The Central Meteorological and Geophysical Institute of Chile has issued a volume containing hourly observations and means for Santiago for the year 1911, including all the principal meteorological elements, prepared under the direction of Dr. W. Knoche. This is the first time that such values have been published *in extenso* in Chile, and it is intended to continue them regularly for Santiago in future. There are several other stations in Chile, where hourly observations are available; the publication of some of these, or at least summaries from them, would be very valuable, but the large amount of work entailed thereby is said to be more than the limited staff is able at present to cope with.

The nineteenth annual report of "Meteorology in Mysore" for 1911 contains, as usual, daily and monthly results of observations for Bangalore and Mysore, and 8h. a.m. observations with monthly means for Hassan and Chitaldrug. Synopses of the monthly and yearly results made at those observatories are carefully arranged as before, for the purpose of comparison, by Mr. Iyengar, in charge of the Mysore meteorological department. A useful table giving the means for the nineteen years 1893–1911 shows that the absolute maxima of temperature ranged from 100·2° at Hassan (3149 ft.) to 103·0° at Chitaldrug (2405 ft.). The minima at the same stations were 42·7° and 51·2° respectively. Yearly rainfall ranged from 25·0 in. (ninety-one days) at Chitaldrug, to 35·8 in. (121 days) at Hassan. The mean relative humidity was about 60 per cent. at all stations; excessively low readings were observed occasionally.

The Royal Magnetical and Meteorological Observatory of Batavia has published the results of rainfall observations in the Netherlands' East Indies for 1911 (part ii. of the thirty-third yearly series). The volume contains the monthly and yearly amounts at a large number of stations, the number of rain-days, greatest amounts in twenty-four hours, averages for the period 1879–1911, departures from those values in 1911, and other useful details. These data, in addition to their general scientific value, are of great importance locally, and it has been pointed out elsewhere by Dr. Van Bemmelen that rainfall is the ruling factor which determines the weather in the archipelago, because the remaining meteorological elements are almost constant. In Java the yearly amounts for 1911 varied from 23 in. at Sitoebondo (long. 114° E.) to 177 in. at Pelantoengan (long. 110° E.), and even more in the outside possessions. The greatest rainfall in one day was 10·2 in. at Padang (Sumatra) in November. The fullest information is given respecting the stations, but this volume contains no general discussion of the results.

IMPROVEMENTS IN LONG-DISTANCE TELEPHONY.

THE subject of improvements in telephony is one in which the general public is very closely interested, and a large audience, including many experts, therefore followed with attention the expositions given by Dr. J. A. Fleming, F.R.S., at the Royal Institution on March 27, in which he described the inventions that of late years have enabled a great increase in the practicable distance of telephonic communication to be made, and also rendered possible the use of submarine telephone cables over distances not hitherto attainable. In his opening remarks, Dr. Fleming gave first a brief description of the construction of the modern telephone transmitter and receiver, and of the transformations and sources of loss of energy in transmitting electrically articulate speech between two places. He stated that he would confine attention chiefly to the action of the line of cable, neglecting the imperfections of the transmitter and receiver *per se* owing to limitations of time.

An experiment was first shown with an instrument which projected upon the screen in the form of a line of light, the motion of the diaphragm of a telephone, when sounds musical or articulate where made near it The sound of an open organ pipe was thus seen to produce a smooth wavy or simple harmonic curve, whilst the less pure sound of a harmonium reed or of the voice uttering a vowel sound produced a complex curve, and a spoken sentence an irregular wave line.

The use of the oscillograph in recording photographically or visually the wave form of the electric current sent into a telephone was next explained, and photographs of various vowel and syllabic sounds shown.

A few words of explanation were then given concerning Fourier's theorem in virtue of which any irregular but single valued curve can be resolved into the sum of a number of simple harmonic curves of various amplitudes and phase differences having frequencies in the ratio of 1, 2, 3, etc.

It was then explained that the action of the transmitter on the line was equivalent to the imposition of a complex electromotive force which in virtue of Fourier's theorem could be regarded as the sum of a large number of simple harmonic electromotive forces of various amplitudes, wave-lengths, and phase differences.

Every telephonic cable has four primary qualities, two conservative, viz., its inductance and capacity, in consequence of which it can store up kinetic and potential energy in the form of a magnetic or electrostatic field. Also it has two dissipative qualities, viz., its conductor resistance and dielectric leakance, which convert a part of the energy given to it into heat. Hence an electromotive impulse given to the cable at one end is propagated along it as a wave. The current in the cable at each point is oscillatory, but the current is not, so to speak, at high tide simultaneously at all points in the cable, but successively, the maximum value travelling along the cable with a certain speed. The mode of propagation of a wave along a string or wire was illustrated by various wave models.

In the case of a wire or string of finite length the wave is reflected at the far end, and if the time taken by the wave to travel to and fro is equal to some exact multiple of the periodic time of the impulses, stationary waves are produced on the cord or wire. These effects, together with a demonstration of the laws of string vibration, were proved by the aid of Dr. Fleming's vibrating string apparatus in which a light cotton cord has one end fixed to a slide rest and the other end twirled uniformly with an irrotational motion by an electric motor.

The production of stationary electric waves on wires was also beautifully shown by the use of a long wire coiled into a helix on an ebonite rod. One end of this helix was connected to the earth and the other to a high-frequency oscillator. On adjusting the frequency of the oscillator, stationary electric waves of wave-length equal to some exact multiple or fraction of the length of the helix were produced and shown to exist by the brilliant glow of a neon vacuum tube held near the ventral segments and its non-glow when held near the nodes.

Dr. Fleming then explained that in the case of a telephone wire the velocity with which the waves travel along it is greater the shorter the wave-length, and also that in virtue of the resistance and dielectric leakance, these waves attenuate in amplitude at a rate which is greater for short waves than for long ones. In the case of the helix operated on by high-frequency currents the wave velocity is the same for waves of all wave-lengths, and is inversely as the square root of the product of the capacity and inductance per unit of length. Hence when a complex electromotive force, the result of speaking to a telephone transmitter, is applied to the end of a cable the various simple harmonic waves into which they may be resolved travel along the cable with unequal speed and attenuation. The shorter waves travel fastest, but are worn out soonest. Hence the wave form is distorted by the disappearance of the higher harmonics and the resulting sound is enfeebled by the attenuation.

Dr. Fleming proved these statements by a new and interesting experiment. A complex electromotive force comprising a fundamental wave having a frequency of about one hundred, and including higher harmonics of greater frequency was applied to one end of an artificial cable built on Dr. Muirhead's plan, representing a submarine cable fifty miles in length. By means of a Duddell oscillograph the wave form of this electric oscillation was projected on the screen. A second wire on the oscillograph was then employed to examine the current in the cable at various distances, ten, twenty, thirty, etc., miles from the sending end, and to project on the screen a second curve representing the wave form at various distances along the cable. It was seen that as the distance increases the wave form is reduced in height and smoothed out so as to show that the higher harmonics are gradually extinguished. In the case of a telephone cable this would mean that the received sound is not only fainter but altered in quality so that the syllable or word is no longer recognisable.

Photographs were then shown, taken by Mr. Cohen at the General Post Office Research Laboratory, showing the distortion of various articulate sounds as transmitted through certain cables. A remedy for this distortion was first suggested by Mr. Oliver Heaviside, who proved mathematically more than twenty-five years ago that if the four constants of the cable were so related that the quotient of the inductance by the resistance was equal to the quotient of the capacity by the leakance, then waves of all wave-lengths would travel at the same speed and attenuate at the same rate.

In all ordinary cables the first-named quotient is much smaller than the second. Hence to remove distortion we may either increase inductance or leakance. Heaviside suggested increasing the former, and Prof. Silvanus Thompson in 1891 suggested increasing the latter by providing the cable with inductive leaks. Practical telephone engineers preferred, however, to decrease the resistance of the cable by increasing the copper section so far as possible. There is, however, a limit to this from the point of view of cost. Also the invention of paper-insulated cables for telephony assisted matters by reducing the capacity of the cable. Nevertheless a very important advance was made by Prof. Pupin, of Columbia College, New York, in 1899 and 1900, when he proved that Heaviside's suggestion could be put into practical form by loading the cable with coils of wire wound on iron wire cores inserted at equal intervals, but so close that at least eight or nine coils are included in the distance of one wave-length of the average wave frequency which is always taken at 800. If the coils are placed farther apart relatively to the wave-length they do more harm than good. Dr. Fleming illustrated this by a very pretty experiment of his own consisting of a string loaded at intervals with beads, one end of the string being fixed and the other twirled round by a motor so as to produce on it stationary waves. When the half wave-length was adjusted to be nearly equal to the distance between the beads, the cord refused to transmit the oscillations.

It was also illustrated by the production of stationary electric waves on a series of helices of wire having loading coils, or coils of high inductance introduced at intervals.

An experiment was also shown with an artificial cable representing forty miles of standard cable into sections of which loading coils could be introduced or cut out as required. It was shown that when the cable was loaded the current flowing out of it at the receiving end was greatly increased when constant electromotive force was applied at the sending end.

It is found then that loading telephone wires by suitable coils of high inductance placed at proper intervals of a mile up to ten or twelve miles according to the cable, greatly reduces the attenuation of the waves, although it is difficult to add sufficient inductance to cure distortion completely.

Dr. Fleming gave a mechanical illustration of this effect. He said, suppose two similar ships were to be launched together side by side down ways of equal inclination and allowed to glide out into the sea as far as they would go until brought to rest by friction of the water. If then one of the ships was loaded with ballast so as to make it much heavier than the other, then, although entering the water with the same speed, the heavily loaded ship would glide out further than the other because it would possess a greater store of kinetic energy. So it is, he explained, with the electric waves on wire. By adding inductance to the circuit the wave energy is increased, and the waves attentuate less for a given distance of travel.

This proposal of Pupin has proved to be a very practical solution of the problem of reducing the attenuation of telephonic waves. Both aerial lines, underground cables, and submarine cables can be "loaded" or "Pupinised" by inserting appropriately made inductance coils at equal distances, and the result is to reduce the attenuation to half or less than a half of that of the unloaded cable, and therefore to reduce the enfeeblement of the sound.

In the case of aerial lines there is no difficulty in inserting these loading coils in the run of the cable. The coils are contained in iron boxes attached to the telegraph posts at intervals of six to twelve miles. The coils themselves consist of an iron wire core wound over with wire, and have generally an inductance of about 0·2 henry, and a resistance of 6 or 8 ohms. In the case of underground cables the loading coils are placed in pits at intervals of two or three miles. Such underground cables consist now of paper-insulated double metallic circuits; a large number of such circuits being included in one water-tight lead sheath. The problem of loading a submarine cable was more difficult to solve because the insertion of heavy iron-cased coils was out of the question. The cable had to be loaded in such manner as not to thicken it up inordinately at any point, and to permit of its being laid in the usual manner and lifted again if necessary for repairs. This particular problem was solved by Messrs. Siemens Bros. by the invention of a particular form of cylindrical loading coil which could be inserted in the run of a cable of the usual double-circuit type at distances of one nautical mile or so. When once it had been shown that such loading was effectual, telephonic engineers in all countries began to adopt it. In the United States the American Telephone and Telegraph Company has equipped with loading-coils lines up to 2000 miles in length. The longest aerial loaded line is that from New York to Denver. It is composed of No. 8 hard-drawn copper wires, the circuits being twisted to avoid cross talk and loaded every eight miles with coils having an inductance of 0·265 henry (see Table I.).

The attenuation constant of the line is thus reduced to less than half of that of the unloaded line, and good speech is possible from New York to Denver. It is the ambition of Mr. Vail, the president, and Mr. Carty, the able engineer of the above company, to complete a loaded line such that speech will be possible from New York to San Francisco, a distance of more than 3000 miles. Another long loaded aerial line just completed is that from Berlin to Rome. This line, with the exception of a short piece of cable through the Simplon Tunnel, is an overhead line of phosphor-bronze, 4·5 mm. in diameter. It is loaded every ten kilometres with loading coils having an inductance of 0·2 henry. It runs from Rome to Milan, thence to Iselle, then through the Simplon Tunnel to Brieg, then to Bâle and Frankfurt, and so to Berlin.

TABLE I.

Loaded Aerial Land Lines.

All values are per mile or per kilometre at 800 frequency.

Line	New York and Denver	Berlin and Rome	Berlin and Frankfurt	London (St. Albans) and Leeds Trunks No. 6	London (St. Albans) and Leeds Trunks No. 7
Length ...	2000 miles	2082 kms.	584 kms.	189 miles	189 miles
Coil Spacing...	8 miles	10 kms.	5 kms.	8 miles	12 miles
Coil Resistance	6 5 ohms.	5	8·7	6·6	4·0
Total Resistance	4·95 ohms.	2·9	11·18	7·58	7·08
Capacity in mfds.	0·0091	0·0056	0·0055	0·0098	0·0098
Inductance in henrys ...	0·0365	0.022	0·0461	0·037	0·0173
Attenuation Constant ..	0·0013	0·0011	0·0019	0·00283	0·00372
Total Attenuation	2·6	2·2	1·12	0·55	0·72
Conductor ...	Copper	Phosphor Bronze	Bronze	Copper	
Weight or Size	435 lb. to mile	4·5 mm. diameter	2·5 mm. diameter	300 lb. to mile	

Dr. Bresig and Dr. di Pirro, who have had the charge of the scientific work in connection with it, find the actual attenuation is closely in accordance with the predicted value, and good speech is possible over the whole distance.

In our own country the longest loaded lines are two trunk lines running from London to Leeds, 200 miles, which are loaded every eight and twelve miles.

The engineer-in-chief, Mr. Slingo, states that the General Post Office has now in operation 30,000 miles of aerial and underground loaded circuits, using 12,448 loading coils; also 45,645 miles more are in course of being loaded, so that before long the G.P.O. will have 75,000 miles of circuits loaded with 30,000 coils. In the United States up to 1912 there were 103,000 miles of loaded circuits in all.

In England one of the longest loaded underground lines is that from Hull to Newcastle *viâ* Leeds, 154 miles in length, which is loaded every 2·5 miles. The Post Office has now under construction an underground loaded line from London to Liverpool *viâ* Birmingham, which will contain fifty circuits, and render communication independent of storms. In the United States a long underground line has been constructed from Boston to Washington, 475 miles, passing through New York, Philadelphia, and Baltimore. A loaded line underground from Berlin to Cologne is in contemplation.

Turning then to submarine cables, we find that at present the General Post Office has three such loaded cables, one from England to France, laid in 1910, one from England to Belgium, laid in 1911, and one from England to Ireland, laid in 1013 (see Table II.). An Anglo-Dutch cable of the same type is being manufactured to be laid between a point in Suffolk and the nearest point on the coast of Holland, a distance of 125 miles.

TABLE II.

Loaded Submarine Telephone Cables.

All values are per nautical mile of loop at 800 frequency.

Cable	Anglo-French Coil loaded 1910	Anglo-Belgian Coil loaded (1911) Side Circuit	Anglo-Belgian Phantom Circuit	Anglo-Irish Coil loaded (1913)
Length in nauts	21	48	48	64
Coil Spacing in nauts	1	1	1	1
Coil Resistance in ohms. ...	6·6	11·5	4·6	6·8
Total Resistance in ohms. ...	20·9	25·7	11·7	21·0
Capacity in mfds.	0·138	0·162	0·314	0·166
Inductance in henrys	0·1	0·1	0·05	0·1
Ratio S/C	120	12	12	12
Attenuation Constant	0·017	0·018	0·0173	0·015
Total Attenuation	0·36	0·86	0·83	0·96
Conductor weight per naut ...	160 lb.	160 b	320 lb.	160 lb.

The Anglo-French uniformly loaded cable has an effective resistance of 8·54 ohms at 1000 frequency, a wire-to-wire capacity of 0·176 mfd., an inductance of 0·0135 henry, and an attenuation constant 0·0185. The total attenuation is 0·39,, the value of S/C is 109, and the conductor weighs 300 lb. to the nautical mile.

These cables were all constructed by Messrs. Siemens Brothers with the cylindrical coils abovementioned. The Anglo-French and Anglo-Belgian were laid under the direction of Major W. A. J. O'Meara, C.M.G., when engineer-in-chief of the General Post Office, and the Anglo-Irish cable under Mr. W. Slingo, now holding the same position. The French Government also laid from France to England a uniformly loaded cable made by the Telegraph Construction and Maintenance Company, which has a copper core of twice the weight of the Anglo-French cable, and is loaded by being uniformly wound over with one layer of soft iron wire. Each of these cables contains two pairs of wires which can be used as two independent circuits, and also by using each pair conjointly, as a lead and return, can be used to make a third or phantom circuit. These cross-Channel loaded cables have enabled telephonic speech to be transmitted from London to Geneva, London to Berlin, and to cities in the south of France.

Broadly speaking, we can say that by loading cables and lines it has been possible to double or more than double the distance of effective telephonic intercourse, and to speak for 2000 miles overland, 500 underground, and up to 100 miles or more under sea.

It is possible that submarine communication in this manner may be increased to 150 or even 200 miles, and overland to 3000 miles.

Turning then to the question of the abolition of the line by so-called wireless telephony, Dr. Fleming gave a brief description of the apparatus used. The arrangements are closely similar to those employed in wireless telegraphy. At the transmitting station there must be an antenna in which continuous oscillations are set up by a Marconi disc generator, a Goldschmidt alternator, or some form of arc generator, such as that of Poulsen or Moretti.

In the base of the antenna, or coupled to it, must be placed a microphone by means of which the speaker's voice makes changes in resistance of the antenna circuit. The continuous electric waves radiated must have a wave-length of not much greater than five or at most ten miles. If a spark system of wave generation is employed, the spark frequency must not be less than about 20,000 a second.

When the microphone is spoken to, the result is to vary the amplitude of the waves emitted without altering their wave-length. It produces waves on waves. At the receiving end the arrangements are similar to those used in wireless telegraphy with a telephonic and crystal or valve receiver. In this case, however, the receiver hears the words spoken to the distant microphone and not merely dot and dash Morse signals.

Using a very ingenious liquid microphone, Prof. Vanni, of Rome, has transmitted speech for 1000 kilometres. In the United States, Fessenden has similarly telephoned a few hundred miles, and Poulsen in Denmark, Colin and Jeance in France, Goldschmidt in Germany, and Ditcham in England have covered greater or less distances. Mr. Marconi also has recently devised appliances for wireless telephony with which he has conducted demonstrations for the Italian Navy lately. All are agreed that the quality of the transmitted speech is good. Since electric waves through the æther all travel with the same velocity, no matter what the wave-length, and attenuate at the same rate, there is no distortion of the wave form. The only difficulty that hinders even greater achievement is that of obtaining a microphone which will carry larger high-frequency currents.

These then are a few of the achievements which have been lately made in covering greater distances in telephonic communication.

We are yet a long way from telephony across the Atlantic, whether with cables or by wireless, but progress will continue to be made, and it is possible that one day speech transmission from England to San Francisco with one repetition at New York may be an accomplished fact.

In the thirty-eight years which have elapsed since Bell and Edison and Hughes gave us the means of commercial telephony much has been done, but there is still a wide field open for invention in improving a means of communication now so essential to our modern life.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Sheffield.—Mr. Wilfred Jevons has been appointed to the post of junior lecturer and demonstrator in physics, and Mr. A. E. Barnes to the post of lecturer in materia medica, pharmacology, and therapeutics.

Prof. Bergson will begin his Gifford Lectures in Edinburgh on Tuesday, April 21. The subject will be "The Human Personality."

It is announced that Lord Elgin has consented to be nominated for the Chancellorship of Aberdeen University in succession to the late Lord Strathcona.

We learn from *Science* that Prof. Frederick Slocum, who for the past four years has been in charge of the solar observations and stellar parallax work at the Yerkes Observatory, has been elected professor of astronomy at Wesleyan University, Middletown, Connecticut, and will assume his new duties next autumn. A new observatory will be erected immediately as a memorial to the late Prof. Van Vleck, for many years in charge of that department at Wesleyan.

Museums are every day being used more generally in teaching, and a committee to deal with the subject was appointed at the Birmingham meeting of the British Association. The Children's Museum arranged by the secretary of the Selborne Society at the Children's Welfare Exhibition, which opens at Olympia on Saturday, is therefore of interest. The points to be emphasised are, preparation of exhibits especially for young people, introduction of a living side, the use of microscopes, the need especially of changing the specimens at frequent intervals, and the advisability of not having too many things displayed at one time.

The work of the schoolmaster is described in a new light by Mr. E. Boyd Barrett in an article in the current issue of the *British Review*. Early in his essay, to which he gives the title, "How to Complete One's Education," Mr. Barrett lays it down that teaching is worthy of the best minds, and is calculated to repay amply the best minds. He goes on to show that in all the practical effects of school education—character training, intellect training, and the acquisition of knowledge—the schoolmaster benefits more from the teaching he receives from the boys than they do from his. He comes to the conclusion that it would be impossible to devise any educational system of such a nature that the pupil alone would be benefited. To complete his education, every man should devote a few years to teaching; university education, however well it prepares for cultured leisure, does not prepare a man to share his possessions with others—it is too egotistic.

The Yorkshire Summer School of Geography will be held at Whitby on August 3–22. The school was instituted last year by the Universities of Leeds and Sheffield, in cooperation with Armstrong College, Newcastle-on-Tyne, and with the help of the Education Committees of the County Councils of the East, North, and West Ridings, and of certain county boroughs in Yorkshire. Its object is to provide instruction in the methods of geography and to furnish opportunities for the discussion of problems connected with teaching it. The course will consist of lectures and laboratory and field work. There will be excursions in connection with the field work. All the apparatus used will be simple and inexpensive, and methods applicable to school work will be adopted. The special subject this year will be the British Isles, which will be treated as a whole in a general course and in two alternative courses at the choice of each candidate: (i) on the agriculture, rocks and soils, and (ii) on the oceanography, rivers and river development, and the evolution of transport and communication. Prof. Kendall, professor of geology in the University of Leeds, will be the director of the school.

The annual report of the Department of Agriculture of the Union of South Africa for the period 1912–13 has just been issued by the secretary, Mr. F. B. Smith, and is a very interesting document. Necessary as agricultural education and research have proved in other countries, there is probably no part of the world where they are more needed than in South Africa. Agricultural problems are very complex; probably more numerous and virulent diseases of live stock and crops exist there than anywhere else in the world; and, owing to the recent occupation of the greater part of the country and the methods of farming pursued, it is more difficult for young men to acquire a knowledge of up-to-date practical agriculture. A number of institutions have been started, and the object of the department has been to place them on an equality as regards educational and experimental facilities, and at the same time to allow them to specialise in the branches of farming for which they are particularly adapted by virtue of their situation. For instance, Elsenburg, in the Cape Province, is particularly devoted to horticulture, viticulture, and Turkish tobacco; Grootfontein, near Middelburg, also in the Cape Province, to Karoo farming, ostriches, and