rays, Prof. Riecke (Göttingen), paper presented by Dr. Emil Bose.

Limitations of space prevent the enumeration of papers not read at the congress but accepted for insertion in the *Comptes rendus*, as well as of the communications read before the biological section. The final meeting of the congress was held on September 14. After several interesting communications had been read, including one from Sir William Huggins, presented by Prof. Becquerel, the following motion was put before the meeting by the executive of the congress, acting at the wish of Prof. Jose Muñoz del Castillo:—

The International Congress for the Study of Radiology and Ionisation assembled in plenary session at Liége on September 14, 1905, considers that, although State regulation and protection may sometimes impede free research among men of science, it is, however, necessary that Governments should, without creating monopolies, be brought to apply to radio-active substances the same legislative measures that prevent the monopolisation of other useful substances, and should guarantee by the play of economic laws free scientific research and the application of these substances to the treatment of the sick; and considers also that it is desirable to be able to advise or remind the Governments of the importance of these measures and that a permanent commission invested with powers by the actual congress, an assembly of men of science devoted to the study of these questions and belonging to different countries, would carry weight in discussing with public authorities matters appertaining to the needs of science or the requirements of the sick. It has therefore decided

(1) That an international commission for examining all questions of general interest relative to radio-active substances shall be instituted.

(2) That the commission shall meet regularly each year, and may be convened on any exceptional occasion by the president, acting with the majority of the executive.

(3) That it shall organise periodically international congresses, to meet every five years, and shall also be empowered to convene the congress in extraordinary session.

(4) That the members of this commission shall be subject to re-election at each meeting of the International Congress.

THE COALFIELDS OF NORTH STAFFORDSHIRE.

THE memoir described below[1] contains detailed accounts of the coalfields of North Staffordshire, especially those of the Pottery and Cheadle Coalfields. The re-survey on the 6-inch scale was commenced in 1898 and completed in 1901. The present volume, which contains detailed descriptions furnished by each geologist of the area surveyed by himself, has been largely written and edited by Mr. Gibson, who personally carried out the greater part of the field-work. It was pointed out by Beete Jukes long ago that, so far as the higher portions of the Coal-measures were concerned, North Staffordshire provided the type development of the Midlands. Mr. Gibson has now established in that region a definite stratigraphical sequence in the comparatively barren strata which conformably overlie the productive Coal-measures, and he has also proved that the same sequence may be recognised in the other coalfields of the Midland area.

The chief points of interest are contained in chapter iv., which describes fully the determination of the Newcastle-under-Lyme group, the Etruria Marl group, and the Black Band group, and more particularly the removal of Hull's "Salopian Permian" into the Carboniferous. A full account of the palæontological and stratigraphical evidence on which this change is based is given at pp. 53 to 55. The evidence shows that the Salopian Permian of Staffordshire, Denbighshire, Worcestershire, Warwickshire, and in all probability Lancashire, occurs as the highest group of a definite sequence everywhere overlying the higher beds of the true Coal-measures, but never discordant to them, and that the Salopian Permian on either side of the Pennine Chain conforms to the Coal-measures, but is unconformably overlain on the eastern side by the Magnesian Limestone series.

It has been found advisable to adopt purely descriptive terms for various subdivisions, and for similar reasons the expressions Upper, Middle, and Lower Coal-measures have not been adopted, since the positions of the palæontological boundary lines which give a definite significance to the terms have not been determined with accuracy. Since the memoir was written, Mr. R. Kidston has contributed a paper to the Geological Society on the divisions and correlation of the upper portions of the Coal-measures, in which he proposes the name "Staffordian" for the series included between the Black Band group and the Newcastle-under-Lyme group, while the Keele group and similar beds in the Midland coalfields, hitherto referred to the Permian system, are classed with the Radstock group, previously called Upper Coal-measures. The distribution of the plants certainly favours such a classification, but there is evidence which seems to show a gradual passage of one group into another, and Dr. Hind, who has devoted considerable attention to the study of the lamellibranchs, is not in favour of the proposed subdivision.

One of the most pleasing features is the accurate and complete description of the palæontology, which is treated in detail by Mr. John Ward, and is accompanied by full lists, with six plates, of the common fossils of the Coal-measures. The Pottery Coalfield has long been recognised as an unrivalled field for the study of Carboniferous fishes, the study of which has to some extent overshadowed the examination of a numerous and varied series of molluscan remains and the equally abundant flora it has yielded. In this section Dr. W. Hind has given Mr. Ward a great deal of assistance. The fossil fishes have been named by Dr. Traquair and Dr. Smith Woodward, while the plants have been dealt with by Mr. Kidston. A complete geological bibliography of the North Staffordshire coalfields, covering fifteen pages, forms a valuable appendix.

The Triassic and Glacial deposits are described in separate chapters, and the economic products of the Pottery Coalfields are treated in chapter xii. The latter account includes the consideration of the future coal supply of the district from the concealed coalfield, to which considerable attention is paid. In addition descriptions are added of the local building stones, clays, and marls, supplemented by an enumeration of the chief source of water.

H. W. HUGHES.

[1] "Memoirs of the Geological Survey of England and Wales. The North Staffordshire Coalfields." By W. Gibson. With Contributions by G. Barrow, C. B. Wedd, and J. Ward. Pp. vii+494; with 1 Coloured Map and 6 Plates. (London: Edward Stanford, 1905.) Price 6*s*.

THE DISTRIBUTION OF POWER.[1]

TWENTY-SIX years ago, at the meeting of the British Association at Sheffield, August, 1879, a lecture, on "Electricity as a Motive Power," was delivered to some thousands of working men, and, for the first time, they realised that forks and spoons could not only be plated with the electric current, but could also be polished with a brush made to spin with the same agency.

The sea of upturned faces beamed with delight when Jack, their popular comrade, stepped on to the platform, took the newly plated spoon in his hands, and burnished it —a pair of thin wires tied to a church steeple being the only connecting link between the dynamo machine in a neighbouring works—ordinarily used there for electro-plating—and the electro-motor driving the polishing brush in the Albert Hall, Sheffield.

But an electro-motor is only a toy, thought my audience; nobody could construct an electro-motor that we could not stop with our hands; and at the end of my lecture they actually tried, and—wondered.

As far as I am aware, it was at that lecture that the following composite suggestion was first put forward—to obtain economy in electric transmission of power the current must be kept small, while to transmit much power the electric pressure between the conducting wires must be made large; and, lastly, to secure safety and convenience

[1] Lecture delivered on Tuesday, August 29, at a meeting of the British Association in Johannesburg, by Prof. W. E. Ayrton, F.R.S., and illustrated with many experiments on moving machinery, diagrams and lantern slides, two lanterns being used, in the American fashion, for enabling pictures to be contrasted on the screen.

in working, this high pressure must be transformed down into a low one at the distant end of the transmission system.

But what did high pressure—produced with a dynamo—mean twenty-six years ago? Why, three or four hundred volts—what, in fact, is called low pressure to-day—a pressure less than is now often used for lifts in buildings, pumps in mines, and tramcars in streets. And how was it proposed to transform this so-called high pressure into a low one? Why, I suggested mechanically coupling a 400-volt direct-current motor to a 50-volt direct-current dynamo—the device that has since been called a "motor generator"—and such a combination was shown in operation at that lecture.

But it was in Paris, at the Palais de l'Industrie, the home of that electrical exhibition of 1881 which has now become classical, that modern electrical engineering was born, and shortly afterwards *Punch* exhibited the young infant thriving, and imbibing liquid nourishment from a storage cell.

"What *will* he grow to?" says the picture. What *has* he grown to? Aladdin's ring, Aladdin's lamp—whose slaves brought a fortune to him, and a fainting fit to his mother—were but poor magic makers compared with the ring evolved by Gramme and that boy, Paccinotti—compared with the lamp constructed by those veterans Edison and Swan.

In the "Arabian Nights" it is stated that Aladdin's would-be uncle, the noted and learned African magician, knew that the wonderful lamp was not fed with oil, and he anticipated by many centuries the plan for reconciling the inhabitants of Johannesburg to having the electric pressure in their houses raised from 110 to 230 volts—for did not he, like the municipal African magician, offer "new lamps for old?"

It is also described how the lamp enabled Aladdin to carry off the Princess Badroulboudour, and the wicked uncle to transport the palace. But electric traction has carried off whole neighbourhoods out of cities into suburbs, and, by transporting hundreds of thousands daily, has helped to solve the problem of housing the working class; while electric distribution of power has discovered, not caves of buried jewels, but waterfalls of ever-flowing wealth.

At the mines near Silver City, Idaho, for example, coal had reached seventy shillings a ton, wood thirty-six shillings a cord. For years the distribution of power was by donkeys, or by long teams of horses slowly hauling heavy loads of wood up the mountain road; and then the magician of this, the electric age, came to Idaho, and what those mines need—power, clean, dustless, weightless power, now courses up the mountain side from Swan Falls on Snake River in the valley below. What fairy of old, who could change dead leaves into jewels, ever worked such beneficent wonder? See how proudly those posts look down upon their conquest of the past. For have they not brought an end, not merely to wasteful extravagance in lifting fuel up to those mines, but also to needless toil for tired cattle.

In 1886, when the boy Electricity was five, the babe Johannesburg was born, and the two youngsters have raced along neck and neck. To-night I will tell you something of their lives.

Nine years after that first lecture, the British Association honoured me by asking for another. In 1888, however, it was beginning to be realised that a pressure of 2000 volts between electric mains might not make too great a call on the funds of life insurance companies. Alternate current transformers had come into use; Ferranti was employing them practically, for distributing electric current from the Grosvenor Gallery, Bond Street. A "transformation scene" Lord Kelvin called the apparatus at that lecture. The male white population of Johannesburg was now—2000.

But, although current, at 100 volts pressure, was beginning to be distributed for electric lighting, the distribution of power for working electro-motors was still but a dream of the future.

In exactly a decade after the Paris Electrical Exhibition of 1881 came the Frankfort Exhibition of 1891. More than ten times 2000 volts was there used to transmit more than 100 horse-power, more than 100 miles, with more than 75 per cent. efficiency.

A death's-head and cross-bones were painted on every post along that 109 miles of railway line, Lauffen to Frankfort, for he who should touch these bare wires, with a pressure of 25,000 volts between them, secured electrocution; and a similar suggestion of mortality greets the wayfarer—in his own language, be he English or Dutch—on the posts of the Rand Central Electric Works.

	1882 Hirschau to Munich	1883 Vizille to Grenoble	1886 Creil to Paris	1891 Lauffen to Frankfort
Pressure at transmitting end in volts	700	3000	6000	25,000
Horse-power delivered by electro-motor ...	5·8	7	52	114·2 to lamps
Distance in miles ...	3·5	8·75	35	108·7
Percentage commercial efficiency of transmission	36	62	45	75·3
Diameter of line wire in inches	0·18	0·079	0·2	3 wires each of 0·158
Material of wire... ...	—	Silicium bronze	Copper	Copper

The table shows that the use of higher and higher pressures has enabled larger and larger amounts of power to be transmitted longer and longer distances, with greater and greater efficiency, that is, with less and less waste. Now, why is this?

The electric current, as you know, is used for lighting buildings, driving machinery, propelling cars and trains. But throw away the notion, if any of you still have it, that electricity is a kind of gas, or oil, or fuel that is used up in these operations. The common expressions, buying electricity, consuming electric current, are most misleading, for just as much electricity flows away per minute—through the return conductor—from your electrically lighted house as flows to it through the coming conductor. If, therefore, it were electricity that you had undertaken to pay for, you must have made a very bad bargain, because you do not retain the smallest portion of what you would have agreed to purchase.

The electric current is like a butcher's cart carrying round meat—you no more consume current than you consume cart. It is not the vehicle, but what it leaves behind that the consumers buy—meat in the case of the butcher's cart, and energy in the case of the electric current.

Exactly the same considerations apply to the distribution of power, with air at 70 lb. pressure per square inch, to the thousands of rock drills on the Rand, to the distribution of power with water at 425 lb. pressure per square inch down the shaft of the Rietfontein Mine, and at 750 lb. pressure in the workshops of the Central South African Railways at Pretoria.

The energy conveyed with air, with electricity, or with water is made up of three factors—(1) the current, (2) the time during which it flows, and (3) the pressure under which it flows; while power depends on the current and the pressure only.

Few words are used more vaguely than this one "power." Before starting for South Africa some of us gave someone a power of attorney; we came on a ship of 12,000 horse-power; the voyage did us a power of good; at the concert on board we sang of the power of love.

In engineering, however, power has one very definite meaning—the rate of doing work—and a stream of air, of electricity, or of water exerts much power, that is, works rapidly, when it quickly loses pressure, or head. Quickly losing one's head, however, is not characteristic of large brain-power, and the power exercised by those who sit in high places is often much in excess of their rate of doing any kind of work.

When water has but a few feet of head, the quantity flowing over a water-wheel must be large if much work has to be done. But since the water usually comes to a low pressure wheel along an open stream, and flows away again also along an open stream, no expense has to be incurred in laying down large pipes. If, however, it were necessary to distribute much power over considerable distances through a pipe conveying such low-pressure water, the pipe would not only have to be long, but of large cross-section, and, therefore, very bulky and costly. For example, this model is a full-size representation of the transmission of only one horse-power with low pressure.

On the other hand, if the water possesses considerable head, the transmission pipe may be of small diameter. In this second model the three-cylinder pump produces a pressure of 425 lb. per square inch, exactly the pressure used in the hydraulic transmission of power down the shaft of the Rietfontein Mine, and with that pressure less than four gallons of water flowing per minute through this three-quarter inch pipe gives as much power to this turbine as would be delivered by 825 gallons pouring per minute over this water-wheel four feet in diameter.

The water pressures in these two illustrations bear about the same proportion to one another as the electric pressure in the Lauffen-to-Frankfort transmission bears to the electric pressure usually maintained between the terminals of a lamp in Johannesburg.

The value of using pressure water is grasped when you realise that at the Rietfontein Mine, by circulating about 85 gallons of water per minute, at 425 lb. pressure per square inch, through a pipe 16 square inches in cross-section, not only is the circulating water all returned to the top of the mine, but in addition 144 gallons are pumped up per minute from a depth of 546 feet through a pipe $38\frac{1}{2}$ square inches in cross-section.

The water supplied by the London Hydraulic Power Company at 1700 feet head, although not filtered, costs nearly four times as much per gallon as the filtered water furnished by the Metropolitan Water Board. In England dirty pressure water is a relatively costly commodity, sparkling drinking water a relatively cheap liquid. In Johannesburg, on the other hand, until quite recently, the charge for drinking water was ten shillings a thousand gallons, plus two-and-six a month for meter rent, or about twenty times the London rate—the temptation to drink other things in Johannesburg must have been very great. Now, since the establishment of the Rand Water Board, it is six shillings a thousand gallons, which, without meter rent, is still ten times the London price, so that liquid with a head in London is still cheaper than plain drinking water here.

In the distribution of power, current and pressure are equally important. It is not merely because, even this month, August, after a phenomenally dry season, about 5,000,000 gallons of water are rushing per minute over the Victoria Falls, but it is because this water also thunders down about 380 feet that these falls are a potential source of power.

The Howick Falls, near Pietermaritzburg, have nearly as much head as the Victoria Falls, and twice as much as Niagara, while a syphon of soda water, when the gas is first pumped in, holds its head higher than any of the three. But, although in Johannesburg you probably pay a shilling for a syphon of soda water as an energy-producer in man, it is not worth 1/10,000th part of a penny as an energy-producer in a turbine, there is so little of it —only a pint and a half.

Probably, like myself, you have heard vague comparisons made between the power of the Victoria and the Niagara Falls. Now, what is the true comparison?

The flow at Niagara varies at different times of the year from about 62 to 104 million gallons per minute. At the Victoria Falls the flow can be as little as one-twelfth of the smaller number—for it is so now; and some authorities, well acquainted with the spot, say that at the end of another three months the flow will only be half of even that. The mean available drop at Niagara is about 160 feet; at the Victoria Falls about 380 feet. Hence, while the *minimum* Niagara flow represents about 3 million horse-power, the *present* Victoria flow represents about 580,000 horse-power, or only about one-fifth of the Niagara flow. Further, if those who predict the flow of the Zambesi sinking to something like $2\frac{1}{2}$ million gallons per minute in November are true prophets, the Victoria Falls will then only give out about 300,000 horse-power, or, say, one-tenth of the *minimum* that Niagara produces.

In all that precedes, I have taken the full power of the direct drop in each case; that is, I have assumed in each case the intake to be close to the main drop, and I have deducted nothing for inefficiency of machinery.

Now, how exactly does the efficiency in the electric transmission of power depend on (1) the pressure, (2) the power transmitted, (3) the length of the transmission line, and (4) the resistance of the conductors composing it?

The very simple approximate formula connects these quantities:—

$$\left\{\begin{array}{c}\text{Percentage}\\ \text{loss of}\\ \text{power on}\\ \text{the road.}\end{array}\right\} = \frac{\text{Horse-power transmitted}}{3\ (\text{thousands of volts})^2} \times \text{miles} \times \left\{\begin{array}{c}\text{Resistance}\\ \text{per mile of all}\\ \text{the conductors}\\ \text{in parallel.}\end{array}\right\}$$

This formula tells us that as long as the electric pressure is limited to some 10,000 or 11,000 volts—a pressure boldly used as early as 1897 by the Rand Central Electric Works, and at the Moodie Mines, near Barberton, but the one that is still the maximum sanctioned in Great Britain—it will not be possible, even with a pair of conductors of good copper, each as thick as the one I hold in my hand, viz. three-quarters of an inch in diameter, to transmit more than about 6000 horse-power, or to transmit that power more than about 10 miles, without the loss on the road exceeding 10 per cent.

The actual efficiency will, of course, be less than 90 per cent., since there will be losses also in the machinery at each end of the transmission system.

If, however, the electric pressure be doubled, that is, raised to 20,000 volts, then through this pair of conductors (kindly put up by the Transvaal Technical Institute, to bring power from their dynamo room to this hall), which are not much more than one-fifth of the cross-section of the former, and therefore not much more than one-fifth of the cost, as regards copper, we can transmit 2700 horse-power 23 miles, and still only lose 10 per cent. on the road.

Now Brakpan, where is the generating station of the Rand Central Electric Works, is almost exactly 23 miles from Johannesburg. Six wires come thence to Johannesburg, three of which may be likened to the going conductor, and three to the return in a two-wire system like this, also any three of those wires have a joint cross-section rather larger than three times the cross-section of this. Hence, with 20,000 volts, about 8000 horse-power could be sent to Johannesburg from Brakpan through the existing wires with only 10 per cent. loss on the road, or about 3400 horse-power (which is rather more than the entire maximum output of that generating station on any occasion last year) could be sent with only 4 per cent. loss.

I should have liked to show you this experimentally, but Mr. Reunert, Principal Hele Shaw, and Prof. Dobson, who, since my arrival, have so kindly put themselves to so much trouble to give expression to my wishes, might have thought me a little exacting had I asked for a lecture hall big enough to include a transmission line from Brakpan; and so, instead of this pair of conductors connecting two places 23 miles apart, I am going to employ a pair of extremely fine wires, each less than 1/100th of the diameter, that is, less than 1/10,000th of the cross-section—so fine, in fact, that you cannot see them.

Switch on the current, more than 100 lamps glow. Now think of a wall of lamps ten times as high, then ten times as wide, and then six times as big as all that, and you will have 2700 horse-power; and that is the power which, put into this pair of wires 23 miles away, say at Brakpan, with this pressure of 20,000 volts, will cause about 2400 horse-power to come out at Johannesburg.

This experiment of transmitting *five* horse-power across the hall is the nearest approach to wireless transmission of power that I have ever seen. But there are wires, although invisible, for if I make them touch at one point with this long stick a flash occurs above your heads, and the glow lamps on the platform go out.

I directed your attention to the fact that in 1888 the male population of Johannesburg was 2000. By 1896, according to the census taken that year, it had grown to 32,387. Now, curiously enough, in 1897 two transmissions were arranged for at 33,000 volts—the one at Crofton, California, and the other at Redlands, California; and no pressure higher than that used on the Lauffen-Frankfort transmission seems to have preceded this 33,000 volts anywhere in the world. Indeed, it would almost appear as if electrical engineers were waiting to use a higher pressure than 25,000 volts until the publication of the census of Johannesburg.

In 1898 the highest working pressure in the world was 40,000 volts for a 34-mile transmission at Provo, in Utah, and the male white population in Johannesburg was also about 40,000. Then came the war, and volts beat white man, for, according to the census of last year, while the white male population was 52,106, there were several examples of transmissions at 60,000 volts, as seen from the following table.

Year	From	To	Country	Transmission distance in miles	Horse-power transmitted	Pressure at transmission end in volts
1897	Crofton	—	California	—	—	33,000
,,	Redlands	—	,,	—	—	,,
	—	Bangalore	India	92	4,300	35,000
1898	Provo	—	Utah	32	—	40,000
—	Gromo	Nembro	Lombardy	22	3,300	,,
—	Logan	Salt Lake City	Utah	150	2,600	,,
—	Canyon Ferry	Butte	Missouri	70	5,700	50,000
—	Shawingan	Montreal	Canada	90	15,000	,,
—	Moutiers	Lyons	France	112	—	57,600
—	Spokane	Washington	—	100	3,000	60,000
—	—	Guanaguato	Mexico	104	4,000	,,
—	Electra	San Francisco	California	147	10,000	,,
—	Colegate	Stockton	,,	218	5,000	,,

But with the influx of the white members of the British Association doubtless the tide will turn, white man will make a spurt and catch up electric pressure, and in this respect, at any rate, the Witwatersrand will become a white man's country.

Indeed, not only have various successful 60,000-volt transmission schemes been carried out, but the Kern River Power Company in California is constructing one for transmitting 4020 horse-power over 110 miles at 67,500 volts.

Transmission at 67,500 volts over 110 miles. Why, when the new railway—Brakpan to Witbank—is completed, 110 miles will be 20 more than will separate the Rand from the coalfields at Witbank—fields that produce such good coal that the Central South African Railways have contracted to purchase 84,000 tons during this year, at six shillings per ton at the pit's mouth. Now, at a pressure of 67,500 volts, these two small wires could, without becoming too warm, bring about 9000 horse-power from Witbank and deliver 7600 of it to the Rand.

Or if six wires were used like those now employed by the Rand Central Electric Works, then, at 67,500 volts, 9000 horse-power might be put in at Witbank and only 5 per cent. lost on the road, that is, about 8550 horse-power delivered on the Rand.

But the insulators would have to be placed much farther apart than on the existing Rand posts to prevent the starting of a brush discharge between the wires—a subject to which I will return.

You will now grasp why in 1895, ten years ago, it was a bold and pioneering policy to equip the Rand Central Works for 10,000 volts, and to use 13,000 volts during times of full load, and why in 1905 the recommendation of some advisers to distribute power at only 10,000 volts to the proposed substations of the contemplated 57 miles of electrified railways—Springs to Randfontein—is most retrograde of those advisers to the railway.

In 1879, a firm of electrical contractors, well known then, and equally well known now, told me that they had been asked to tender for the construction of an electric transmission system to convey a comparatively small amount of power 10 miles. But since they considered that they could not possibly hope to deliver more than half, while, in practice, they feared that they would only succeed in delivering much less, the proposal had to be ranked with the exploits of Gulliver and Baron Munchausen, and so even that firm declined to tender. To-day, twenty-six years later, electric power is, from an engineering and from a business point of view, being successfully transmitted 232 miles—nearly as far as some of you took fifteen hours the night before last in being transmitted from Ladysmith.

Now, how are these electric pressures of 10, 20, 30, 40, 50, 60,000 volts produced? Why, by means of the alternate current transformer, which does for electric power exactly what the lever does for mechanical power. Exert a small force through a long distance at the long end of this lever, and you have a large force exerted through a short distance at the short end. Apply a small electric pressure with a large current at one side of this transformer, and you have a large pressure with a small current at the other. But there are no moving parts, therefore the arrangement is called a "static transformer." It requires no adjustment from day to day, therefore it may be kept entirely immersed in oil to improve its insulation.

Such statical transformers I used to step up the pressure from 100 to 20,000 volts at the transmitting end, and to step down the pressure from 20,000 to 100 volts at the lamp end in the last experiment. Everything looked quite harmless until I intentionally brought the transmission wires into contact. So does the transformer, immersed in a huge cylinder of oil, now projected on the screen, although it regularly produces 60,000 volts, and can supply 1100 horse-power at that pressure. So does this water-cooled transformer (the interior of which is seen in an X-ray picture to the right, and the exterior to the left), although it can supply 2000 kilowatts, that is, 2700 horse-power. Its size can be realised by comparing it with the tiny transformer by its side—the size of the one which I have on this table.

60,000 volts, well, what of it? some of you may say. It cannot start a discharge between even sharp needle points separated by a greater distance than about six inches, and some of you have produced such a spark with an electrical machine—I am producing such a one now.

But each time that a spark passes between the terminals of the electrical machine the pressure is relieved, so no arc is maintained. Bring the terminals of that transformer within six inches of one another, however, and a roaring arc of 2700 horse-power will be kept up, dealing destruction around.

Let me show you a spark started with a 70,000-volt transformer when supplied with only one horse-power. What a banging is produced. Now picture to yourselves what would be the result if the power were not of one, but of 2700 horses, such as that transformer can furnish.

The photographs show the sort of discharge that may occur over the surface of an insulator 1 foot high—such as is used on a high voltage transmission line—when the testing voltage is 80,000 in this case and 105,000 in that, and when there is plenty of power to maintain the arc. It is veritable lightning, not a mere flash, but a continued flame; and the sort of insulator that is used in practice for a 70,000-volt transmission is realised by looking at the specimens, which are only intended for 10,000 volts.

There is nothing new in high voltage by itself—it existed in the period of the frictional electrical machine more than 100 years ago, but it was associated with only a very small current; next, dating from the development of the dynamo, came the low voltage large current period; and now we have entered on a third era, the high pressure moderate current period, that is, the period of high pressure combined with horse-power.

Next I come to a very important question, and one that merits far more consideration than it has yet received. There are two kinds of electric current—direct current and alternating current. Direct current is like a continuously flowing stream of water, such as, for example, the one that flowed through this pipe and drove this turbine. Alternating current, on the contrary, is like this band, which, although swinging backwards and forwards, also turns a wheel in one direction at the other end. Now, which kind of electric current should be used for the distribution of power over *long distances*? Practically, every electrical engineer will at once reply, alternating, of course. Well, I am going to preach heresy. I say direct current!

The alternating current has undoubtedly the great advantage that a motor can be constructed with no rubbing electric contacts, every wire may be permanently soldered in position, a condition of considerable importance in dusty places like mines. Here is such a motor—the first polyphase motor ever sent from America to Europe, the first ever seen in Great Britain, constructed seventeen years ago by Tesla with his own hands, when he was too poor to employ a workman.

Another advantage possessed by an alternating current is that an alternating current dynamo can be constructed to produce a large horse-power at a high voltage, and further, as we have already seen, this alternating voltage can be transformed into a still higher one without the use of moving machinery.

This is one of the five largest dynamos in the world. Its size you can better estimate by looking at the ring standing on end, now projected to the left. The latter is the stationary portion of a 5000 horse-power horizontal shaft dynamo, while the photograph to the right is that of a vertical shaft machine of double that power, viz. a dynamo that can develop 10,000 horse-power at a pressure of 11,000 volts. Fifteen years ago, Ferranti—the Brunel of electricity—spent a mint of money constructing some of the parts of a 10,000 horse-power, 10,000 volt alternator, which were, however, never put together. This dynamo projected on the screen stands complete, with its four sisters, in the Canadian Niagara Power House, and the tests already made show that its efficiency reaches the extremely high value of 98·2 per cent., that is, 1·8 per cent. of the power developed is sufficient to cover all losses. Ferranti's dream is more than realised, and the old story is repeated. We break up the pioneer leviathan, the *Great Eastern* steamship, as a great unwieldy giant very weak in its knees, a little later we build the *Baltic*, a third as large again, and with twice the engine power.

Without any transformation at all, these dynamos will economically drive machines some miles away, and, with the pressure transformed up from 11,000 to 60,000 volts, power will be distributed in Toronto, 85 miles away from the falls.

Contrasted with this, no single large *direct* current machine has ever been constructed to generate more than about 3500 volts, and no means is known for efficiently converting a direct current voltage into a higher, or a lower one, without the use of moving machinery.

So far, then, my case seems weak! The advantages of using great electric pressures we have seen. Are there any disadvantages? This is a disadvantage, the risk of piercing the insulation! See how thick the insulating material has to be on cables, how far apart the conductors have to be placed, even when the cable is intended for only 10,000 volts. But does this consideration supply any argument for or against the use of one kind of current rather than the other? Small current and high pressure must be used for the economical transmission of power over long distances, whether the current be alternating or direct, I agree; but, ladies and gentlemen of the jury, I submit that, while from the point of view of economic transmission, 60,000 volts alternating means exactly the same as 60,000 volts direct, from the point of breakdown of the insulation, 60,000 volts alternating is as bad as 85,000 volts direct, indeed may be worse than 100,000 volts direct. For an alternating current consists of waves like the waves of the sea. In a storm, the waves may be running mountains high, and yet the average depth of the sea remains the same as in a calm. But what does it benefit the poor passengers, when tossed helplessly backwards and forwards in their berths, and feebly calling "steward," to be assured that, although the waves be peaked, and the maximum elevation large, the square root of the mean square of the amplitude of oscillation is quite consistent with perfect internal tranquility? And so feels the poor insulating material—the mean electric pressure may not be very large, and yet the crests of the waves may be so high, and the troughs so low, that its strength cannot stand the electric tossing.

Each of those waves of electric pressure on the diagram gives the same reading on a voltmeter, but the peaked one has far more destructive action than the flat topped one.

But there are other disadvantages in the use of alternating current. This coil of wire represents one of the conductors which, when unwound, might join two places, the one where incandescent lamps (for example) have to be made to glow, and the other where is the water-power which drives the dynamo that generates the current. If a *direct* pressure of 100 volts be applied at one end of the system, the lamps at the other end glow brightly, as you see, whereas if now I apply an *alternating* pressure, although of exactly the same value, the lamps are quite dull.

The explanation of this striking difference is that in such a case only a fraction of the *alternating* pressure is used in making the lamps glow, the remainder being employed in maintaining a rapidly reversing magnetic field.

This magnetic effect—this self-inductive effect as it is called—is small if the going and return conductors be straight, short, and near together. But if the distance over which the power is to be transmitted be long, the wires obviously cannot be short, and if to obtain economy high electric pressure be used, the wires cannot be put very near together, since that would lead to a brush discharge through the air from one conductor to the other, producing leakage.

Indeed, the minimum distance that must separate the conductors has to be increased very rapidly with the pressure unless their diameter is greatly increased at the same time. The table gives this minimum distance for conductors 1/10th, 2/10ths, and 4/10ths of an inch diameter respectively, and it will be seen that increasing the thickness of the wire greatly diminishes this minimum. For instance, at 80,000 volts, doubling the thickness of the wire from 1/5th to 2/5ths of an inch diminishes the minimum distance from 6½ feet to 13½ inches.

JOHANNESBURG.

Elevation, 5689 feet, January, 1905. Barometer, 24·3 inches. Temperature, 91°·5 F.

Minimum distance that must separate two parallel wires to prevent the starting of a Brush Discharge.

Root mean square electric pressure in volts between wires	Diameter of wires in inches		
	1/10	2/10	4/10
40,000	8·8 in.	—	—
50,000	32·2 in.	—	—
60,000	9·9 ft.	14·7 in.	—
70,000	35·7 ft.	33·8 in.	—
80,000	—	6·5 ft.	13·6 in.
90,000	—	—	23 in.
100,000	—	—	38 in.

It must, of course, be remembered that these are minimum distances, and that the distances apart at which the wires have actually to be fixed in practice are much greater.

But that is not the whole indictment against the use of alternating current for *long distance* transmission. Leakage from wire to wire can be rendered small, but still, if the current be alternating, it always flows along the wires, even if all the apparatus at the distant end be entirely disconnected from them. Let me show you this.

I apply a direct pressure of 100 volts, and no current enters the transmission line, for it is well insulated along its length and at its ends. I apply instead an alternating pressure of the same value, without making any other change, and you observe a very perceptible current. The very first thing that struck Ferranti when he commenced transmitting power with alternating current at 10,000 volts pressure, from Deptford to London, was that the current flowing into the system at Deptford was as large during the daytime, when practically no lamps were turned on in London, as during the evening, when many were glowing. Again, in the case of the 150 miles transmission, at 50,000 volts, by the Bay Counties Power Company, in California, it was found that to charge even the aërial lines as a condenser required 40 amperes, so that the current flowing into the system remained practically unchanged when the useful load was decreased from several thousand horse-power down to nought.

Now this is the very opposite of the effect we previously noticed, for in that case it was the alternating pressure that left the lamps dull by failing to send enough current into the transmission system. Surely, then, the one effect is a correction of the other. That is so, and I will give you a practical illustration.

I have here two transmission lines, the one with its going and return conductors placed far apart so as to exaggerate the first effect, the other with its going and return conductors near together to exaggerate the second effect; indeed, as I am employing for this experiment only a pressure of 100 volts, there is no risk of brush discharge, and so I have put the wires extremely near together on the second transmission line. The alternating current produced by the dynamo divides itself between the two transmission lines, and the two branch currents are about equal.

But, as you may see by means of the oscillograph—an instrument developed in my laboratories by Mr. Duddell, one of my students, for giving us a picture of the current and pressure waves in each of the two circuits—there is a great difference between the waves in the two circuits. In the transmission line with the wires far apart, the reversals of the alternating current occur after the reversals of applied pressure, the crests of the current wave lag behind the crests of the pressure wave, whereas in the case of the transmission line, with the wires very near together, the exact opposite occurs, viz. the crests of the current wave are in advance of the crests of the pressure wave.

Now, in the circuit coming from the dynamo, both current waves exist together, and as the crests of the one wave coexist with the troughs of the other there is interference, and the result is practically no current at all. So here we have the rather surprising result of practically no current in a main circuit, and yet a considerable current in each of the branch circuits into which the main circuit divides.

This may perhaps be regarded as a beneficial result, and should be added to the score of alternating current. But just as a very small alternating current in the main circuit can be split up into two large currents in the branch circuits, a small alternating pressure can be split up into two large alternating pressures, and in that case the result must be scored against the use of alternating current.

In this experiment I use also two circuits, one with the conductors very far apart, and the other with them very near together; but instead of employing these circuits as two *branch* transmission lines I put them end on, so that they constitute *successive* portions of the same transmission line. An alternating pressure of only 100 volts is provided by the dynamo and applied to the whole arrangement, and yet you observe that, between the going and return conductors in that part of the circuit in which they are far apart, as well as in that part in which they are near together, a pressure exists of 2400 volts, which is twenty-four times as great as the entire pressure supplied by the dynamo to the mains.

This result with alternating electric pressures is not unlike that obtained with mechanical forces when a small force is resolved into two very large ones, with each of which it makes nearly a right angle.

Much damage has been done to electric cables, used for the distribution of power, by these unexpected high pressures produced by resonance in alternate current circuits. A cable may have been tested at twice or thrice the working pressure and passed as satisfactory. But if there is a liability of a pressure being applied, which, as you see, may in somewhat extreme cases be twenty or thirty times the working pressure, what avails it that there is a factor of safety of 2 or 3?—disaster must follow.

Now with direct current for long distance transmission there is no question about the electric pressure at the top and bottom of a wave being much greater than the mean pressure, no question about self-induction reducing the current—no objection, therefore, to putting the conductors as far apart as the risk of brush discharge may necessitate—no question about capacity current, no resonance troubles, &c.

I wonder whether any of you are thinking—Well, perhaps there may be something in this heresy after all. No? Oh! then you are thinking, if the arguments were sound, the direct current system would have been already employed for long distance transmission. Well, but it has! Power up to 3000 horse has been transmitted with direct current, at 14,000 volts, from Combe Garot to Le Locle and La Chaud de Fonds, round a circuit 32 miles long; 4600 horse-power has been transmitted with direct current, at 23,000 volts, 35 miles from St. Maurice to Lausanne; and a transmission system for 6000 horse-power, at 60,000 volts, over 114 miles from Moutiers to Lyons, is in course of construction.

Another advantage that is possessed by all these examples of direct current transmission carried out by M. Thury is that it is the current that is kept constant and the electric pressure that is automatically raised when the demand for power is increased, whereas with the ordinary alternate current system it is the pressure at the lamp end that they aim at keeping constant, and the current that varies automatically with the demand for power

Now it is far more easy to maintain the constancy of the current flowing round a long circuit than to prevent the bobbing up and down of the electric pressure at the distant end of a long transmission line, and that irritating dancing of the lights, with which Johannesburg is so familiar, would be particularly difficult to avoid if the transmission line were long and the electric pressures at its two ends differed by some thousands of volts.

Constant current has also its well known disadvantages, but these would not come into play if the constant current were not taken into houses, mines, &c., but used to drive motor generators in substations, the dynamo portion of the motor generator being of any type desired.

The pioneering development that American boldness, enterprise, initiative, and originality have brought about in the electric distribution of power, combined with the extraordinary commercial success that it has won on both sides of the Atlantic, have made people ask, "Is such an industrial revolution in store for South Africa?"

At first sight one is inclined to answer "No!" This country is dotted with coalfields—coalfields blacken the map, and the produce of some of them is reported to be nearly equal to the best Welsh coal in quality. A humorous English paper said that I was going to give this lecture standing on a coal waggon to indicate how superior, as a carrier of energy, was a coal cart to a current.

When, on the one hand, one hears that good coal is brought from Witbank and delivered to the mines on the Rand at 13*s.* a ton, and that even this price will be lowered on the completion of the new railway from Witbank to Brakpan, one feels that long distance electric distribution has not much chance—indeed, a proposal to burn slack coal at Vereeniging, only 33 miles from Johannesburg, and electrically distribute the power on the Rand, fell through.

On the other hand, when one finds that at the Wankei coalfields themselves large coal costs 15*s.* a ton *at the pit's mouth*, and that Salisbury pays 36*s.* 5*d.*, Umtali 43*s.* 6*d.*, and Kimberley 67*s.* per ton, one feels that electric distribution in this country possesses possibilities.

South Wales has many coal mines—cheap slack coal lies heaped at the pit's mouth. Let me put this question to you: "If an electric supply distributing company were to start in South Wales to obtain their electric energy, *not* from waterfalls, mark you, but from coal brought to their generating stations from coal mines, would you anticipate, I ask, that such a company would obtain customers for their electric energy at coal mines themselves?" "No, emphatically no," you would reply, for that would be taking coals to Newcastle with a vengeance. Yet, what does that map tell us? Why that, within four years since that South Wales company was merely applying to Parliament for an Act to enable them to establish a distribution of power system, fourteen of the largest colliery companies and thirty of the mines are taking power at about one halfpenny a horse for an hour, the demand three months ago having reached 13,000 horse-power, and rapidly increasing.

That the North-Eastern Railway, and such a large number of manufactories along the Tyne, should, as seen from that other diagram, take power from the Tyneside Electric Power Supply Company—which also has been but four years in existence—was perhaps to be expected, but that coal mines should obtain power by the burning of the product of distant collieries resembles at first sight the method of earning a living attributed to a certain village, viz. by taking in one another's washing.

But this result is but an example of the subdivision of labour. At a coal mine getting coal, and at a gold mine getting gold, is the business, and at both, especially in the early days of sinking the mine, it should pay better to buy electric energy from an outside source than to generate the current on the spot.

Niagara sends 24,000 horse-power to Buffalo, 30 miles away, and sells it at 0.7*d.* per horse-power hour to an eight-hour user there—a price which is *not* cheaper than the total cost of generating a horse-power hour at Buffalo with a *large* steam engine. But tapping electric wires to obtain any amount of power that may be needed, and just at the time that it is required, is far more convenient than erecting steam engines and getting up steam, and certainly cheaper in the early days of sinking a mine.

It has been objected that the total steam-power curves of all the gold mines on the Rand show the same sort of falling-off during the hours 4 to 7 a.m. and 5 to 8 p.m., and, therefore, that, apart from using larger and more economical engines, and from diminishing the cost of superintendence for the energy sent out, there would be no saving by supplying many mines with electric power from a common generating station. But if there be a railway in the neighbourhood, largely used by workmen, the slack hours on the mines will be the busy hours on the railway. Hence, if that railway be run electrically from the same generating station, the load curve will be flattened and much improved.

On the Rand, however, there is an indisposition, apparently, to utilise distribution of power on a large scale. The labour conditions in this country are certainly peculiar. My friend Mr. Denny, in his book on "Deep Level Mines of the Rand and their Future Development," expresses this opinion—and there is no man whose opinions on such matters I value more highly:—"It has, however, been fairly conclusively proved that in average conditions hand labour is both speedier and cheaper than machine drilling."

But when one watches this hand labour one thinks of this picture rather than that. Contrary to American and Australian experience, it may be true that in this country white men and machinery may be dearer and slower than black machinery and man rolled into one. But it makes one uncomfortable, even unhappy, to think it possible, for it means that the muscular machine is more valuable than the inventor's brain.

Another objection felt by mine owners here to investing much capital in machinery is the somewhat uncertain character of their business, and a third against a mine depending for a supply of power on an electric current coming from a distance is the climatic conditions.

South Africa has various unique big things, but it has not a monopoly of big atmospheric disturbances, and these disturbances do not prevent electrical distribution of power schemes being pushed forward by leaps and bounds in the other three quarters of the world—the list given on p. 615 is merely a selection from some of those using the highest working voltages. During my short stay in this country I have been giving this matter much consideration. Without stopping this evening to discuss the subject in detail, I may mention that, after the admirable work of Mr. Wilms, Mr. Spengel, Mr. Heather, and others here on the improvement of lightning arrestors for electric transmission lines, I think I also see my way to putting a nail into the coffin of these bugbear lightning troubles.

But while advocating electric transmission of power I should not start by constructing a transmission line from the Victoria Falls to Johannesburg; and I say that, not because I am of opinion that it could not be made to work, nor that, if direct current were used, it could not be relied on to give as satisfactory results as, or even better results than, some shorter existing ones on the alternate current system, but because it does not appear to me that along the route there is at present sufficient demand for power to justify as large an expenditure of capital as would be compatible with a transmission line 586 miles long as the crow flies, and which would be no less than 745 miles long if made along a railway through Pietersburg and Gwanda, should the missing stretch of railway between these two places ever be constructed.

Those who hold the opposite view will doubtless urge that when the Cataract Construction Company of Niagara acquired in 1890 the right to use 100,000 horse-power, and a further right to use subsequently another 100,000 horse-power, it required an extraordinary belief in the future of electrical engineering to expect that 200,000 horse-power could ever be distributed at a price that could compete with large local steam engines, and they will ask, did not even Mr. George Westinghouse, in 1890, advise Mr. Stetson, the first vice-president of the Cataract Construction Company, that it would only be by compressed air that power could be commercially transmitted from Niagara to Buffalo? And now what is the state of things? Power House No. 1, with ten 5000 horse-power dynamos, has been working for some time, Power House No. 2, with eleven more 5000 horse-power dynamos, was completed last year. Hence 105,000 horse-power can be developed, and of this 75,000 horse-power is regularly distributed.

Further, the Canadian Niagara Power Company is constructing an electric station of an ultimate capacity of 110,000 horse-power, the Ontario Power Company an electric station, a little lower down, of 200,000 horse-power, and the Toronto Power Company one, a little higher up, of 100,000 horse-power, all these three being on the Canadian side.

Also the Electric and Hydraulic Company, which in 1881 started with a station, on the American side, to supply only 1500 electrical horse-power, has in hand a third station which will bring its plant capacity up to 135,500 electrical horse-power.

Consequently the total electrical horse-power that could be sent out from these various Niagara power houses, when completed, will approach 700,000 horse-power, and represents about 30 per cent. of the water going over the falls at the time of *minimum* flow. But taking into account the further fact that water is already abstracted to feed the Welland Power Canal and the Chicago Drainage Canal, and that other canals are projected, Mr. A. D. Adams has estimated that about 41 per cent. of the minimum flow of Niagara will cease to pass over the falls. In fact, I conclude that *the water that will, in the near future, cease to pass over the Niagara Falls will be nearly five times as large as the total amount passing over the Victoria Falls this month, August.*[1]

The "Thunder of the Waters," the "Cataract of Fearful Height," in America, which have inspired us and our ancestors with reverential awe, may appeal to our descendants as only a vast electric generating station. Very gratifying to us as engineers, extremely distressful to us as lovers of the beautiful.

Now what has caused this vast development in the distribution of power, what is the secret of this extraordinary success? It is that in the immediate neighbourhood of the falls there have grown up works which take some 60,000 horse-power, works which not only want cheap power, but power in an electric form for electro-chemical processes, and need it in an undiminished amount day and night, week-day and Sunday. The Carborundum Company, which manufactures emery's rival grinding material, furnishes an absolutely steady load of 5000 electric horse-power; the Union Carbide Company 15,000, and so on; loads which, from their magnitude and their absolute steadiness, make the electric light engineer's mouth water.

Now what is the prospect of such a steady load growing up locally within, say, 3 miles of your falls? Even

[1] The Resident Commissioner of the Bechuanaland Protectorate, writing to *The Times* from Mafeking the day after the delivery of this lecture, said:—"The volume of water passing over the (Victoria) Falls, was, it is true, infinitely less on August 16, 1905, than on the same date in 1883. It is less to-day than it has ever been in the memory of man."

on the spot it is difficult to obtain trustworthy information; by some it is said that one condition of the contract for the construction of the railway, which is being pushed forward to the copper, lead, and zinc fields at Broken Hill, 400 miles to the north-east, is that 100,000 tons of the ore must be sent to Beira yearly for ten years. If true, then that ore will not be available for reduction at the falls.

There is a convenient spot for a power station near the water at the end of the second gorge—all the Niagara power stations are on the top of the falls, with the exception of those of the Ontario Power Company, and the old Electric and Hydraulic Company—and it is the latter method of construction that would be the most suitable to follow at a Victoria power station.

But jealously guard the beauty of your falls. The protection of the grandeur of their American sister was the underlying idea of Thomas Evershed's hydraulic power scheme of 1886. How little has that object been kept sight of?

Niagara *was* glorious nature, to-day it is power, Victoria is poetry.

FORTHCOMING BOOKS OF SCIENCE.

MR. EDWARD ARNOLD gives notice of:—"The Great Plateau, being an Account of Exploration in Central Tibet, 1903, and of the Gartok Expedition, 1904–1905," by Captain C. G. Rawling, illustrated; "In the Desert," by L. M. Phillipps, illustrated; "Two Years in the Antarctic, being a Narrative of the British National Antarctic Expedition," by Lieut. A. B. Armitage, illustrated; "Common Ailments and their Treatment," by Dr. M. H. Naylor; "Electric Lighting for the Inexperienced," by H. Walter; "Races of Domestic Poultry," by E. Brown, illustrated; "Recent Advances in Physiology," by Drs. A. P. Beddard, L. Hill, F.R.S., J. J. R. Macleod, B. Moore, and M. S. Pembrey; "Valves and Valve Gear Mechanisms," by Prof. W. E. Dalby, illustrated; "Surgical Nursing and the Principles of Surgery for Nurses," by Dr. R. Howard, illustrated; "The Laws of Health," by Dr. D. Nabarro, illustrated; and new editions of "Practical Physiology," by Drs. A. P. Beddard, J. S. Edkins, L. Hill, F.R.S., J. J. R. Macleod, and M. S. Pembrey, illustrated; and "Food and the Principles of Dietetics," by Dr. R. Hutchison, illustrated.

Messrs. Baillière, Tindall and Cox's list includes:—"Psychiatry," by Prof. Bianchi, translated by Dr. J. H. MacDonald; "Manual of Anatomy," by Dr. A. M. Buchanan, illustrated; "Manual of Military Hygiene," by Lieut.-Colonel R. Caldwell, illustrated; "Aids to Surgical Diagnosis," by H. W. Carson; "Sound and Rhythm," by Dr. W. Edmunds, illustrated; "Aids to Pathology," by Dr. W. d'Este Emery; "Trypanosomata and the Trypanosomiases," by A. Laveran and F. Mesnil, translated and edited by Dr. D. Nabarro; "Nodal Fevers," by Dr. A. A. Lendon, illustrated; "Applied Bacteriology," by C. G. Moor and Prof. R. T. Hewlett; "Practical Agricultural Chemistry," by F. Robertson; "Sanitary Science Laboratory Work," by Dr. D. Sommerville, illustrated; and new editions of "Heart Disease, with Special Reference to Prognosis and Treatment," by Sir W. H. Broadbent, Bart., F.R.S., and Dr. J. F. H. Broadbent, illustrated; "Physical Diagnosis," by Dr. R. C. Cabot; "Lectures on Clinical Psychiatry," by Dr. E. Kraepelin, authorised translation revised and edited by Dr. T. Johnstone; "Ambulance Work," by Drs. J. W. and J. Martin; "Manual of the Diseases of the Eye, for Students and Practitioners," by Dr. C. H. May and C. Worth, illustrated; "A Manual of Surgery for Students and Practitioners," by Dr. W. Rose and A. Carless; "The Nature and Treatment of Cancer," by Dr. J. A. Shaw-Mackenzie; "Manual of Physiology, with Practical Exercises," by Dr. G. N. Stewart, illustrated; "The Röntgen Rays in Medical Work," by Dr. D. Walsh, illustrated; and "The Deformities of the Human Foot; with their Treatment," by Drs. W. J. Walsham and W. K. Hughes.

Messrs. George Bell and Sons announce:—"Integral Calculus for Beginners," by A. Lodge; and a new edition of "Elementary Dynamics," by W. M. Baker.

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Messrs. A. Constable and Co., Ltd., will issue:—"The Ways of Nature," by J. Burroughs; "A Study of Aboriginal Life in Australia, the Euahlai Tribe," by Mrs. L. Parker, illustrated; "Two Bird-Lovers in Mexico," by C. W. Beebe, illustrated; "The Fixed Period," five addresses by Prof. W. Osler; "Scarabs, an Introduction to the Study of Egyptian Seals and Signet Rings," by P. E. Newberry, illustrated; "Ethics and Moral Science," by L. Lévy-Bruhl, translated by E. Lee; "The Subconscious, a Study in Descriptive Psychology," by Prof. Jastrow; "Motor Vehicles and