is 51 mm. The length from the socket of the median incisor to a line drawn across the back of the third molars is also 51 mm. The whole dentition is much affected with caries, and the disease has spread to the tooth-sockets, which are pierced in some places.

The lower jaw is unfortunately absent, but the size of the palate and the extent of the temporal fossæ show that it must have been massive. Even the Heidelberg jaw is slightly narrower and shorter than this must have been.

Although the new skull from the Rhodesian cave so much resembles that of Neanderthal man, the shape of the brain-case and the position of the foramen magnum are so different that we may hesitate to refer the two skulls to the same race. This hesitation seems to be justified when the associated limb-bones are considered, for the tibia is long and slender, of the typically modern type, and the extremities of the femur do not differ in any essential respect from the corresponding parts of a tall and robust modern man. They are thus very different from the tibia and femur of Neanderthal man found in the caves of Belgium and France. As the skull appears to postulate an erect attitude, the congruous limb-bones may well be referred to it. We therefore recognise in the Rhodesian cave man a new form which may be regarded as specifically distinct from *Homo neanderthalensis*, and may be appropriately named *Homo rhodesiensis*.

The precise systematic position of this new species of primitive man can be determined only by further discoveries. It has, however, been pointed out by Prof. Elliot Smith that the refinement of the face was probably the last step in the evolution of the human frame. The newly discovered Rhodesian man may therefore revive the idea that Neanderthal man is truly an ancestor of *Homo sapiens*; for *Homo rhodesiensis* retains an almost Neanderthal face in association with a more modern brain-case and an up-to-date skeleton. He may prove to be the next grade after Neanderthal in the ascending series.

Problems of Physics.[1]

By PROF. O. W. RICHARDSON, D.Sc., F.R.S.

RELATIVITY is the revolutionary movement in physics which has caught the public eye, perhaps because it deals with familiar conceptions in a manner which for the most part is found pleasantly incomprehensible. But it is only one of a number of revolutionary changes of comparable magnitude. Among these we have to place the advent of the quantum. The various consequences of the electronic structure of matter are still unfolding themselves to us, and are increasing our insight into the most varied phenomena at a rate which must have appeared incredible only a few decades ago.

The enormous and far-reaching importance of the discoveries being made at Cambridge by Sir Ernest Rutherford cannot be over-emphasised. These epoch-making discoveries relate to the structure and properties of the nuclei of atoms. At the present time we have, I think, to accept it as a fact that the atoms consist of a positively charged nucleus of minute size, surrounded at a fairly respectful distance by the number of electrons requisite to maintain the structure electrically neutral. The nucleus contains all but about one-two-thousandth part of the mass of the atom, and its electric charge is numerically equal to that of the negative electron multiplied by what is called the atomic number of the atom, the atomic number being the number which is obtained when the chemical elements are enumerated in the order of the atomic weights; thus hydrogen = 1, helium = 2, lithium = 3, and so on. Consequently the number of external electrons in the atom is also equal to the atomic number. The evidence, derived from many distinct and dissimilar lines of inquiry, which makes it necessary to accept the foregoing statements as facts, will be familiar to members of this Section of the British Association, which has continually been in the forefront of contemporary advances in physical science.

The diameters of the nuclei of the atoms are comparable with one-millionth of one-millionth part of a centimetre, and the problem of finding what lies within the interior of such a structure seems at first sight almost hopeless. It is to this problem which Rutherford has addressed himself by the direct method of bombarding the nuclei of the different atoms with the equally minute high-velocity helium nuclei (alpha-particles) given off by radioactive substances, and examining the tracks of any other particles which may be generated as a result of the impact. A careful and critical examination of the results shows that hydrogen nuclei are thus expelled from the nuclei of a number of atoms such as nitrogen and phosphorus. On the other hand, oxygen and carbon do not eject hydrogen under these circumstances, although there is evidence in the case of oxygen and nitrogen of the expulsion of other sub-nuclei whose precise structure is a matter for further inquiry.

The artificial transmutation of the chemical elements is thus an established fact. The natural transmutation has, of course, been familiar for some years to students of radio-activity. The philosopher's stone, one of the alleged chimeras of the mediæval alchemists, is thus within our reach. But this is only part of the story. It appears that in some cases the kinetic energy of the ejected fragments is greater than that of the bombarding particles. This means that these bombardments are able to release the energy which is stored in the nuclei of atoms. Now, we

[1] Abridged from the presidential address delivered to Section A (Mathematics and Physics) of the British Association at Edinburgh on September 9.

know from the amount of heat liberated in radio-active disintegration that the amount of energy stored in the nuclei is of a higher order of magnitude altogether, some millions of times greater, in fact, than that generated by any chemical reaction such as the combustion of coal. In this comparison, of course, it is the amount of energy per unit mass of reacting or disintegrating matter which is under consideration. The amounts of energy which have thus far been released by artificial disintegration of the nuclei are in themselves small, but they are enormous in comparison with the minute amounts of matter affected. If these effects can be sufficiently intensified there appear to be two possibilities. Either they will prove uncontrollable, which would presumably spell the end of all things,[2] or they will not. If they can be both intensified and controlled then we shall have at our disposal an almost illimitable supply of power which will entirely transcend anything hitherto known. It is too early yet to say whether the necessary conditions are capable of being realised in practice, but I see no elements in the problem which would justify us in denying the possibility of this. It may be that we are at the beginning of a new age, which will be referred to as the age of sub-atomic power. We cannot say; time alone will tell.

Thermionic Emission.

At the Manchester meeting of the Association in 1915 I had the privilege of opening a discussion on thermionic emission—that is to say, the emission of electrons and ions by incandescent bodies. I recall that the opinion was expressed by some of the speakers that these phenomena had a chemical origin. That view, I venture to think, is one which would find very few supporters now. It is not that any new body of fact has arisen in the meantime. The important facts were all established before that time, but they were insufficiently appreciated, and their decisiveness was inadequately realised.

It may be worth while to revert for a moment to the issues in that controversy, already moribund in 1915, because it has been closely paralleled by similar controversies relating to two other groups of phenomena—namely, photo-electric emission and contact electro-motive force—which, as we shall see, are intimately connected with thermionic emission. The issue was not as to whether thermionic emission may be looked upon simply as a type of chemical reaction. Such an issue would have been largely a matter of nomenclature. Thermionic electron emission has many features in common with a typical reversible chemical reaction such as the dissociation of calcium carbonate into lime and carbon dioxide. There is a good deal to be said for the point of view which regards thermionic emission as an example of the simplest kind of reversible chemical action, namely, that kind which consists in the dissociation of a neutral atom into a positive residue and a negative electron, inasmuch as we know that the negative electron is one of the really fundamental elements out of which matter is built up. The issue in debate was, however, of a different character. It was suggested that the phenomenon was not primarily an emission of electrons from the metallic or other source, but was a secondary phenomenon, a kind of by-product of an action which was primarily a chemical reaction between the source of electrons and some other material substance such as the highly attenuated gaseous atmosphere which surrounded it. This suggestion carried with it either implicitly or explicitly the view that the source of power behind the emission was not the thermal energy of the source, but was the chemical energy of the postulated reactions.

This type of view has never had any success in elucidating the phenomena, and I do not feel it necessary at this date to weary you with a recital of the facts which run entirely counter to it, and, in fact, definitely exclude it as a possibility. They have been set forth at length elsewhere on more than one occasion. I shall take it to be established that the phenomenon is physical in its origin and reversible in its operation.

Establishing the primary character of the phenomenon does not, however, determine its nature or its immediate cause. Originally I regarded it as simply kinetic, a manifestation of the fact that as the temperature rose the kinetic energy of some of the electrons would begin to exceed the work of the forces by which they are attracted to the parent substance. With this statement there is, I think, no room for anyone to quarrel, but it is permissible to inquire how the escaping electrons obtain the necessary energy. One answer is that the electrons have it already in the interior of the substance by virtue of their energy of thermal agitation. But thermal agitations now appear less simple than they used to be regarded, and in any event they do not exhaust the possibilities.

We know that when light of short enough wave-length falls on matter it causes the ejection of electrons from it—the so-called photo-electric effect. Since the formula for the radiation emitted by a body at any given temperature contains every wave-length without limitation, there must be some emission of electrons from an incandescent body as the result of the photo-electric effect of its own luminosity. Two questions obviously put themselves. Will this photo-electric emission caused by the whole spectrum of the hot body vary as the temperature of the incandescent body is raised in the way which is known to characterise thermionic emission? A straightforward thermodynamic calculation shows that this is to be expected from the theoretical point of view, and the anticipation has been confirmed by the experiments of Prof. W. Wilson. Thus the autophoto-electric emission has the correct behaviour to account for the thermionic emission. The other question is: Is it large enough? This

[2] To reassure the nervous I would, however, interpolate the comforting thought that this planet has held considerable quantities of radio-active matter for a very long time without anything very serious happening so far as we know.

is a question of fact. I have considered the data very carefully. There is a little uncertainty in some of the items, but when every allowance is made there seems no escape from the conclusion that the photo-electric effect of the whole spectrum is far too small to account for thermionic emission.

This question is an important one, apart from the particular case of thermionic emission. The same dilemma is met with when we seek for the actual *modus operandi* of evaporation, chemical action, and a number of other phenomena. These, so far as we know, might be fundamentally either kinetic or photochemical or a mixture of both. (I am using the term photochemical here in the wide sense of an effect of light in changing the composition of matter, whether the parts affected are atoms, groups of atoms, ions, or electrons.) For example, the approximation about boiling points known as Trouton's rule is a fairly obvious deduction from the photochemical point of view. The photochemical point of view has recently been put very strongly by Perrin, who would make it the entire *motif* of all chemical reaction, as well as of radio-activity and changes of state. In view of the rather minor part it seems to play in thermionic emission, where one would *a priori* have expected light to be especially effective, this is probably claiming too much for it, but the chemical evidence contains one item which is certainly difficult to comprehend from the kinetic point of view. The speed of chemical decomposition of certain gases is independent of their volume, showing that the decomposition is not due to molecular collisions. The speed does, however, increase very rapidly with rising temperature. What the increased temperature can do except increase the number and intensity of the collisions, factors which the independence of volume at constant temperature show to be without effect, and increase the amount of radiation received by the molecules, is not too obvious. It seems, however, that, according to calculations by Langmuir (Journ. Amer. Chem. Soc., vol. 42, p. 2190, 1920), the radiation theory does not get us out of this difficulty; for, just as in the ordinary photoelectric case, there is nothing like enough radiation to account for the observed effects. It seems that in the case of these mono-molecular reactions the phenomena cannot be accounted for either by simple collisions, or by radiation, or by a mixture of both, and it is necessary to fall back on the internal structure of the decomposing molecule. This is complex enough to afford material sufficient to cover the possibilities; but, from the point of view of the temperature energy relations of its parts, it cannot at present be regarded as much more than a field for speculation.

Contact Electricity.

A controversy about the nature of the contact potential difference between two metals, similar to that to which I have referred in connection with thermionic emission, has existed for over a century. In 1792 Volta wrote: "The metals . . . can by themselves, and of their own proper virtue, excite and dislodge the electric fluid from its state of rest." The contrary position that the electrical manifestations are inseparably connected with chemical action was developed a few years later by Fabroni. Since that time electrical investigators have been fairly evenly divided between these two opposing camps. Among the supporters of the intrinsic or contact view of the type of Volta we may recall Davy, Helmholtz, and Kelvin. On the other side we have to place Maxwell, Lodge, and Ostwald. In 1862 we find Lord Kelvin ("Papers on Electrostatics and Magnetism," p. 318) writing: "For nearly two years I have felt quite sure that the proper explanation of voltaic action in the common voltaic arrangement is very near Volta's, which fell into discredit because Volta or his followers neglected the principle of the conservation of force." On the other hand, in 1896 we find Ostwald ("Elektrochemie, Ihre Geschichte und Lehre," Leipzig, 1896, p. 65) referring to Volta's views as the origin of the most far-reaching error in electrochemistry, which the greatest part of the scientific work in that domain has been occupied in fighting almost ever since. These are cited merely as representative specimens of the opinions of the protagonists.

Now, there is a close connection between thermionic emission and contact potential difference, and I believe that a study of thermionic emission is going to settle this little dispute. In fact, I rather think it has already settled it, but before going into that matter I would like to explain how it is that there is a connection between thermionic emission and contact potential difference, and what the nature of that connection is.

Imagine a vacuous enclosure, either impervious to heat or maintained at a constant temperature. Let the enclosure contain two different electron-emitting bodies, A and B. Let one of these, say A, have the power of emitting electrons faster than the other, B. Since they are each receiving as well as emitting electrons, A will acquire a positive and B a negative charge under these circumstances. Owing to these opposite charges A and B will now attract each other, and useful work can be obtained by letting them come in contact. After the charges on A and B have been discharged by bringing them in contact, let the bodies be quickly separated and moved to their original positions. This need involve no expenditure of work, as the charges arising from the electron emission will not have had time to develop. After the charges have had time to develop the bodies can again be permitted to move together under their mutual attraction, and so the cycle can be continued an indefinite number of times. In this way we have succeeded in imagining a device which will convert all the heat energy from a source at a uniform temperature into useful work.

Now, the existence of such a device would contravene the second law of thermodynamics. We are therefore compelled either to deny the principles of thermodynamics or to admit that there is some fallacy as to the pretended facts in

the foregoing argument. We do not need to hesitate between these alternatives, and we need only look to see how the alleged behaviour of A and B will need to be modified in order that no useful work may appear. There are two alternatives. Either A and B necessarily emit equal numbers of electrons at all temperatures, or the charges which develop owing to the unequal rate of emission are not discharged, even to the slightest degree, when the two bodies are placed in contact.

The first alternative is definitely excluded by the experimental evidence, so I shall proceed to interpret the second. It means that bodies have natural states of electrification whereby they become charged to definite potential differences whose magnitudes are independent of their relative positions. There is an intrinsic potential difference between A and B, which is the same, at a given temperature, whether they are at a distance apart or in contact.

Admitting that the intrinsic potentials exist, a straightforward calculation shows that they are intimately connected with the magnitudes of the thermionic emission at a given temperature. The relation is, in fact, governed by the following equation. If A and B denote the saturation thermionic currents per unit area of the bodies A and B respectively, and V is the contact potential difference between them at the absolute temperature T, then $V = kT/e \log A/B$, where k is the gas constant calculated for a single molecule (Boltzmann's constant), and e is the electronic charge.

I have recently, with the help of Mr. F. S. Robertson, obtained a good deal of new information on this question from the experimental side. We have made measurements of the contact potential difference between heated filaments and a surrounding metallic cylinder, both under the high-vacuum and gas-free conditions which are now attainable in such apparatus, and also when small known pressures of pure hydrogen are present. As is well known, both contact potentials and thermionic emission are very susceptible to minute traces of gas, but we find that under the best conditions as to freedom from gas there is a contact potential of the order of one volt between a pure tungsten filament and a thoriated filament. We also find that changes of a similar magnitude in the contact potential difference between a thoriated tungsten filament and a copper anode take place when the filament is heated. These changes are accompanied by simultaneous changes in the thermionic currents from the filament, and we find that the change in the contact potential calculated from the change in the currents with the help of the foregoing equation is within about 20 per cent. of the measured value. Considering the experimental difficulties, this is a very substantial agreement. Whilst the evidence is not yet as complete as I hope to make it, it goes a long way towards disproving the chemical view of the origin of contact potential difference.

From what has been said you will realise that the connection between contact potentials and thermionic emissions is a very close one. I would, however, like to spend a moment in developing it from another angle. To account for the facts of thermionic emission it is necessary to assume that the potential energy of an electron in the space just outside the emitter is greater than that inside by a definite amount, which we may call w. The existence of this w, which measures the work done when an electron escapes from the emitter, is required by the electron-atomic structure of matter and of electricity. Its value can be deduced from the temperature variation of thermionic emission, and, more directly, from the latent heats absorbed or generated when electrons flow out of or into matter. These three methods give values of w which, allowing for the somewhat considerable experimental difficulties, are in fair agreement for any particular emitter. The data also show that in general different substances have different values of w. This being so, it is clear that when uncharged bodies are placed in contact the potential energies of the electrons in one will in general be different from those of the electrons in the other. If, as in the case of the metals, the electrons are able to move freely they will so move until an electric field is set up which equilibrates this difference of potential energy. There will thus be an intrinsic or contact difference of potential between metals which is equivalent to the difference in the values of w and is equal to the difference in w divided by the electronic charge.[3]

Photo-electric Action.

We have seen that there is a connection on broad lines between thermionic emission and both contact potentials on one hand and photo-electric emission on the other. The three groups of phenomena are also related in detail and to an extent which up to the present has not been completely explored. In order to understand the present position, let us review briefly some of the laws of photo-electric action as they have revealed themselves by experiments on the electrons emitted from metals when illuminated by visible and ultra-violet light.

Perhaps the most striking feature of photoelectric action is the existence of what has been called the threshold frequency. For each metal whose surface is in a definite state there is a definite frequency n_0, which may be said to determine the entire photo-electric behaviour of the metal. The basic property of the threshold frequency n_0 is this: When the metal is illuminated by light of frequency less than n_0 no electrons are emitted, no matter how intense the light may be. On the other hand, illumination by the most feeble light of frequency greater than n_0 causes some emission. The frequency n_0 signalises a sharp and absolute discontinuity in the phenomena.

Now let us inquire as to the kinetic energy of the electrons which are emitted by a metal when illuminated by monochromatic light of frequency,

[3] This statement is only approximately true. In order to condense the argument certain small effects connected with the Peltier effect at the junction between the metals have been left out of consideration.

let us say, n. Owing to the fact that the emitted electrons may originate from different depths in the metal, and may undergo collisions at irregular intervals, it is only the maximum kinetic energy of those which escape which we should expect to exhibit simple properties. As a matter of fact, it is found that the maximum kinetic energy is equal to the difference between the actual frequency n and the threshold frequency n_0 multiplied by Planck's constant h. In mathematical symbols, if v is the velocity of the fastest emitted electron, m its mass, e its charge, and V the opposing potential required to bring it to rest,

$$eV = \tfrac{1}{2}\ m\ v^2 = h\ (n - n_0).$$

From this equation we see that the threshold frequency has another property. It is evidently that frequency for which kinetic energy and stopping potential fall to zero. This suggests strongly, I think, that the reason the electron emission ceases at n_0 is that the electrons are not able to get enough energy from the light to escape from the metal, and not that they are unable to get any energy from the light.

The threshold frequencies have another simple property. If we measure the threshold frequencies for any pair of metals, and at the same time we measure the contact difference of potential K between them, we find that K is equal to the difference between their threshold frequencies multiplied by this same constant h divided by the electronic charge e.

These results, as well as others which I have not time to enumerate, admit of a very simple interpretation if we assume that when illuminated by light of frequency n the electrons individually acquire an amount of energy hn. We have seen that in order to account for thermionic phenomena it is necessary to assume that the electrons have to do a certain amount of work w to get away from the emitter. There is no reason to suppose that photo-electrically emitted electrons can avoid this necessity. Let us suppose that this work is also definite for the photoelectric electrons and let us denote its value by hn_0. Then no electron will be able to escape from the metal until it is able to acquire an amount of energy at least equal to hn_0 from the light—that is to say, under the suppositions made—until n becomes at least as great as n_0. Thus n_0 will be identical with the frequency which we have called the threshold frequency, and the maximum energy of any electron after escaping will be $h\ (n - n_0)$.

The relation between threshold frequencies and contact potential difference raises another issue. We have seen that the contact potential difference between two metals must be very nearly equal to the difference between the amounts of work w for the electrons to get away from the two metals by thermionic action, divided by the electronic charge e. The photo-electric experiments show that the contact electromotive force is also nearly equal to the differences of the threshold frequencies multiplied by h/e. It follows that the photo-electric work hn_0 must be equal to the thermionic work w to the same degree of accuracy. The photoelectric and thermionic works are known to agree to within about one volt. To decide how far they are identical needs better experimental evidence than we have at present. The indirect evidence for their substantial identity is stronger at the moment than the direct evidence.

I do not think that the complete identity of the thermionic work w and the photo-electric hn_0 is a matter which can be inferred *a priori*. What we should expect depends to a considerable extent on the condition of the electrons in the interior of metals. We cannot pretend to any real knowledge of this at present; the various current theories are mere guesswork. Unless the electrons which escape all have the same energy when inside the metal we should expect the thermionic value to be an average taken over those which get out. The photo-electric value, on the other hand, should be the minimum pertaining to those internal electrons which have most energy. The apparent sharpness of the threshold frequency is also surprising from some points of view. There seems to be scope for a fuller experimental examination of these questions.

I have spoken of the threshold frequency as though it were a perfectly definite quantity. No doubt it is when the condition of the body is or can be definitely specified, but it is extraordinarily sensitive to minute changes in the conditions of the surface, such as may be caused, for example, by the presence of extremely attenuated films of foreign matter. For this reason we should accept with a certain degree of reserve statements which appear from time to time that photo-electric action is some parasitic phenomenon, inasmuch as it can be made to disappear by improvement of vacuum or other change in the conditions. What has generally happened in these investigations is that something has been done to the illuminated surface which has raised its threshold frequency above that of the shortest wave-length in the light employed in the test. Unless they are accompanied by specific information about the changes which have taken place in the threshold frequency, such statements are of little value at the present stage of development of this subject.

Light and X-rays.

One of the great achievements of experimental physics in recent years has been the demonstration of the essential unity of X-rays and ordinary light. X-rays have been shown to be merely light of particularly high frequency or short wave-length, the distinction between the two being one of degree rather than of kind. The foundations of our knowledge of X-ray phenomena were laid by Barkla, but the discovery and development of the crystal diffraction methods by v. Laue, the Braggs, Moseley, Duane, and de Broglie have established their relations with ordinary light so

clearly that he who runs may read their substantial identity. The actual gap in the spectrum of the known radiations between light and X-rays is also rapidly disappearing. The longest stride into the region beyond the ultra-violet was made by Lyman with the vacuum grating spectroscope which he developed. For a time Prof. Bazzoni and I held the record in this direction with our determination of the short wave limit of the helium spectrum, which is in the neighbourhood of 450 Ångstrom units. More recently this has been passed by Millikan, who has mapped a number of lines extending to about 200 ngstrom units—that is to say, more than four octaves above the violet limit of the visible spectrum. I am not sure what is the longest X-ray which has been measured, but I find a record of a Zinc L-ray by Friman (*Phil. Mag.*, vol. 32, p. 494, 1916) of a wave-length of 12·346 Ångstrom units. There is thus at most a matter of about four octaves still to be explored. In approaching this unknown region from the violet end the most characteristic property of the radiations appears to be their intense absorption by practically every kind of matter. This result is not very surprising from the quantum point of view. The quantum of these radiations is in excess of that which corresponds to the ionising potential of every known molecule, but it is of the same order of magnitude. Furthermore, it is large enough to reach not only the most superficial, but also a number of the deeper-seated electrons of the atoms. There is evidence, both theoretical and experimental, that the photo-electric absorption of radiation is most intense when its quantum exceeds the minimum quantum necessary to eject the absorbing electron but does not exceed it too much. In the simplest theoretical case the absorption is zero for radiations the frequencies of which lie below the minimum quantum, rises to a maximum for a frequency comparable with the minimum, and falls off to zero again at infinite frequency. This case has not been realised in practice, but, broadly judged, the experimental data are in harmony with it. On these general grounds we should expect intense absorption by all kinds of matter for the radiation between the ultra-violet and the X-ray region.

The Botanic Gardens, Victoria, Cameroons Province, Nigeria.

HIS Excellency the Governor of Nigeria, Sir Hugh Clifford, G.C.M.G., in a remarkable address to the Nigerian Council,[1] which is deserving of careful study by those interested in our West African colonies, directed attention to the neglected condition of the Victoria Botanic Gardens in the recently acquired Cameroon Province, and stated that at his request the Assistant Director of the Royal Botanic Gardens, Kew, was about to visit Nigeria for the purpose of advising the Government "as to the action that should be taken for their restoration and future maintenance." We learn from the *Kew Bulletin*, No. 6, issued in September last, that Captain A. W. Hill has returned from his mission, and fully endorses the remarks made by the Governor as to the beauty and value of these gardens.

To quote from His Excellency's address:—

> The Botanical Gardens at Victoria compare in everything save size with their prototypes at Buitenzorg in Java and Peradeniya in Ceylon. They contain a fine and varied collection of trees and plants and shrubs which have been brought together from every part of the tropics; and, in spite of their close proximity to the sea, the soil in them appears to be abundantly fertile. A special feature of these gardens is a stream of water, crystal clear, that patters noisily over a bed of pebbles. . . .
>
> It would be a lasting discredit to this Government, I consider, if it were to neglect to repair the damage which the war has already unhappily inflicted upon these lovely and valuable gardens.

The gardens, we learn, cover an area of some 200 acres, and are provided with a good laboratory, a herbarium, and museum building, as well as a building which served the purpose of an agricultural school. All these are in a very fair state of repair, and are only awaiting the time when they can be restored to their proper functions. The site is admirably adapted to garden purposes, since the soil is a highly fertile decomposed volcanic rock. There are some steep hills, commanding fine views either across the bay or to the lofty Cameroon Mountain, but there is also a considerable tract of more or less level ground, so that it is possible to cultivate useful economic plants under varied tropical conditions. Connected with these gardens were the experimental plots of tea and cinchona at Buea, situated at an altitude of 3300–3600 ft., on the slope of the Cameroon Mountain. Photographs of these plantations are given in the Bulletin, and though now in a very neglected condition, they show that the cultivation of these products is a practical proposition in the Cameroon Province. High-level stations are thus a necessary adjunct to the gardens.

The importance of the Victoria Botanic Gardens and substations, with the laboratory and other buildings, where mycological, chemical and entomological research can be carried out, can best be realised when it is pointed out that the lower slopes of the Cameroon Mountain are covered by extensive plantations of such economic plants as cocoa, coffee, Hevea and Funtumia rubber, kola, bananas, oil palms, etc. The Cameroon Province thus differs essentially from Nigeria proper, where large plantations are rare and widely separated. In Nigeria fungus and insect diseases are not able to spread far, since

[1] Nigerian Council, Address by the Governor, Sir Hugh Clifford, December 29, 1920. See especially pp. 184–86 and 208–11.