a minimum of those risks of fire which are inherent to every system of artificial illumination. They point out that the chief dangers of every new application of electricity arise mainly from ignorance and inexperience on the part of those who supply and fit up the requisite plant.

The difficulties that beset the electrical engineer are chiefly internal and invisible, and they can only be effectually guarded against by "testing" or probing with electric currents. They depend chiefly on leakage, undue resistance in the conductor, and bad joints, which lead to waste of energy and the production of heat. These defects can only be detected by measuring, by means of special apparatus, the currents that are either ordinarily or for the purpose of testing, passed through the circuit. Bare or exposed conductors should always be within visual inspection, since the accidental falling on to, or the thoughtless placing of other conducting bodies upon such conductors might lead to "short circuiting" or the sudden generation of heat due to a powerful current of electricity in conductors too small to carry it.

The Committee point out that it cannot be too strongly urged that amongst the chief enemies to be guarded against are the presence of moisture and the use of "earth" as part of the circuit. Moisture leads to loss of current and to the destruction of the conductor by electrolytic corrosion, and the injudicious use of "earth" as a part of the circuit tends to magnify every other source of difficulty and danger.

The chief element of safety is the employment of skilled and experienced electricians to supervise the work.

The rules deal with the installation of the dynamo-machine, the fixture of the wires, the character of the lamps to be used, and the danger that accrues to the person.

To secure persons from danger inside buildings, it is essential so to arrange the conductors and fittings, that no one can be exposed to the shocks of alternating currents exceeding 60 volts; and that there should never be a difference of potential of more than 200 volts between any two points in the same room.

If the difference of potential within any house exceeds 200 volts, whether the source of electricity be external or internal, the house should be provided outside with a "switch," so arranged that the supply of electricity can be at once cut off.

The rules are very valuable, and should be obtained by all those who are contemplating the use of the electric light.

PROF. HAECKEL IN CEYLON [1]

II.

IN the July number of the *Deutsche Rundschau*, Prof. Haeckel gives a further account of his stay in Ceylon, a stay which his ardent enthusiasm and unwearied industry cannot fail to have made fruitful in results to the scientific world. The present series of papers being intended for magazine readers in general, is, as might be expected, altogether popular in tone. The Professor's researches and discoveries in support of the theory of Evolution, are only implied, not described in detail. His letter is written from the point of view of an intelligent and cultivated traveller, fully alive to the novelty and beauty of the scenes in which he found himself, and of a naturalist anxious to make the most of his very limited time to become familiar with the fauna and flora of that lovely island which Buddhist poets gracefully apostrophise as "a pearl on the brow of India." The energetic Professor was evidently a subject of much wonder to the languid Anglo-Indians and lazy Singhalese, as, in his white linen suit and "Sola" hat, he braved the mid-day sun and even occasionally the tropical rains, besides setting at nought the bites of countless leeches and the stings of mosquitoes and scorpions, and prosecuted his researches from morning till night. It is, however, to this constant bodily exercise and to his invariably temperate diet, that Prof. Haeckel ascribes his perfect health while on the island; but it is doubtful whether, as the body became enervated by the climate, such habits could be long sustained.

Continued from p. 256.

The first, and one of the most delightful excursions made by Prof. Haeckel in Ceylon, consisted in a visit to a Singhalese village called Kaduwella, situated on the left (southern) bank of the Kalany, about ten miles from Colombo. The party from Whist Bungalow, joined by their fellow countrymen residing at the neighbouring Elie House (formerly the residence of Sir J. Emerson Tennent) drove to the appointed place in the little one-horse carriages universal in Ceylon, which are drawn by brisk Burmese ponies, whose speed is superior to their staying powers, ten miles being quite sufficient to tire them out. Horses are rarely used in Ceylon, except in spring carriages, and are almost all imported from the Indian mainland, or from Australia; European horses cannot survive the climate. Bullocks may be said to be the only animals of draught or burden, and Prof. Haeckel mentions the long string of bullock carts, some single, some double, which are constantly met on the road; "the bullocks all belong to the class of the Zebu or humped oxen of India (*Bos indicus*), but there are many varieties; one of the smaller kinds is very swift and agile." [1]

Prof. Haeckel notes as among the most beautiful effects of the Ceylonese lowlands through which the road to Kaduwella lies, the middle place which they occupy between garden and forest, between cultivated and uncultivated nature." Surrounded by majestic trees, all overhung and overgrown with creepers and climbers, one might often imagine oneself in the midst of the wildest forest; but a little hut almost hidden beneath a bread-fruit tree, a dog or a pig issuing from the brushwood, children playing hide and seek behind the caladium leaves, serve to remind us that we are in fact in a Ceylonese garden. The real forest, on the other hand, which is closely adjacent, with its manifold juxtaposition of every variety of tropical trees, with its orchids, cloves, lilies, malvaceæ, and other lovely flowering plants, shows all the variety and apparent design of a costly pleasure garden. This singular mixture of nature and culture is visible also in the human accessories of these forest-gardens; for so great is the simplicity of the dwellings and the clothing of the Singhalese inhabiting them, that although the descendants of an old and cultivated race, there is little in their appearance to distinguish them from mere savages." Arrived at Kaduwella, after a halt and refreshment at the Rest-house (the government substitute for hotels, which are altogether wanting in Ceylon except in the chief towns), Prof. Haeckel made his first attempt to penetrate an Indian jungle, with what success his own words must tell: "The jungle is not, properly speaking, 'primeval forest,' forest, that is, untrodden by the foot of man (such are in Ceylon of small extent and rare occurrence); but it corresponds to our idea of such a forest in that it consists of a dense and impenetrable mass of mighty trees of all kinds, which have sprung up without regularity or any interference from man, and are surrounded and overgrown by a wilderness of creeping and climbing plants, of ferns, orchids, and other parasites, the interstices being so completely filled up with a motley mass of smaller weeds that it is quite impossible to disentangle the coil of tendrils so as to distinguish one species from the other. My first attempt to penetrate such a jungle as this was sufficient to convince me of the impossibility of the undertaking except with the aid of axe and fire. A hard hour's work brought me only a few steps into the thicket

[1] A pair of these little bullocks carry up about twenty bushels of rice to the hills, and bring down from fifty to sixty bushels of coffee to Colombo (Sir J. E. Tennent's "Nat. Hist. of Ceylon," p. 52)

and then I was obliged to acknowledge myself vanquished and make good a retreat, stung by mosquitoes, bitten by ants, with torn clothes, and arms and legs bleeding from the thorns and prickles with which the climbing palm (*Calamus*), the climbing Hibiscus, the Euphorbia, and a multitude of other jungle plants repulse every attack made on their impenetrable labyrinth. But the attempt had not been made altogether in vain, for it enabled me to gain a very fair idea of the jungle as a whole, more especially of the magnificence of its trees and creepers, besides introducing me to many separate varieties of animal and vegetable life, which were of the highest interest; here I saw the magnificent *Gloriosa superba*, the poisonous climbing lily of Ceylon, with its red and amber flowers; the prickly *Hibiscus radiatus*, with large cup-shaped brimstone-coloured flowers, deepening to violet in the hollow; while round them fluttered gigantic black butterflies with blood-red spots on their tail-shaped wings, and chafers and dragon-flies flew past with a metallic gleam. But my delight reached its height when on this, my first attempt to penetrate a jungle in Ceylon, I came across the two most characteristic of its inhabitants from among the higher class of animals—parrots and apes. A flock of green parrots flew screeching from a lofty tree, as they became aware of the gun in my hand, and at the same moment a herd of great black apes sprang with a growling cry into the thicket. I did not succeed in getting a shot at either one or the other; they appeared to be too familiar with the look of a gun. I was consoled, however, by securing with my first shot a colossal lizard or iguana six feet long, of a kind held in much awe by the superstitious natives (*Hydrosaurus salvator*). The huge crocodile-like beast was sunning himself on the edge of a water-tank, and the shot hit him so precisely on the head as to kill him at once; had it struck any less vital part he would probably have dived into the water and disappeared; when seized, the iguana has the power of hitting so sharp a blow with its scaly tail as to cause a severe wound and even sometimes a broken limb."

We regret that want of space forbids us to quote entire Prof. Haeckel's account of a Buddhist temple built on the wooded heights above Kaduwella, and the scene of constant pilgrimages. It was constructed originally out of a natural grotto, the back part of the temple being composed of the bare rock, from which also is hewn the colossal figure of Buddha, which is invariable in all Buddhist temples. Almost as invariable is the adjoining Dagoba, a bell-shaped dome without any opening, containing a relic of Gotama. The size of the dagobas varies from that of a large church bell to the circumference of the dome of St. Peter's at Rome. Near the Dagoba is generally to be seen a large Bo-Ga, or sacred fig-tree (*Ficus religiosa*).

"These 'Buddha-trees' with their venerable stems, fantastic roots, and colossal crown of foliage form a prominent feature in the picturesque surroundings of the temples; their leaves, which are heart-shaped, with long stalks, quiver like our aspens."

The description given by Prof. Haeckel of the Royal Botanic Garden at Peradenia will be read with interest by all who value the efforts, whether of governments or of individuals, to encourage scientific knowledge by placing the means of gaining it within the reach of all. This admirable institution was founded sixty years ago on the site of an ancient royal residence, and placed under the direction of Dr. Gardner. His successor, Dr. Thwaites, the learned compiler of the first "Flora Ceylanica," laboured for thirty years to render the garden worthy of its extraordinary advantages of position and climate. On his retirement a few years ago, Dr. Henry Trimen was appointed director, and from him Prof. Haeckel received a pressing invitation, which all that he had heard and read of Peradenia urged him to accept.

Peradenia is now connected with Kandy, the original capital of Ceylon, by a railway, the first in the island. Prof. Haeckel notes by the way that railway travelling affords the greatest delight to the natives, many of whom make the journey up and down daily for the mere pleasure of the ride! It is the only indulgence on which they are willing to spend their money, and fortunately the line is a cheap one. The journey is of between four and five hours' duration, and the first half of it lies through low lands covered with swampy jungle, alternating with rice fields and swamp meadows. After that, the line begins to ascend, and a constant succession of beautiful mountain landscapes unfold themselves to the view. One of the most magnificent of these is afforded to the traveller at the point called the "Sensation Rock." "Here the line, after passing through several tunnels, runs under projecting cliffs at the edge of a precipice with a sheer descent of 1200 to 1400 feet. Roaring waterfalls from the rocky heights on the left are spanned by railway bridges, and, dashing downwards, are dissolved into spray before they reach the foot of the precipice; the sunshine striking them forms them into glittering rainbows. The green valley lying far below our feet is covered partly with jungle, partly with cultivated land scattered over with huts, gardens, and rice-fields, arranged in terraces. Towering above all other trees, rise the giant stems of the majestic Talipat palm, queen of all the palms of Ceylon (*Corypha umbraculifera*). Its perfectly straight white stem resembles a slender marble pillar, and often exceeds 100 feet in height. Each of the fan-shaped leaves which form its stately crown covers a half-circle sixteen feet in diameter; they, like every other part of the tree, are turned to manifold uses, being especially employed for thatching; they formerly provided the Singhalese with a substitute for paper, and are still used in that capacity. The old Puskola manuscripts of the Buddhist monasteries are all written with an iron style upon this "ola" paper, narrow strips of talipat leaves boiled and dried in the sun. The stately talipat palm blooms but once, usually between the fiftieth and eightieth year of its life; the pyramidal clusters of flowers crowning the summit of the palm, reach the length of thirty to forty feet, and are formed of millions of small yellow-white blossoms; when the seed-vessels ripen, the tree dies. By a fortunate chance it happened that an unusual number of talipat palms were in flower during my stay; I counted more than sixty between Rambukhana and Kadugannawa, and more than a hundred during the whole railway journey. Excursions were made from Colombo to witness the rare and beautiful sight."

The following extract gives Prof. Haeckel's first impression of the Botanic Garden of Peradenia:—

"The entrance to the Garden is through a noble avenue of india-rubber trees (*Ficus elastica*). The milky sap of this tree thickens into *caoutchouc*. Young plants of it are cultivated in heated rooms of our cold north, for the sake of the decorative beauty of their oval sap-green leaves: but while with us india-rubber plants of six or eight feet high, are esteemed a wonder, here in their native land they take rank with the noblest of forest trees, and would rival our oaks in size and strength. A huge crown of many thousand leaves proceeding from horizontal branches 40 to 50 feet long, covers the superficial area of a stately palace, and from the base of its powerful stem rises a network of roots, often between 100 feet and 200 feet in diameter, more than the height of the tree itself. This marvellous mass of roots rises on all sides and twists round the tree in such a manner, that the natives have given it the name of the "snake-tree."[1]

"Scarcely had I recovered from my astonishment at this

[1] "Like snakes in wild festoon
In famous wrestlings interlaced
A forest Laocoon."
(Hood's Poem of "The Elm Tree.")

wonderful avenue of snake trees, when my attention was arrested by a noble group of palms, including nearly all those indigenous to the island, and a number of foreign representatives of this noblest of tropical trees; all festooned with masses of flowering creepers, and adorned with graceful ferns growing at their base. Another similar, but larger and more beautiful group of palms stands at the further end of the avenue. Here the path divides and leads on the left to a little eminence, on which the director's bungalow stands. This charming residence is, like most of the villas of Ceylon, a low one-storied building, surrounded by a verandah, the projecting roof of which is supported by a row of white pillars." . . . The villa stands on the highest point of the garden, which covers an area of 150 acres, and overlooks the noble Mahawelli River, which encircles it on three sides. Its position and climate are unusually favourable for the cultivation of all the wonders of the Ceylon flora.

"In four days spent in Peradenia," says Prof. Haeckel, "I learnt more of the life and nature of the vegetable world than I should have acquired by as many months of close botanical study at home. I can never be grateful enough to my good friend Dr. Trimen for his hospitality and the rich stores of learning which he placed at my service; the days spent in his bungalow were among the most fruitful of my life.

"Another English botanist, Dr. Marshall Ward, was at Peradenia at the same time as myself; he had pursued his studies for the most part in Germany, and bore the official title of 'Royal Cryptogamist.' He had been sent here two years previously by the English government to study the coffee-leaf disease which for many years has raged with inceasing violence in the coffee-plantations of Ceylon, and has in great measure destroyed this valuable source of revenue to the island. Dr. Ward made many valuable observations and experiments on the natural history of the microscopic fungus, which contains the germ of the disease; but unfortunately he did not succeed in discovering any radical remedy for it. Instead, therefore, of receiving the gratitude due to him for his assiduous labours, he found himself violently taken to task by the press, and especially by the coffee planters. As if the hundreds of European naturalists engaged at the present time in investigating the nature and causes of similar plant epidemics should all be expected to discover a remedy for the disease they are studying! That this is seldom successfully done is a well established fact, and no axiom is more devoid of truth than that current in what are called 'cultivated circles,' that 'every disease has its cure.'

"It would lead me too far, and would weary my readers to no purpose were I to attempt a mere verbal description of the botanical paradise of Peradenia; even the drawings and water-colour sketches which I there made give a very inadequate idea of its beauties. Unlike most of our botanic gardens in Europe, the plants are not disposed in stiffly laid out beds, but are arranged with a regard to æsthetic effect, as well as to scientific classification. The principal groups of trees and the plants of kindred families are gracefully divided by smooth lawns of turf, and good paths lead from one to the other. In a more retired part of the park are the less attractive and more useful growths of both hemispheres, the seeds, fruit, and shoots of which are distributed among the gardeners and growers of the island. In this way the garden has been for many years of great practical utility as a centre of experiments and a garden of acclimatisation."

We must conclude our extracts with a suggestion from Prof. Haeckel which seems worthy of notice. He says:

"The singularly favourable climatic and topographical conditions of the Garden of Peradenia would seem to fit it for a wider sphere of scientific usefulness as a botanic station. In the same way that zoological students are now provided with invaluable means of assistance in the prosecution of their studies by the establishment of zoological stations on the sea-coast (at Naples, Roscoff, Brighton, Trieste, &c.) might young botanists in such a botanic station as Peradenia learn and accomplish as much in one year as they would in ten years under less favourable circumstances. Hitherto the tropical zone, the richest of all in materials for study, contains no such institution. If the English Government would establish and maintain a botanic station at Peradenia and a zoological station at Galle, she would add an important item to the services bestowed on science by her *Challenger* Expedition and other similar scientific undertakings; and she would once more put to shame those States of Continental Europe who can find no more useful or beneficial way of spending their money than in the manufacture of breech-loaders and cannon."

KŒNIG'S EXPERIMENTS IN ACOUSTICS[1]

II.

IN a preceding article it was recounted how Kœnig has applied the principle of the wave-siren to prove by direct experiment the influence which *phase* has upon the quality of a sound. The view taken by Kœnig that this difference may be completely explained by observing the difference in the form of the resultant waves was also briefly set forth. Two large diagrams were given which illustrated the matter very completely. A set of odd members only was taken from a harmonic series in which the amplitudes decreased in inverse ratio to the order of the harmonic; the series having for the ratios of its frequencies the numbers 1 : 3 : 5 : 7 : 9, with the respective amplitudes $1 : \frac{1}{3} : \frac{1}{5} : \frac{1}{7} : \frac{1}{9}$. These were compounded together, firstly without any difference of phase, and secondly with a difference of phase of $\frac{1}{4}$ the wave-length. The resultant in one case showed well-rounded sinuosities, and in the other angular zigzags. In the first case the whole of the components had at their origin zero amplitudes, in the second they all, at the origin, had their individual amplitudes at maximum values. Kœnig found the result, when the curves were actually tried upon his wave-siren, to be that though the constituent tones in the two cases were identical in pitch and amplitude the resultant sound from the zig-zag curve was harsh and strident compared with that produced by the rounded sinuosities; thus clearly proving an influence due to difference of phase only.

We give in Fig. 4 the resultant curves found by Kœnig in four typical instances. The first line of curves (*a*) shows the resultants of a set of ten partial tones with regularly diminishing amplitudes, as compounded together, first with *no* difference of phase, then with differences of $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ respectively. The sounds corresponding to these combinations were found to be loudest and most forcible for difference of phase $=\frac{1}{4}$, and to be least forcible for $d=\frac{3}{4}$, the phases of 0 and $\frac{1}{2}$ having intermediate intensity.

Fig. 4 (*b*) illustrates the combination first mentioned above, for which the differences of phase $\frac{1}{4}$ and $\frac{3}{4}$ produced a strident tone as compared with 0 and $\frac{1}{2}$, which agreed in giving a smoother resultant sound.

In Fig. 4 (*c*), which represents a series of harmonic tones with amplitudes whose successive values diminish each time by $\frac{1}{2}$, the results agreed in general with those obtained from the same series when the amplitudes diminished less suddenly, the phases $\frac{1}{4}$ and $\frac{3}{4}$ corresponding respectively to the maximum and minimum of intensity.

In Fig. 4 (*d*), where again we deal with a series of odd harmonics only, there is a harsher and louder sound for $d=\frac{1}{4}$ and $d=\frac{3}{4}$ than for $d=0$ and $d=\frac{1}{2}$.

In order to carry out these researches more fully, Kœnig has constructed a very large and complete appa-

[1] Continued from p. 206.