This liquid has nothing whatever to do with the present subject, and should be put entirely out of the mind. The second use of the word is as the name of a substance colorless, unseen, and unknown, we will say—except in a theoretical sense—which is supposed to fill all space. The original conception of this substance is as old as Plato's time. Newton, Descartes, all the beacon lights of science through the ages, have assumed its existence, and all modern physical students accept it. The ether theory of the formation of worlds must be familiar to many. In fact, up to twenty years ago, as the men of to-day who were then in college will remember, the word "ether" was a familiar name, a harmless necessary conception, a great convenience in bridging a tremendous void in science which nobody knew anything about or ever would know anything about, so far as could then be seen.

But the electrical advance in the last twenty years has been most extraordinary. Invention and experiment have daily, if not hourly, thrown open new doors in the electrical wing of the temple of truth. And now, at the close of the nineteenth century, the great mass of new facts concerning light, electricity, inaudible sound, invisible light, and the Lenard and Röntgen rays; the eager inquiry, based upon new discoveries, into the properties of living matter, crystallization, the transference of thought, and the endeavor to establish scientifically the truth of certain great religious concepts—all the special sciences thus represented, marching abreast of one another along the old Roman road of science, which leads no one knows whither, have come upon a great high wall blocking the way completely in all directions. It is an obstacle which must be conquered in whole or in part before science can go any farther. And upon the wall, as upon the wall in the palace of Babylon, is a strange and as yet unintelligible inscription—the mysterious word "ether." What new and great dis-

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coveries lie beyond this wall, no one knows; but more than one high authority believes that these discoveries will startle the twentieth century more greatly than the nineteenth has been startled.

To suggest, in the crudest possible fashion, how ether is at present regarded by scientists, let the reader imagine that the whole universe, to the uttermost stars, is a solid mass of colorless jelly; that in this colorless jelly the stars, solar systems, and space-worlds are embedded, like cherries in a mould of fruit jelly for the table; that this jelly, though it is at present believed to have density and rigidity, is so inconceivably thin that it soaks completely through all the cherries and through everything upon them; that the minute atoms composing the cherries are so large when compared with the thinness of the jelly that each atom is surrounded by the jelly just as the whole cherry is surrounded; that the jelly is continuous, without a point in the whole universe at which there is a single break in its continuity; that, consequently, if we tap the glass containing the jelly on the table a quiver will run through the jelly completely: the cherries will not quiver, but the quiver will run through them, the jelly which has soaked into them carrying the quiver through them as easily as through the spaces between the cherries; that, in short, this jelly or ether is a universal substance so thin that it permeates everything in space and on earth—glass, stone, metal, wood, flesh, water, and so on—and that only by its quivering, only by the waves in it which light rays, electric rays, and Röntgen rays excite, are these rays enabled to travel and produce their various results. Light enables us to see. But all the light which comes to us from any object and enables us to see that object comes by means of waves in the ether. These light waves pass through glass; that is, the wave continues right through the glass in the ether which lies between the particles of glass. From causes yet undefined, the ether carries light rays through certain substances, but will not carry Röntgen rays through those substances. Röntgen rays, on the other hand, are carried through substances which stop light. Electric rays, or electric rays of a low rate of vibration, differ in some respects from both light and Röntgen rays in the substances which they can traverse. Electric rays of high oscillation show other differences still. Other classes of rays or waves which remain to be discovered, and which will also have different properties, will doubtless be found to receive different treatment from the ether, the sum and substance of the whole matter being that the comparatively new research for new rays has now concentrated the whole scientific world's attention on the ether, its different treatment of different rays affording to-day a means of studying it that has never been enjoyed before.

DR. JAGADIS CHUNDER BOSE.

The density of the ether has been calculated from the energy with which the light from the sun strikes the earth. As there are twenty-seven ciphers after the decimal point before the figures begin, its density is of course less than anything we can imagine. From its density its rigidity has been calculated, and is also inconceivably small. Nevertheless, with this small rigidity and density it is held to be an actual substance, and is believed to be incompressible, for the reason that otherwise it would not transmit waves in the way it does. As it is believed to fill all the interplanetary space, many profound and searching experiments have been made to determine whether, as the earth moves in its orbit through space at the rate of nineteen miles per second, it passes through the ether as a ship goes through the water, pressing the ether aside, or whether the ether flows through the earth as water flows through a sieve forced against it. Through the elusive character of the substance none of these experiments have as yet produced any very satisfactory results.

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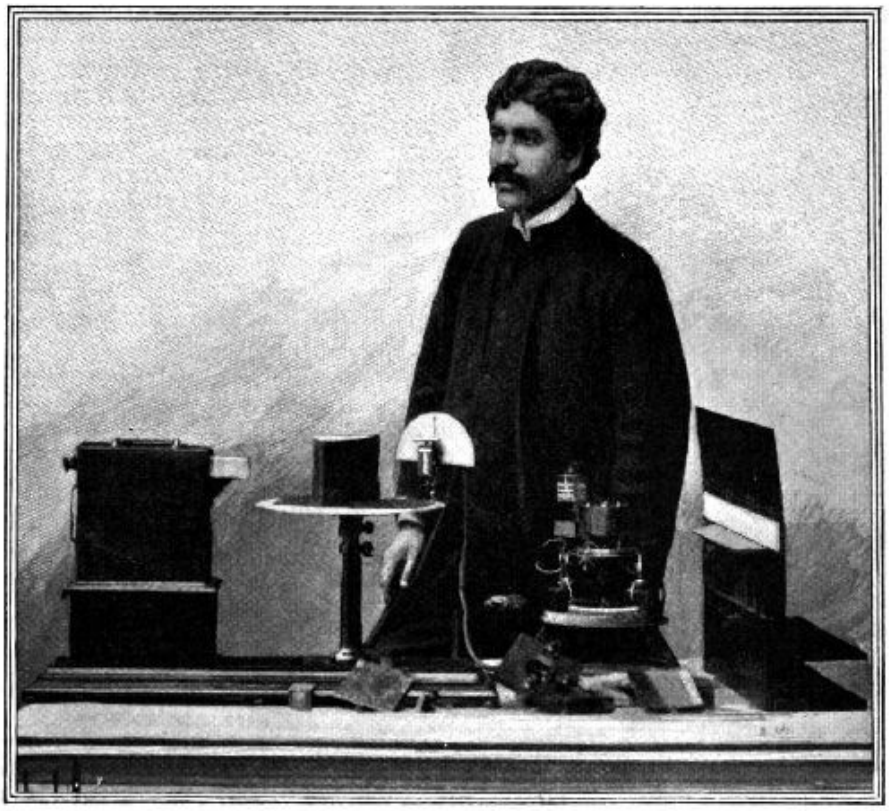

DR. BOSE AND HIS NEW APPARATUS FOR THE STUDY OF ELECTRIC RADIATION.

It has been found, however, that the ether enclosed in solid bodies is much less free in transmitting waves than the ether in the air. Thus glass, alone, transmits light waves at the rate of about three miles per second. The ether in the glass transmits them at a rate 40,000 times greater, or about 120,000 miles per second, while the ether in the air transmits them at the rate of 192,000 miles per second. The reason why the ether in the glass and other solids transmits more slowly than that outside is a mystery at present; but, as said before, this is one of a mass of gathered facts which have now placed science in a position from which it is possible to attack the mystery of the ether.

Electric waves were discovered by an American, Joseph Henry, in Washington, D. C., in the year 1842. He did not use the phrase "electric waves"; but he discovered that when he threw an electric spark an inch long on a wire circuit in a room at the top of his house, electrical action was instantly set up in another wire circuit in his cellar. There was no visible means of communication between the two circuits, and after studying the matter he saw and announced that the electric spark set up some kind of an action in the ether, which passed through two floors and ceilings each fourteen inches thick, and caused induction—set up what is called an induced current—in the wires in the cellar. This fact of induction is now one of the simplest and most commonplace phenomena in the work of electricians. Edison has already used it in telegraphing to a flying train. Hertz, the great German investigator, developed the study of these waves, and announced that they penetrated wood and brick but not metal. Strange to say, however, considering the number of brilliant electricians in the more western countries to-day, and the enormous amount of interest in and experimental investigation of electrical phenomena therein, it has been left to a young Italian, Guglielmo Marconi, to frame the largest conception of what might be done with electric waves and to invent instruments for doing it. Marconi's story will be told with the utmost simplicity and care. But it sounds like a fairy tale, and if it had not for a background four grave and eager committees representing the British Army, the British Navy, the British Post-Office, and the British Lighthouse Service, which are now investigating it, it might well be doubted.

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Before introducing Marconi, however, the attention of the reader is called, for several good reasons, to his immediate predecessor in London, Dr. Jagadis Chunder Bose. Dr. Bose is a Hindoo, and is at present the Professor of Physics in the Presidency College, Calcutta. He is a graduate of Cambridge, with the degree of Master of Arts, and has been honored with the degree of Doctor of Science by the University of London, as a recognition of certain inventions regarding electric waves which have won him the highest praise in the Royal Society, the British Association, and elsewhere. It should be said at once that Dr. Bose has no interest in the new telegraphy. Though he has been named as its discoverer, he has done little more in it than was announced by Hertz in 1888. He has done great work in his own field, but it is that kind of detail work which is only understood and appreciated by other investigators, and in the matter of telegraphy his statements are here given largely as a preparation for and corroboration of those of Marconi.

Dr. Bose, as he sits in the drawing-room of his temporary London home in Maida Vale, is a man of medium height, thirty-six years old. His father was a distinguished scholar and mathematician. His manner is modest and very reserved. He dislikes publicity in the extreme. To be interviewed for publication, and to have his delicate, complex, and ultra-technical work described in the non-technical language of a popular magazine is something from which he shrinks visibly. Consequently, though he submits to the ordeal of an interview, he disclaims all responsibility for the statements made in it and the language in which these statements are expressed. If any man of science, therefore, reads this article, it is understood that he is to base no opinion or criticism upon it; but if he is interested in Dr. Bose's work, he is requested to refer to the Journal of the Royal Society for December, 1895, and June, 1896, and the Journal of the British Association meeting of this year. The ethereal waves of courtesy between speaker and writer having vibrated to the conclusion of this happy understanding, Dr. Bose says:

"My special work for the last three years has been the study of electric radiation; more particularly the comparatively slow electric waves, varying between about one-quarter and about one-half an inch in length. My results were represented in the complete apparatus which I had the honor of describing before the British Association, an apparatus for the verification of the laws of reflection, refraction, selective absorption, interference, double refraction, and polarization of these waves. I also contributed a paper to the Royal Society in December, 1895, on the determination of the indices of refraction of various substances for the electric ray, and another in June of this year [1896] on the determination of the wave length of electric radiation by means of a diffraction grating. These have been duly reported and discussed in the scientific journals, and I fear would not be appreciated or understood outside of their circle."

This is too evident a fact to be disputed, and the conversation is turned to the wave-telegraphing in Calcutta.

"That," said Dr. Bose, "was simply an incident in the course of a popular lecture, an illustration of the ability of electric rays to penetrate wood and brick. My radiator was a small platinum ball between two small platinum beads, connected with a two-volt storage battery. By pressing a key the ball was made to spark and start an electric wave which progressed outward through the ether in the air. Popularly speaking, an electric wave in the ether, though it moves in all directions, progresses outward like a wave produced by dropping a stone in a pond. The water wave can be seen. An electric wave is, of course, invisible. Supposing a cork on the surface of the pond at any distance from the place where the stone was dropped, the cork, when the wave reaches it, will bob up and down. Now, though we cannot see the electric wave, we can devise an arrangement which indicates the presence of the wave as the cork does. This mechanical arrangement detects and records the passage of the wave.

"This is the whole idea simply expressed; an electric radiator and a receiver for the waves. My receiver was in a room seventy-five feet distant from the radiator, with three walls of brick and mortar, eighteen inches thick, between them. The electric wave thus induced penetrated the walls and traversed this distance with sufficient energy, when it was converted, to fire a pistol and ring a bell, these being the simplest and best evidences of its reception that I could devise."

"Do you mean to say that the wave, outgoing in all directions, had this effect when a very small part of it reached the receiver?"

"No. A large portion of it was concen-

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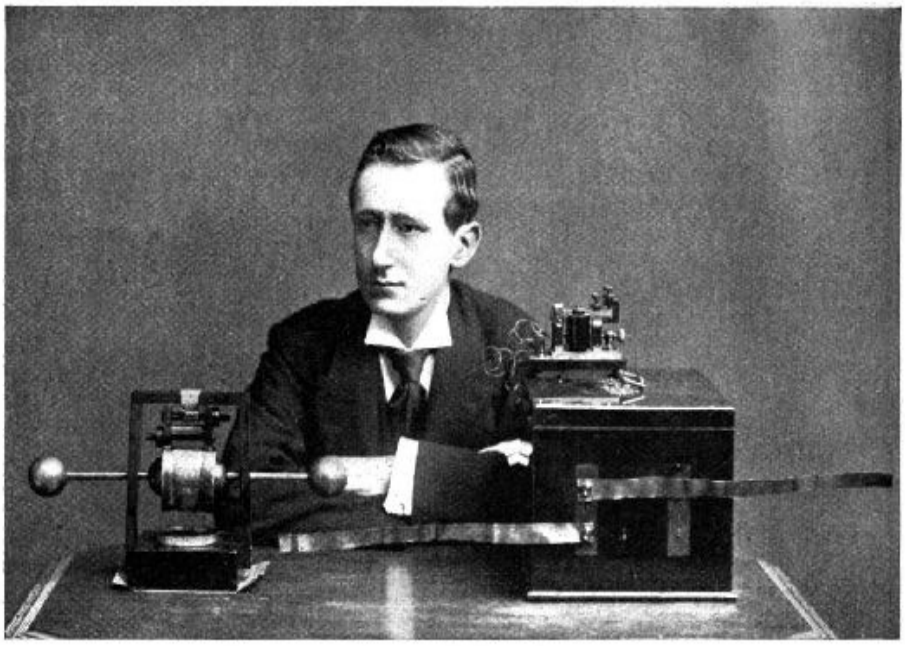

SIGNOR MARCONI AND HIS EARLIER APPARATUS FOR TELEGRAPHING WITHOUT WIRES.

From a photograph taken by Russell & Sons, London, expressly for McCLURE'S MAGAZINE.

trated, as rays of light are concentrated, by a lens placed close to the radiator. This received a large portion of the wave and bent all the rays which fell upon it into parallel lines, thus making a beam proceeding outward in a straight line through the walls to the receiver. I have made and used various concentrating lenses, the best materials being sulphur, ebonite, and pitch."

"Instead of ringing a bell or firing a pistol, could a telegraph message have been sent with it and received through the walls?"

"Certainly; there would be no difficulty about that."

"What is the law describing the intensity or power of the wave at any given distance?"

"Exactly the same as the law of light. Generally speaking, these electric waves act like rays of light."

"Do you mean to say, then, that you could telegraph in this way through houses as far as you could send a beam of light, say with a search-light?"

"I would not like to say it in these terms, but, generally speaking, such is the fact."

"How far could this ether dispatch, so to speak, be sent?"

"Indefinitely. That depends on the exciting energy. At Salisbury Plain, I am told, electric rays were sent with a parabolic reflector a quarter of a mile through the ether in the air, and then reproduced as Morse signals by a relay."

"But in telegraphing through houses—across a block of houses, for instance—supposing the lens and reflector properly aimed at the receiver, what would stop the rays?"

"Metal stops the waves I have been working with. Also water. They will penetrate wood, brick, glass, granite, rock, earth, and retain their properties."

"How far have they been successfully sent?"

"Through the air? I believe a mile. Through three walls? A distance of seventy-five feet, so far as I know."

"What is their relation with the Röntgen rays?"

This brought up the whole question of the differences in rays. Without committing Dr. Bose to exact language it may be said that the rays with which he is working are of comparatively slow vibrations, representing about fifty billion oscillations per second. Those ether vibrations which lie between 200 trillions and 400 trillions of vibrations in a second are heat rays, producing the sensation of warmth. Above 400 trillions and as far as 800 trillions per second the vibrations are light rays, producing the sensation of light. According to their rapidity, these light rays produce a gradation of colors. The lowest num-

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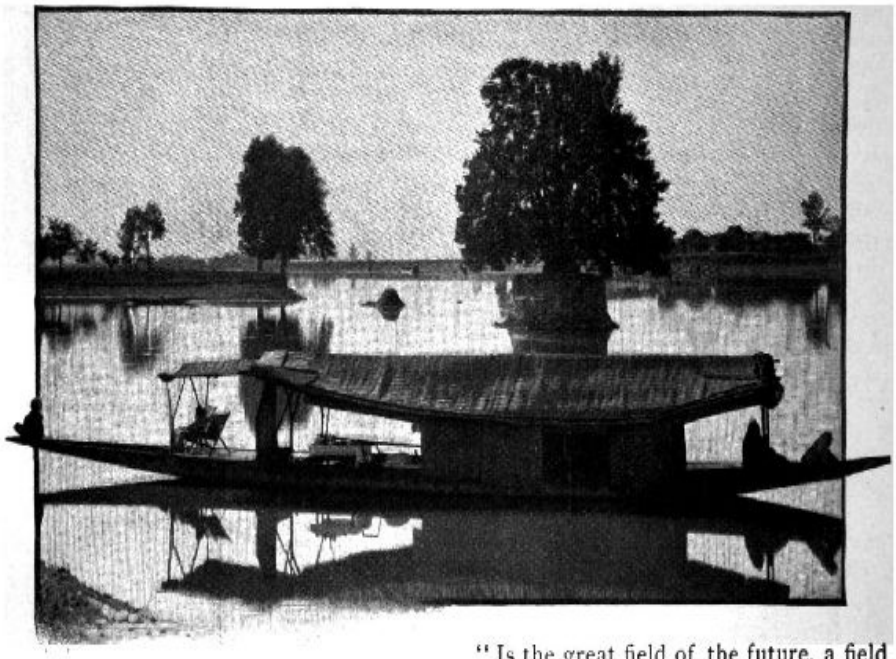

DR. BOSE'S HOUSEBOAT.

bers of light vibrations give our eyes the sensation of red, and the scale mounts through the yellows, greens, and blues, to the violets. When the number of vibrations passes 800 trillions per second they become invisible. The human eye is limited in its perceptive power to vibrations between 400 trillions and 800 trillions. Below and above these numbers lie the regions of what are called "invisible light rays." The same is true of the ear. Sound is conducted by air vibrations. When these vibrations are below sixteen per second or above 32,000 per second, they make no impression on our ear drums and our consciousness. These are the so-called regions of "inaudible sound."

"I think the Röntgen rays," said the doctor, "lie above 800 trillions of vibrations per second."

"And what other unknown forces also lie in that upper region?"

"That remains for the future to develop. It is impossible to forecast what new facts the study of the ether is destined to give us. It is a tremendous field, from which we may expect new facts and new forces."

"New forces?"

"That is merely a phrase. Force is a confusing word. Say new forms of energy, enabling us to accomplish results now impossible—results now unthought of and unthinkable."

"Then the ether—"

"Is the great field of the future, a field whose products no one can imagine or attempt to conceive."

"Have you ever considered thought impulses generated by the brain, with reference to their radiation and reception by other brains, over small or great distances?"

"I have."

"What is your opinion with reference to thought transference?"

"I must decline to express it. There is no experimental basis upon which to make a satisfactory statement."

Dr. Bose would say no more for publication. Opinions and convictions as to the unexplored regions of physical phenomena are the luxury of every scientific thinker, but he does not express them except under the seal of confidence. It was a delight, however, to hear this wise man of the East, thinking and speaking the language of exact science, discuss the region of the occult. That Theosophy and Christian Science will shortly hug the ether to their breasts as the undoubted vehicle of their claimed marvels is entirely certain. The present difficulty with regard to thought phenomena is that the human body is not a machine and cannot be used in an exact way to exact ends in experiments. That some one ingenious enough to accomplish this will ultimately appear is highly probable, however, and that the silent influence of brain on brain will in time be measured under mathematical conditions is as reasonable to expect as it would be rash to deny.

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II.

THE NEW TELEGRAPHY.—INTERVIEW WITH SIGNOR MARCONI.

Guglielmo Marconi, whose name will doubtless be often heard in the years which lie before us, is a young Anglo-Italian. He was born in Bologna, Italy, and will be twenty-two years old next April. His father is an Italian gentleman of independent means, and his mother is an English lady connected with several well-known English families. He is a tall, slender young man, who looks at least thirty, and has a calm, serious manner and a grave precision of speech, which further give the idea of many more years than are his. He is completely modest, makes no claims whatever as a scientist, and simply says that he has observed certain facts and invented instruments to meet them. Both the facts and the instruments are new, and the attention they are at present exciting is extraordinary.

This attention is largely due to the enterprise and shrewdness of Mr. W. H. Preece, the able chief of the electrical department of the British postal system. Marconi's invention is a year old, but he could obtain no satisfactory recognition of it in his own country. Mr. Preece, however, had for a long time been at work upon the problem of telegraphing through the air where wires were not available. Last year the cable broke between the mainland and the island of Mull. By setting up lines of wire opposite each other on the two coasts, he was enabled to telegraph by induction quite successfully over the water and through the air, the distance being four miles and a half. He sent and received in this way 156 messages, one of them being 120 words in length. Ordinary Morse signals were used, the dispatches being carried by the ether in the air. In a late lecture at Toynbee Hall, Mr. Preece admitted that Marconi's system, which is electro-static, far surpassed his own, which is electro-magnetic. He expressed the fullest faith in Marconi, describing his inventions as new and beautiful, scientifically speaking, and added that he (Mr. Preece) had been instructed by the postal department to spare no expense in testing them to the fullest degree. It will be understood, therefore, that it is due to Mr. Preece that Marconi has received the fullest recognition in England and that engineers from four different departments of the English government are now supervising his work.

Marconi was educated at Leghorn, Florence, and Bologna, and has more recently been following his special study at his home in the last named city. He speaks English perfectly, and said, in his London home, in Westbourne Park: "For ten years past I have been an ardent amateur student of electricity, and for two years or more have been working with electric waves on my father's estate at Bologna. I was using the Hertz waves from an apparatus which you may photograph, a modified form of the apparatus for exciting electric waves as used by Hertz. My work consisted mainly in endeavoring to determine how far these waves would travel in the air for signalling purposes. In September of last year, working a variation of my own of this apparatus, I made a discovery."

"What was the discovery?"

"I was sending waves through the air and getting signals at distances of a mile, or thereabouts, when I discovered that the wave which went to my receiver through the air was also affecting another receiver which I had set up on the other side of the hill. In other words, the waves were going through or over the hill."

"Do you believe that the waves were going through the hill?"

"That is my present belief, but I do not wish to state it as a fact. I am not certain. The waves either went through the hill or over it. It is my belief, based on many later experiments, that they went through."

"And what was the thickness of the hill?"

"Three-quarters of a mile."

"And you could send a dispatch with Morse signals through this hill or over it to some one on the other side?"

"With ease."

"What followed?"

"What followed was the conception and completion of my special invention, the instruments I have been using at Salisbury Plain in the presence of the Royal engineers. I find that while Hertz waves have but a very limited penetrative power, another kind of waves can be excited with the same amount of energy, which waves, I am forced to believe, will penetrate anything and everything."

"What is the difference between these and the Hertz waves?"

"I don't know. I am not a scientist, but I doubt if any scientist can yet tell.

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I have a vague idea that the difference lies in the form of the wave. I could tell you a little more clearly if I could give you the details of my transmitter and receiver. These are now being patented, however, and I cannot say anything about them."

"How high an alternation were you using?"

"About 250,000,000 waves per second."

"Do these waves go farther in air than Hertz waves?"

"No. Their range is the same. The difference is in penetration. Hertz waves are stopped by metal and by water. These others appear to penetrate all substances with equal ease. Please remember that the amount of exciting energy is the same. The difference is in the way they are excited. My receiver will not work with the Hertz transmitter, and my transmitter will not work with the Hertz receiver. It is a new apparatus entirely. Of course the waves have an analogy with the Hertz waves and are excited in the same general way. But their power is entirely different. When I am at liberty to lay my apparatus and the phenomena I have observed before the scientists, there may be some explanation, but I have been unable to find any as yet."

"How far have you sent a telegraphic dispatch on the air?"

"A mile and three-quarters. We got results at two miles, but they were not entirely satisfactory. This was at Salisbury Plain, across a shallow valley between low hills."

"What battery were you using?"

"An eight-volt battery of three amperes, four accumulators in a box."

"Did you use a reflector?"

"Yes. It was a roughly-made, copper parabolic reflector with a mistake of an inch in the curve. I shall not use one in future, however. A reflector is of no value."

"Nor a lens?"

"Nor a lens."

"Why not?"

"Because the waves I speak of penetrate everything and are not reflected or refracted."

After Professor Röntgen's distances of a few yards and limitations as to substances this was rather stunning. Marconi, however, was entirely serious and visibly in earnest in his statement.

"How far have you verified this belief?"

"Not very far, but far enough, I think, to justify the statement. Using the same battery and my transmitter and receiver we sent and received the waves, at the General Post-Office building, through seven or eight walls, over a distance of one hundred yards."

"How thick were the walls?"

"I can't say. You know the building, however. It is very solidly constructed."

"And you sent an ordinary telegraphic dispatch by those signals?"

"No. We did not do that, though we could have done so. We were working with agreed signals, and we obtained the taps which we sought and repeated them till there was no room for doubt."

"Do you think that sitting in this room you could send a dispatch across London to the General Post-Office?"

"With instruments of the proper size and power, I have no doubt about it."

"Through all the houses?"

"Yes."

We were in a drawing-room in Talbot Road, Westbourne Park, a distance of about four and one-half miles from the General Post-Office.

"And how far do you think a dispatch could thus be sent?"

"Twenty miles."

"Why do you limit it to twenty miles?"

"I am speaking within practical limits, and thinking of the transmitter and receiver as thus far calculated. The distance depends simply upon the amount of the exciting energy and the dimensions of the two conductors from which the wave proceeds."

"What is the law of the intensity at a given distance?"

"The same as the law of light, inversely as the square of the distance."

This means that whatever the energy with which the waves are sent out, their power at, say twenty feet, when compared with their power at ten feet would be in the proportion of 10×10 to 20×20, or one-fourth, in this special instance.

"Do you think they are waves of invisible light?"

"No; in some respects their action is very different."

"Then you think these waves may possibly be used for electric lighthouses when fog prevents the passage of light?"

"I think they will ultimately be so used. A constant source of electrical waves, instead of a constant source of light waves, and a receiver on the vessel would indicate the presence of the lighthouse and also its direction."

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"But would not the fog interfere with the passage of the waves?"

"Not at all."

"Nor metal?"

"Nothing affects them. My experience of these waves leads me to believe that they will go through an ironclad."

"Concerning the size of the apparatus, how large is it?"

"The transmitter and receiver we have been using at Salisbury Plain and at the post-office are each about"—he held up his hands to indicate the dimensions—"say fifteen inches by ten by eight. Small ones, effective enough for ordinary purposes, can be made of half that size."

"What are you working on at present?"

"Mr. Preece and I are working at Penarth, in Wales, to establish regular communication through the air from the shore to a light-ship. This will be the first direction in which my apparatus is utilized—communication with the light-ships. The light-ships lie off this coast at any distance from half a mile to twenty miles or more."

"What length of waves have you used?"

"I have tried various lengths, from thirty meters down to ten inches."

"Why would not these waves be useful in preventing the collision of ships in a fog?"

"I think they will be made use of for that purpose. Ships can be fitted with the apparatus to indicate the presence of another ship so fitted, within any desired distance. As soon as two approach within that distance the alarms will ring on each ship, and the direction of each to the other will be indicated by an index."

"Do you limit the distance over which these waves can be sent?"

"I have no reason to do so. The peculiarity of electric waves, which was noted, I believe, by Hertz, is the distance they travel when excited by only a small amount of energy."

"Then why could you not send a dispatch from here to New York, for instance?"

"I do not say that it could not be done. Please remember, however, that it is a new field, and the discussion of possibilities which may fairly be called probabilities omits obstacles and difficulties which may develop in practical working. I do not wish to be recorded as saying that anything can actually be done beyond what I have already been able to do. With regard to future developments I am only saying what may ultimately happen; what, so far as I can now see, does not present any visible impossibilities."

"How large a station would be necessary, assuming the practicability, to send a message from here to New York?"

"A station the size of this room in square area. I don't say how high." The room was twenty feet square.

"What power?"

"Fifty or sixty horse-power would, I think, suffice."

"What would be the cost of the two stations completed?"

"Under £10,000, I think."

"Would the waves go through the ether in the air or through the earth?"

"I cannot say with certainty. I only believe they would go that distance and be recorded."

"You say that no lens or reflector is of value. Then the waves would go outward in all directions to all places at the same distance as New York?"

"Yes."

"Do you think that no means will ever be found to stop this progress in all directions and concentrate it in one direction?"

"On the contrary, I think that invention will give us that."

"Do you see any way of accomplishing this?"

"No, not as yet."

"In what other directions do you expect your invention to be first utilized?"

"The first may be for military purposes, in place of the present field telegraph system. There is no reason why the commander of an army should not be able to easily communicate telegraphically with his subordinate officers without wires over any distances up to twenty miles. If my countrymen had had my instruments at Massowah, the reinforcements could easily have been summoned in time."

"Would the apparatus be bulky?"

"Not at all. A small sender and receiver would suffice."

"Then why would it not be equally useful for the admiral of a fleet in communicating with his various ships?"

"It would," said Marconi, with some hesitation.

"Is there any difficulty about that?"

"Yes," said he, very frankly, but in a way which set the writer to wondering. "I do not know that it is a difficulty yet, but it appears to be."

The writer pondered the matter for a moment. Then he asked: "Do you remember Hertz's experiment of exploding gunpowder by electric waves?"

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"Yes."

"Could you not do the same from this room with a box of gunpowder placed across the street in that house yonder?"

"Yes. If I could put two wires or two plates in the powder, I could set up an induced current which would cause a spark and explode it."

"Then if you threw electric waves upon an ironclad, and there happened to be two nails or wires or plates in the powder magazine which were in a position to set up induction, you could explode the magazine and destroy the ship?"

"Yes."

"And the electric lighthouses we are speaking of might possibly explode the magazines of ironclads as far as light from a lighthouse could be seen?"

"That is certainly a possibility. It would depend on the amount of the exciting energy."

"And the difficulty about using your instruments for fleet purposes—"

"The fear has been expressed that in using the instruments on an ironclad the waves might explode the magazine of the ship itself."

It is perhaps unnecessary to say that this statement was simply astounding. It is so much of a possibility that electric rays can explode the magazine of an ironclad, that the fact has already been recognized by the English Royal engineers. Of all the coast defences ever dreamed of, the idea of exploding ironclads by electric waves from the shore over distances equal to modern cannon ranges is certainly the most terrible possibility yet conceived.

Such are the astonishing statements and views of Marconi. What their effect will be remains to be seen. In the United States alone, considering the many able experimenters and their admirable and original equipments, like Tesla's dynamos, the imagination abandons as a hopeless task the attempt to conceive what—in the use of electric waves—the immediate future holds in store. The air is full of promises, of miracles. The certainty is that strange things are coming, and coming soon.

Because, underlying the possibilities of the known electric waves and of new kinds of electric waves, which seem to be numerous and various—underlying these is still the mystery of the ether. Here is a field which offers to those college students of to-day who have already felt the fascination of scientific research, a life work of magical and magnificent possibilities, a virgin, unexplored diamond field of limitless wealth in knowledge. Science knows so little, and seems, in one sense, to have been at a standstill for so long. Lord Kelvin said sadly, in an address at Glasgow the other day, that though he had studied hard through fifty years of experimental investigation, he could not help feeling that he really knew no more as he spoke than he knew fifty years before.

Now, however, it really seems that some Columbus will soon give us a new continent in science. The ether seems to promise fairly and clearly a great and new epoch in knowledge, a great and marked step forward, a new light on all the great problems which are mysteries at present, with perhaps a correction and revision of many accepted results. This is particularly true of the mystery of living matter and that something which looks so much like consciousness in certain non-living matter, the property which causes and enables it to take the form of regular crystals. Crystallization is as great a problem as life itself, but from its less number of conditions will perhaps be easier and earlier attacked. The best conception of living matter which we have at present, completely inadequate though it be, is that of the most chemically complex and most unstable matter known. A living man as compared to a wooden man responds to all kinds of impulses. Light strikes the living eye, sound strikes the living ear, physical and chemical action are instantly and automatically started, chemical decomposition takes place, energy is dissipated, consciousness occurs, volition follows, action results, and so on, through the infinity of cause and infinity of results which characterize life. The wooden man is inert. There is no chemical or physical action excited by any impulse from without or within. Living matter is responsive, non-living is not. The key to the mystery, if it ever comes, will come from the ether. One great authority of to-day, Professor Oliver Lodge, has already stated his belief that electricity is actually matter, and that if the ether and electricity are not one and the same, the truth will ultimately be found to be near that statement. If this be true, it will be a great and startling key to the now fathomless mystery of life.

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