THE PRACTICABILITY OF WIRELESS TELEGRAPHY.

By G. MARCONI.

THE first paid message by etheric wave telegraphy was sent by Lord Kelvin on June 3, 1898. The circumstances were these: Lord and Lady Kelvin and Lord Tennyson visited my Alum Bay station in the Isle of Wight. I explained the working of the apparatus and showed how messages were sent and received. Lord Kelvin was so much pleased with what he saw that he desired to send telegrams to various friends on the mainland of England, insisting first that he be permitted to pay for their transmission to Bournemouth at the rate of a shilling royalty per message in order to show his appreciation of the system and to illustrate its immediate availability for commercial use. Messages were sent by Lord Kelvin to Dr. MacLean, his chief assistant in the physical laboratory of the University of Glasgow, to Sir George Stokes, at Cambridge, and to Lord Rayleigh and Sir William Preece in London.

He has given his permission to reprint one of the messages—that to Sir George Stokes:

"Stokes, Lensfield Cottage, Cambridge. This is sent commercially paid at Alum Bay for transmission through ether, 1s. to Bournemouth, and thence by postal telegraph, 15d. to Cambridge.—Kelvin."

Lord Tennyson's message was to his nephew at Eton, and was as follows:

"Sending you message by Marconi's ether telegraph, Alum Bay to Bournemouth, paid commercially, thence by wire; very sorry not to hear you speak your Thackeray to-morrow.—Tennyson."

Commenting on these messages, the Electrical Review of June 17, 1898, says:

"With the achievement of these striking results, one ought not to wait long before a practical application is made of the wireless telegraph."

The success of my various trials led me to desire some opportunity of testing the practical application of my system on a more extended scale. It is difficult with a new invention such as mine to convince the public, even after the most successful trials, that here is something that should and must be adopted. In a sense it must create a new field for itself, as well as threaten established rivals in old fields. Not only was I compelled to construct a satisfactory apparatus for telegraphing wirelessly, but I had to show by actual tests some of the ways in which it could be utilized—all of which required much time and money.

I welcomed, therefore, the opportunity presented to me in July, 1898, of showing the practical serviceability of my new system in reporting the races of the Kingstown Regatta for the Dublin Express. One of my assistants fitted up a land station at Kingstown and another set up instruments on board the steamer "Flying Huntress." During the progress of the race the "Flying Huntress" followed the course of the yachts, and wireless messages were sent shoreward every ten or fifteen minutes. Several hundred bulletins were dispatched and not a single message had to be repeated.

The land station was in a room at the rear of the residence of the harbor-master. A wire from the instruments was carried to the top of a mast forty feet in height, on which was suspended a wire netting arrangement corresponding to that attached to the mast of the steamer. While the tug was running down to the Kish lightship the final preparations were made for receiving and transmitting messages. The test for finding whether the instruments were sensitive enough is a very simple one. The operator takes an ordinary electric bell, which he holds at some distance from the Morse indicator. He sends out from the battery of the bell a very tiny current, which is instantly responded to by a click, or by the sound of the bell on the indicator. This is of itself a very simple exhibition of wireless telegraphy.

At length all was in readiness, and the first message was received from the tug. The tape emerged with the familiar dots and dashes beautifully printed, ready to be translated for the reporter. As fast as the messages arrived they were telephoned to the office of the newspaper in Cork Hill. The operations were carried out with precision, and in a perfectly matter-of-fact manner.

"Is it an Irish characteristic," said a writer of the Express, who was a partner of the experiments, "or is it the common impulse of human nature, that when we find ourselves in command of a great force, by means of which stupendous results can be produced for the benefit of mankind, our first desire is to play tricks with it. No sooner were we alive to the extraordinary fact that it was possible, without connecting wires, to communicate with a station which was miles away and quite invisible to us, than we began to send silly messages, such as to request the man in charge of the Kingstown station to be sure to keep sober, and not to take too many 'whisky-and-sodas.' Playing in this way with the great invention probably enabled us to realize better the means at our command than we should have done if the mail boat, which passed us during the afternoon, had gone aground on the Kish Bank, and we had been able to avert a catastrophe by sending the news to shore. What really impressed us most of all was the fact that by depressing a key at Kingstown it was possible to ring a bell on the 'Flying Huntress' lying out in the neighborhood of the Kish light. It is on the same principle that one is more impressed by seeing a steam-hammer crack a nut than by seeing it crush a ponderous mass of ore."

The following portion of the description of one of the races sent by wireless telegraphy, and published in the Evening Mail and Daily Express, may be of interest:

"10:55. The 'Rainbow' having crossed the line before the gun was fired, was recalled, thereby losing 3¼ minutes.

"11:25. Time round Rosbeg buoy:

	H.	M.	S.
"Ailsa"	10	54	0
"Bona"	10	54	30
"Isolde"	10	58	0
"Rainbow"	10	59	0
"Astrild"	10	59	45

"The 'Ailsa' stayed, and went away on the port tack, as did also the 'Astrild.' After going a short distance, the 'Bona' also stayed, following the example of the other two, the 'Rainbow' and the 'Isolde' standing in under Howth.

"11:17. The 'Rainbow' and the 'Isolde' are still standing on the port tack, getting a nice breeze, the 'Isolde' being well to weather, the 'Ailsa' and 'Bona' having gone about on the same tack. 'Astrild' stood to southward to get the first of the ebb tide, and is now heading for the ship."

The race reports were entirely satisfactory in every respect, a large number of bulletins being sent, so that the race news was issued by the Express much earlier than it could have been in any other way. The "Flying Huntress" was constantly in motion, of course, but this made no difference in the legibility of messages. The distances crossed were small, from five to ten miles.

ON THE ROYAL YACHT.

About this time the Prince of Wales, then stopping with Lord Rothschild, had the misfortune to injure his knee most severely, so that he was confined to the royal yacht "Osborne" in Cowes Bay. The Prince had already expressed his interest in wireless telegraphy, and when the Lord Lieutenant of Ireland asked if communication between the royal yacht and Osborne House, Isle of Wight, could be established, I told him I would be delighted to make the necessary installations. We were not long in putting up our stations, and once up there was no hitch in the working either way.

The first telegram sent was:

"The Prince of Wales sends his love to the Queen, and hopes she is none the worse for being on board yesterday."

More than 150 messages were sent in the sixteen days I was on the royal yacht, many of great length. Every morning a bulletin was sent to the Queen, of which the following is a sample:

"August 4th.

"From Dr. Fripp to Sir James Reid.

"H. R. H. the Prince of Wales has passed another excellent night and is in very good spirits and health. The knee is most satisfactory."

"August 5th.

"From Dr. Fripp to Sir James Reid.

"H. R. H. the Prince of Wales has passed another excellent night, and the knee is in good condition."

The instruments on the yacht were operated and observed with great interest by the various distinguished persons aboard, notably the Duke of York, the Princess Louise, and the Prince of Wales himself. What seemed to amaze them above all was that the sending could go on just the same while the yacht was in rapid motion. The following message was sent on August 12 by the Prince of Wales while the yacht was steaming at a good rate off Bembridge, seven or eight miles from Osborne:

"To the Duke of Connaught.

"Will be pleased to see you on board this afternoon when the 'Osborne' returns."

The Electrical Review, August 19, 1898, gives some particulars as to the methods employed:

"The height of the mast on shore was 105 feet, and that of the top of the wire from the deck of the 'Osborne' was 83 feet. The yacht was moored in Cowes Bay, at a distance of nearly two miles from Osborne House, the two positions not being in sight of one another, as they were intercepted by a hill to the rear of East Cowes, which would have rendered signaling impossible between these two stations by means of any optical system. The messages varied in length, some having as many as 100 to 150 words, which is tantamount to a decent letter. Mr. Marconi's assistants were on duty from 9 A. M. until 7:30 P. M. without intermission during the whole period. Toward the end of the time, on the 10th instant, the yacht went on a cruise toward Sandown, and the messages were received correctly close off the 'Nab' lightship, which is moored off Bembridge. On the way there, when under steam, a lengthy message was received by the Prince from the Duke of Connaught, and the reply was successfully dispatched, though well out of sight of Cowes and Osborne. On the 12th instant the yacht cruised as far as the Needles, or rather outside, and went on until the instruments picked up Alum Bay station—the Needles Hotel—continuing in communication with them all the way, perfect messages being passed to and from. Communications were kept up throughout the cruise with either the Osborne station or the Wireless Telegraph Company's station at Alum Bay. During the whole of the cruise the 'Osborne' pole was obscured, and all the messages had to pass over land, and the Alum Bay pole was also obscured until coming right into the bay, on account of the station being situated very much below Heatherwood. The messages were sent to Alum Bay from a distance of nearly seven and a half miles, although the ground lying between was exceedingly high; in fact, it was about the highest land met with during the time. It was so high that the poles were screened by hundreds of feet.

"The Prince of Wales and other royalties gave expression to Mr. Marconi of their high appreciation of his system, and their astonishment at the perfection to which it had been brought. The Prince presented Mr. Marconi with a souvenir in the shape of a very handsome scarfpin, and wished him every success with his interesting invention."

One of the first and most commonly suggested uses for wireless telegraphy was for connecting lightships and lighthouses lying off shores on dangerous rocks or shoals with land stations. The year 1898 was to see the first installation of this nature, between the East Goodwin lightship, located over one of the most dangerous shoals on the British coast, and the South Foreland lighthouse, twelve miles distant. Communication was first established on Christmas eve, 1898, just about four years after my first experiments in wireless telegraphy were made in Italy, and the apparatus had remained in active and successful operation for nearly two years.

The Deputy Master of Trinity House has publicly stated that there was never a hitch from the start, and that he could indorse every word I said in my

lecture before the Institute of Electrical Engineers (March, 1899) regarding the practicability of the apparatus.

The Prince of Wales, as president of the Royal National Lifeboat Institution of Great Britain, expressed himself to the same effect, and said that at last a system had been found which would make navigation much safer and diminish the perils at sea.

Indeed, the apparatus had not long been installed before its value was shown most conclusively by the saving of the lightship herself. She was run down at 4 o'clock on the morning of March 3, 1899, by the steamer "R. F. Matthews," outward bound from London. The wireless telegraphy operator hurriedly called up South Foreland lighthouse, said that the lightship had been run into and was leaking. Lifeboats were sent out at once and the lightship was saved. Since then several other ships have gone upon the sands and assistance has been obtained by means of wireless telegraphy, the operators telegraphing ashore in each case.

The success of the installation between the East Goodwin lightship, and the South Foreland lighthouse awakened great interest, and the public began to see the practical uses to which the system might be put.

THE INTERNATIONAL YACHT RACE.

My first American tests were made during the International Yacht Races in 1899. Shortly after the Kingstown Regatta, the New York Herald arranged with me to report by wireless telegraphy the yacht races between the "Shamrock" and the "Columbia," which took place in New York Bay in October, 1899. There was nothing different, so far as my methods were concerned, in this work, from what had been accomplished long before, but the subject is worthy of mention in a chronology of the system because of the interest manifested in the trials by the American people. With three assistants, Mr. Bradfield, Mr. Densham and Mr. Richard, I arrived in New York on September 29, and on the following day was joined by another assistant, Mr. W. Bowden, who had been conducting experiments in Newfoundland, and had given demonstrations before the Houses of Parliament there. In a few days we had fitted up a land station at Navesink, near Atlantic Highlands, in New Jersey, and ship stations on the cable ship "Mackay Bennett," and on the steamer "Ponce." The "Ponce" followed the course of the racing yachts and sent frequent bulletins to the shore station whence they were cabled to all the principal cities of the United States, and to the cable ship, whence they were cabled to London, Paris and other points in the East.

The suspended wires were about 150 feet high in all cases and the distances through which the messages were sent varied from five to twenty miles. The instruments were located in the chart rooms of the ships, and messages were sent at intervals of not more than fifteen minutes. Naturally the many failures of the yachts to reach decisive results were disappointing, but in every case, in spite of storm or fog, the messages I sent were accurate and much in advance of all other means of transmitting the news.

One of the interesting, perhaps amusing, facts connected with my work in America was the diversion caused by rival claimants for wireless telegraphy honors. They believed, and wanted others to believe, that I was receiving credit that belonged to them, which is a not unusual claim in connection with any successful invention.

I am grateful to the SCIENTIFIC AMERICAN for this expression regarding my work:

"Whatever may be the merits of this controversy, we are satisfied that it would be as easy to sweep back the tide with a broom as to prevent the system of telegraphy which has just done such good work off New York Harbor and with the English Fleet from becoming for ever identified with the name of the man who first brought wireless telegraphy to a practical and useful consummation."

Before the races began we went over the course carefully, and the first day's trial showed me that nothing could prevent the correct working of the apparatus. From the start down the Bay messages were flashed back and forth with unvarying accuracy, in spite of intervening objects. Many private messages were sent to be forwarded to Washington, or to be cabled to Europe; engagements were made for dinners in New York that evening, and so on.

At the close of the trial cruise, which reached an extreme distance of twenty-two miles, my assistant, Mr. Bradfield, telegraphed:

"Everything has gone off first rate all day. Signals could not have been better if we had been connected with you by wire."

The work of reporting went on regularly during the races, over 1,000 words being transmitted daily. It acquainted the American people with my purpose, and the possibilities of my invention. I was much gratified at the generous treatment accorded me by the American people.

UNITED STATES NAVY TRIALS.

Immediately following the yacht races I was requested to make some experiments for the United States navy. The cruiser "New York," and the battleship "Massachusetts," were arranged for the demonstrations. The commission in charge of the test consisted of Lieut.-Commander J. T. Newton, Lieut. John B. Blish, and Lieut. F. G. Hill. Lieut.-Commander Newton was with me on board the "New York," and directed the experiments required by the Navy Department. Lieut. Hill was on the "Massachusetts," and Lieut. Blish was at the Highlands of Navesink, where a wireless telegraphy apparatus was rigged for the purpose of interrupting the messages.

Curiously enough, one of the first requests of the officers was for official proof that the system could be operated for short distances, and two or three days were spent in the East River signaling a few hundred feet. In view of the fact that three navies of Europe had used the systems at distances varying from twelve to eighty miles, the following comment from the New York Times is not without point:

"... Is there not something a little provocative of smiles in the 'tests' of wireless telegraphy now making by the Navy Department? It was so very well

known to all who have paid the slightest attention to the operation of Signor Marconi that much more can be accomplished by the aid of his device than was attempted in Thursday's experiments! To send signals and messages between warships anchored a few hundred feet apart is a task vastly easier than others which he performed with complete success months and months ago, and surely our naval officials should not need to enter the primer class in this method of communication. There was a trace of deserved sarcasm in the inventor's tone when he said that the telegraphing done on this occasion was a trial of the operators' skill, not of the system. The curious slowness of the government in taking up new ideas and new implements has often had expensive consequences, and more than once it has had tragical ones, as in the case of smokeless powder and high-power rifles. At present, apparently, they are tempting the laughter of foreigners by treating as novel things that have long been matters of common talk among amateur and professional scientists alike."

However, under direction of Rear-Admiral Farquhar, the ships proceeded out to sea a few days later, and very satisfactory results were attained up to thirty-six miles, the longest distance attempted.

The apparatus on the "New York" consisted of a vertical wire attached to a wooden mast and sprit fastened to the mainmast of the cruiser. The wire, at an acute angle with the mast, extended from the top of the sprit to the after gunroom of the warship, just over the propeller on the gun deck, where it was attached to the telegraphing apparatus. The "Massachusetts" was fitted with a similar contrivance. At the Highlands of Navesink a 150-foot mast was erected, and a vertical wire and electrical attachment of the same kind used by the warships was set up. The electricity used for sending the wireless telegraph messages was furnished by a relay of dry-cell batteries specially prepared for the purpose. Each one of the telegraph instruments was equipped with a Morse ink-writer, so that the messages received were recorded on ordinary tape in the Morse code. At a point about five miles off the Highlands of Navesink, the "New York" anchored, while the "Massachusetts" maneuvered about the flagship.

The first few messages sent back and forth between the two warships consisted of orders to the "Massachusetts" as to the rate at which she was to keep under way, and questions as to the distance she had covered. Then a long dispatch was sent from the "New York" to the "Massachusetts," with the instruction that it be repeated to the sender word for word. This message was sent and repeated without an error. Then messages were sent to the "Massachusetts" and to Navesink ordering the operators there to send messages simultaneously to the "New York."

The purpose of this order was to have Navesink interrupt the message from the "Massachusetts" to the "New York." This interference test was in every way successful, with the result that the two messages sent at the same time were jumbled into utter confusion. The dots recorded on the tape of the ink-writer were indiscriminately ticked off and absolutely unintelligible.

The messages between the two warships at intervals of ten minutes, with interruptions from Navesink at longer intervals, were kept up until the "Massachusetts" was thirty-six miles from the "New York," and then the battleship put about and came back.

Two days later further tests were made. Among the messages received by the "New York" there came suddenly a dispatch from the "Massachusetts" reading: "Man overboard." The message was given to Capt. Chadwick, and a cutter was lowered from the "New York." Ten minutes had elapsed from the time the wireless message was received before the same news was conveyed to the flagship by the wigwag man on the bridge of the "Massachusetts." Before the cutter had even been lowered from the "New York" to put out for the man who had fallen overboard from the "Massachusetts," another wireless message was received saying that the man had a buoy and was safe. Before beginning the test for the United States Navy Department, I sent the following letter to the Commission appointed to make the tests:

"To the Board appointed by the United States Navy Department to report on the trials of Marconi's system of wireless telegraphy:

"Gentlemen: With reference to the tests of my system which are now being carried out under your supervision, I wish to state:

"First—That the installation fitted up at the Navesink Highlands lighthouse has been installed to meet the wish expressed by various members of your Board in order to facilitate their investigations, but I want it to be understood that the instruments now at the station are not as efficient (being of an earlier type and intended for short-distance demonstrations) as those installed on the "New York" and "Massachusetts," and results obtained at that station cannot be taken as a test of the system in its present state.

"Second—Having consulted with my partners, I regret to be unable to give a demonstration of the devices I use for preventing interference, and of the system employed for tuning syntonizing instruments. The reasons why I cannot give such demonstrations are:

"(a) The means employed are not yet completely patented and protected.

"(b) Insufficient material and instruments were with me to give full demonstration.

"(c) No detailed information from the United States Navy Department was received by my company prior to my departure from England as to the extent of the demonstrations required.

"Since I last had the pleasure of meeting you, I have received advices from England to the effect that the British government has decided to make use of my system in the present South African war and also on the fleet. This necessitates my company supplying to the British government a large number of instruments and expert assistants, and also further necessitates my early return to Europe. I shall, therefore, be unable to continue the tests for the United States Navy Department after Wednesday.

"I am, gentlemen, your obedient servant.

"G. MARCONI."

The report of the United States Navy Commission concerning wireless telegraphy trials is here given:

"We respectfully submit the following findings as the result of our investigation of the Marconi system of wireless telegraphy: It is well adapted for use in squadron signaling under conditions of rain, fog, darkness and motion of speed. Wind, rain, fog and other conditions of weather do not affect the transmission through space, but dampness may reduce the range, rapidity and accuracy by impairing the insulation of the aerial wire and the instruments. Darkness has no effect. We have no data as to the effects of rolling and pitching, but excessive vibration at high speed apparently produced no bad effect on the instruments, and we believe the working of the system would be very little affected by the motion of the ship. The accuracy is good within the working ranges. Cipher and important signals may be repeated back to the sending station, if necessary, to insure absolute accuracy. When ships are close together (less than 400 yards) adjustments, easily made, of the instruments are necessary. The greatest distance that messages were exchanged with the station at Navesink was 16.5 miles. This distance was exceeded considerably during the yacht races, when a more efficient set of instruments was installed there. The best location of instruments would be below, well protected, in easy communication with the commanding officer. The spark of the sending coil or of a considerable leak, due to faulty incitation of the sending wire, would be sufficient to ignite an inflammable mixture of gas or other easily-lighted matter, but with direct lead (through air space, if possible) and the high insulation necessary for good work, no danger of fire need be apprehended. When two transmitters are sending at the same time, all the receiving wire within range receives the impulses from the transmitters, and the tapes, although unreadable, show unmistakably that such double sending is taking place. In every case, under a great number of varied conditions, the attempted interference was complete. Mr. Marconi, although he stated to the Board before these attempts

MULTIPLEX TELEGRAPHONE.

were made that he could prevent interference, never explained how or made any attempt to demonstrate that it could be done. Between large ships (height of masts 130 feet and 140 feet) and a torpedo boat (height of mast 45 feet), across open water, signals can be read up to seven miles on the torpedo boat and eighty-five miles on the ship.

"Communication might be interrupted altogether when tall buildings of iron framing intervene. The rapidity is not greater than twelve words per minute for skilled operators. The shock from the sending coil of wire may be quite severe and even dangerous to a person with a weak heart. No fatal accidents have been recorded. The liability to accident from lightning has not been ascertained. The sending apparatus and wire would injuriously affect the compass if placed near it. The exact distance is not known, and should be determined by experiment. The system is adapted for use on all vessels of the navy, including torpedo boats and small vessels, as patrols, scouts and dispatch boats, but it is impracticable in a small boat. For landing parties the only feasible method of use would be to erect a pole on shore and then communicate with the ship. The system could be adapted to the telegraphic determination of differences of longitude in surveying. The Board respectfully recommends that the system be given a trial in the navy."

The call from England was now imperative. Already six of my assistants with full equipment of instruments had started for the Transvaal, and there seemed a probability that more would be called upon. I was, therefore, obliged to stop the work for the United States navy and also the negotiations with the Signal Service Corps under General Greely. On the eve of my departure the Navy Commission expressed great satisfaction over the results.

FURTHER PROOFS OF PRACTICABILITY.

While I was in New York, the British Association for the Advancement of Science met at Dover, the French at Boulogne and the Italian at Como. Under the direction of my good friend and adviser, Prof.

Fleming, of University College, London, my system was used in a demonstration before the English and French bodies, and frequent messages were sent across the Channel from one to the other. On the centenary of the day when Volta's great discovery of the electric current became known to the world, messages of congratulation were sent by the English Association through the ether to the French scientists, thence on to the Italian body by land wires.

Again, a most convincing proof of practicability was given on the afternoon of November 15, 1899, on board the "St. Paul," in which I was returning to England. I had notified my company in London that I would communicate with our stations at Alum Bay and The Haven from the incoming steamer. Because of the hurried orders to South Africa, these two land stations had been dismantled and the instruments taken to London, but the day before my arrival Major Flood-Page and Mr. H. Jameson Davis, with assistants, rigged up the stations and awaited signals from me. On the ship we waited until the morning of the 15th, and then secured our vertical wire to a sprit fastened to the mainmast and set up our instruments in the smoking room. It was while we were still sixty miles from Southampton that we received the signals. Within another hour, still over forty miles away, we had received their "Is that you, 'St. Paul'?" and then "Hurrah, welcome home, where are you?" Then came war news, four hours before we landed, and we sent telegrams ashore for officers and passengers of the ship. The enthusiasm of all those aboard led to the publication of a paper, which was sold for a dollar a copy for the benefit of the Seamen's Fund, for which \$150 were raised.—From *Fortnightly Review*. Leonard Scott Publishing Company, New York.

THE MULTIPLEX TELEGRAPHONE.

POULSEN'S assistant, Peder Oluf Pedersen, has received United States patents for a method of using the Poulsen telegraphone so as to record a number of messages on a single steel strip and to reproduce them without confusion. As a result of his improvement, it follows that the size of the drum, or the length of the wire used is reduced, so that a long speech can be recorded upon a very short magnetic body.

The gist of the invention is to be found in the use of two or more recording magnets, the connections of which are varied with each message with a corresponding variation in the combined action of the magnets on the recording strip. To reproduce this message, the connections of the magnets must be adjusted to the same combination used in impressing it. The first two of our engravings show that two messages can be recorded on and reproduced from the same portions of two adjacent steel strips. The third figure shows how several messages can be simultaneously transmitted over a single line by means of the telegraphone. In Figs. 1 and 2, two separate steel ribbons are drawn past the poles of two horseshoe magnets, connected in series with the secondary of the telephone circuit. By means of plugs, the connections of the magnets in the circuit can be varied. A message spoken into the transmitter will be recorded magnetically on the strips and can be reproduced on substituting a receiver for the transmitting-coil, according to the well-known action of the telegraphone. By changing the connections of the magnets, as shown in the second of our figures, the polarity of one is reversed. In this set of magnets, the original message cannot be reproduced, because each magnetic condition in one of the strips will be equal to the corresponding condition in the other, and as they oppose each other in the magnets, there will be no current in the circuit and silence in the receiver; but while the magnets are thus connected it is possible to fix on the two steel strips an entirely new message, which will not in any way obliterate the first message and which can be reproduced, while the connections will remain the same and will not prevent the reproduction of the first message when the connections of the magnets are changed back to the conditions illustrated in the first diagram. It is not necessary to use separate recording strips for each magnet; for the desired results can be obtained by using a single strip. It is necessary simply that the magnets shall act at different parts of the strip. In using a drum carrying the spirally-wound steel wire, the magnets should be arranged to effect two convolutions of the spiral. The third figure shows the application of the principle of varying combinations of magnets to the simultaneous transmission of several messages along the same wire. It is assumed that three messages are to be simultaneously transmitted along the line. At the transmitting end is a steel disk and at the receiving end a similar steel disk, both of which are simultaneously rotated in operation. Each station has three local circuits with four electro-magnets connected in different combinations. The combinations of the different circuits at each end correspond. The line circuit is connected at each end with an electro-magnet facing the corresponding disk. The magnetism created in the transmitting disk by the three different sets of magnets acting simultaneously thereon, will affect the magnet connected with the line and send impulses over the line, which will be received by the magnet connected with the receiving end of the line and impressed upon the receiving disk. The impulses created by the first circuit at the transmitting end are delivered to the receiver in the first circuit at the receiver end; in like manner two and three receiving circuits will select the messages delivered through the corresponding circuits at the transmission station. After the disk has passed all the recording and receiving magnets, it passes an obliterating magnet which cleans off the record, so that the disk can be presented to the recording magnets in condition to receive a new portion of a message.

NATURE OF THE ELECTRONS. In an article entitled "Aepinus Atomized," Lord Kelvin sketches a system in which the single fluid of Aepinus consists of exceedingly minute equal and similar atoms, which he calls "electrons," much smaller than the atoms of ponderable matter. These permeate freely through the spaces occupied by ordinary atoms and also freely