THURSDAY, SEPTEMBER 7, 1905.

MARINE ENGINEERING.

Marine Engines and Boilers, their Design and Construction. Based on the work by Dr. G. Bauer. Translated from the second German edition by E. M. and S. Bryan Donkin. Edited by Leslie S. Robertson. Pp. xxviii+744. (London: Crosby Lockwood and Son.) Price 25*s*. net.

THIS considerable work fills a gap in English engineering literature. For while the related subject of naval architecture has been treated by writers of authority, there is no very good modern book on marine engineering. Dr. Bauer states that it is intended to be a condensed treatise, embodying the theoretical and practical rules used in designing marine engines and boilers. But though thus limited in scope, it treats only of the most modern types and excludes even modern engines and boilers of special types. As might be expected from the engineer-in-chief of the Vulcan Works at Stettin, the machinery of warships and of some of the great German Atlantic liners are very fully illustrated. There is not a great deal of theoretical investigation, but what there is bears very definitely on design, and is sound so far as it goes. Perhaps the most valuable part of the book is the great amount of tabulated information about the proportions of the machinery in good examples of modern practice. There is also a very large collection of those empirical or semi-empirical rules, based on extensive practical experience, on which engineers necessarily so much rely. There is reason to be grateful that an engineer so distinguished as Dr. Bauer, with the care of a great factory on his shoulders, should have found time to produce such a systematic treatise, and that he has been able to obtain the aid of some of his principal technical assistants in dealing with parts of the subject.

The book has been excellently and competently translated, and the translators have undertaken the necessary, but very laborious, task of converting the numerical statements of formulæ from the metric to English measures. However bad our English system of measures may be, English engineers can only think and work in English measures, and the translation would have lost very much of its usefulness if the conversion had not been made. Mr. Leslie S. Robertson, who has edited the volume, has had practical experience in this branch of engineering, and has already published valuable works relating to it. His name is a guarantee that the adaptation of the work for English readers has been, from the technical point of view, thoroughly well done.

The general arrangement of the book is convenient. Part i., which occupies four-tenths of the volume, deals with the main engines. First, indicator diagrams are discussed, and the application of theoretical diagrams in settling cylinder proportions. The well known method of constructing theoretical diagrams from a diagram of the volumes occupied by the steam is given, and an example worked out. The remark is made that "the diagrams so obtained show the characteristics of actual diagrams, but their mean pressures are naturally much higher than they would be in actual practice." That is not our experience. If the data are rightly used, there is a fairly close approximation between the theoretical and actual mean pressures. It is a case in which the precise law of expansion assumed does not very much affect the result. There is one other small point in this chapter. The ratio of an actual to a theoretical diagram is called an "efficiency" (p. 17). This leads to the awkward statement on p. 35 that "the efficiency of triple expansion engines is less than that of single cylinder engines." If the more usual term "diagram factor" had been used instead of efficiency the statement would be less misleading.

Next there is a very short section dealing with some thermal circumstances affecting the utilisation of steam. This is too brief to be satisfactory, even from the point of view of engine design. For instance, the loss due to cylinder condensation is explained by saying that "heat is withdrawn from the steam at high pressure and restored to it at a lower pressure" (p. 37). The essential point that the heat is chiefly restored during exhaust is not mentioned. So the economy of multiple expansion engines is traced to reduction of temperature range. But the re-evaporation during exhaust from one cylinder increases the work in the next. In other respects also the explanation is deficient. However, the thermodynamics of steam engines is fully given in other treatises. An important section follows, in which the stroke, speed, and turning moment are discussed. The theory of torsional vibrations is given, and practical methods of determining the critical speed at which liability to strong torsional vibrations occurs. In connection with this there is a brief but clear and practical treatment of the problem of balancing. Then the arrangement of main engines is explained, and there is a long section dealing with the proportions of engine details and including a sufficient account of valve diagrams.

Part ii. deals with pumps. Part iii. discusses shafting, and in connection with this ship resistance, and the proportioning of propellers. German writers are adepts at tabulating coefficients and data, and the tables in this section are excellent. Part iv. is on pipes and connections. Part v. deals with steam boilers, and is chiefly descriptive of modern types. Here again the tabulated data from actual cases is information of the most useful kind, and the rules of the classification societies, which leave the engineer very little discretion, are fully given. The last section gives some account, rather too much condensed, of instruments used in steam engine and boiler trials. To many readers an account of Fottinger's torsion indicator for measuring the effective horse-power of engines by observing the torsion of the screw shaft will be interesting. Hirn first used a torsion dynamometer of this kind. As a diagram of the torsion angle is obtained, the variation of the power transmitted can be determined.

No account is given of the most recent change in marine engineering, namely, the adoption of the steam turbine in place of reciprocating engines. The success of the steam turbine in this field is already so well assured that a revolution in marine engineering is promised. But there are, no doubt, good reasons for the omission. Experience in the use of steam turbines in ships is almost confined to this country, and naturally at present full information as to the results, mechanical and economic, of the use of turbines is only possessed by a few engineers, and is not generally available.

In this country we still rightly pride ourselves on retaining the highest position in shipbuilding and marine engineering. But, if we still do more work of this kind than any other nation, and if our best work is as good as any in the world, yet Dr. Bauer's book should remind us that in science, experience and skill, other nations now run us very close.

THE BIRDS OF ICELAND.

Beitrag zur Kenntnis der Vogelwelt Islands. By B. Hantzsch. Pp. vi + 341; illustrated. (Berlin: Friedländer and Son, 1905.) Price 12 marks.

SINCE Iceland lies on one of the main migration routes, namely, that which starts from Greenland and Iceland itself, and passes by the Færöes to the British Islands, its bird-fauna is naturally of special interest and importance. This is testified by the appearance within a comparatively short period of two works on the subject, namely, Mr. H. N. Slater's "Manual of the Birds of Iceland," published at Edinburgh in 1901, and the present larger and more pretentious volume. In addition to the general fauna, there is special interest attaching to Iceland as the chief European resort in former days of the gare-fowl, or great auk. The history of this lost bird and the literature relating to it the author reserves for a supplemental volume. Despite all that has been done by travellers and collectors, Mr. Hantzsch is of opinion that our knowledge of the bird-fauna of Iceland is still far from complete, much of the interior of the country being difficult of access and still imperfectly explored by collectors. Accordingly he is fain to admit that the last word on the subject still remains to be said.

The volume commences with an historical survey of the growth of our knowledge of Icelandic ornithology, with notices of the chief explorers and workers in this field of research, and a list of the more important memoirs and books treating of the subject. Then comes a detailed account of the author's own journeys in the island for the purpose of collecting specimens and personally observing the birds. This is followed by an interesting description of the main physical features of Iceland and the neighbouring islets, such as Grimsey in the north and the Westman group in the south, this being illustrated with a number of reproductions of photographs of the scenery taken by the author himself. Special lists are given of the birds of Grimsey and the Westman Islands. Changes in the bird-fauna of the whole group of islands, and the general relationships of the fauna form the subjects of two succeeding chapters, a brief note being appended on domesticated species.

This completes the introductory portion of the subject, which occupies ninety-two pages, and the remainder of the text is devoted to the detailed synopsis of the birds. The total number of species, exclusive of the great auk, recorded in the preliminary list as definitely known to occur in Iceland is 120, in addition to which are a few of which the right to a place among the fauna is somewhat uncertain. Perhaps the most striking feature of the descriptive part of the work is the almost painful severity with which new fashions in ornithological nomenclature are followed, such appalling alliterations as *Merula merula merula* and *Gallinago gallinago gallinago* occurring with wearisome frequency. Without reiterating his own private opinion on nomenclature of this nature, which is now pretty well known, the reviewer may point out that when the typical form of a species is alone recorded, it is perfectly superfluous to add the terminal trinomial, *Merula merula* and *Gallinago gallinago* being in such cases apparently all that can possibly be required.

Excellent photographs of the eggs, nests, or breeding-haunts of some of the rarer species serve to enliven the text, and ornithologists will be greatly interested in the two pictures of the eggs and callow young of the great skua in their natural surroundings. The work will doubtless long remain the standard authority on Icelandic birds, at all events for German readers.

R. L.

OUR BOOK SHELF.

Neue Fische und Reptilien aus der böhmischen Kreideformation. By Prof. Dr. Anton Fritsch and Dr. Fr. Bayer. Pp. 34; plates ix. (Prague: Fr. Rivnac, 1905.)

VERTEBRATE fossils are not only rare, but also badly preserved, in the Cretaceous rocks of Bohemia. Palæontologists must therefore admire the enthusiasm of Dr. Anton Fritsch, who continues to devote to the interpretation of difficult fragments so much study as is evidenced by his numerous writings on these remains. In 1878 he published a complete synopsis of the subject as then understood. Now, with the aid of Dr. Franz Bayer in the determination of fishes, he again publishes an up-to-date treatise, including the discoveries of the last quarter of a century. The work is illustrated in Dr. Fritsch's usual style, and a few of the figures are revised drawings of specimens previously described.

Dr. Bayer's chapter on the Cretaceous fishes was originally published in the Bohemian language in 1902, but is now made more readily accessible in German. He describes evidence of several new genera and species, and concludes that in the Bohemian Chalk there are more varied representatives of the higher fishes than have hitherto been found below the Tertiary formations. In view of the fragmentary nature of most of the fossils, it must be admitted that this conclusion needs confirmation from future discoveries before it can be definitely accepted. The specimens on which the new genera Coryphænopsis and Bayeria (Fritsch) are founded are certainly remarkable.

Dr. Fritsch's section of the work shows that all the usual groups of Cretaceous Reptilia are represented in the Bohemian rocks. There are undoubted fragments of Plesiosaurs, and there is one interesting brain-cast which the author describes as probably referable to Polyptychodon. Dr. Fritsch, however, overlooks the fact that the skull of Polyptychodon is actually known in England, and is undoubtedly Plesiosaurian or Pliosaurian, not Mosasaurian. Chelonian remains occur, evidently representing turtles related to the small *Chelone Benstedi* from the English Chalk. Some fragments appear to be Mosasaurian, but those described under the new name of *Iserosaurus litoralis* are extremely problematical. Other fragments, ascribed without much reason to Dinosauria, scarcely suffice to justify the new names bestowed on them. Some good new figures of the interesting wing-bones of the small Pterodactyl, *Ornithocheirus hlavaci*, are given, and the volume concludes with a systematic list of species.

A. S. W.

Die Bedeutung des Experimentes für den Unterricht in der Chemie. By Dr. Max Wehner. Pp. 62. (Leipzig and Berlin: B. G. Teubner, 1905.) Price 1.40 marks.

THIS brochure forms part of a "Sammlung naturwissenschaftlich-pädogogischer Abhandlungen," and is very hard reading for an ordinary English chemist. It is divided into two parts, the first of which deals with the importance of experiment for attaining the object of chemical instruction, and the second with the importance of experiment in relation to method in chemical instruction. It is hard reading in the sense that one has to wade through detailed arguments which culminate in conclusions such as "description does not suffice for the instruction of the pupil in chemical processes," and "the development of the laws concerning chemical processes from experimental observations is more effective for chemical teaching than their deduction from quoted examples." The work is, in fact, an example of pure pedagogical exercitation, and it may be recommended with confidence only to those who have a liking for that kind of literature.

A. S.

Monographie des Cynipides d'Europe et d'Algérie. By l'Abbé J. J. Kieffer. Tome second. 2me. fascicule. Pp. 289–748; plates ix–xxi. (Paris: A. Hermann.) Price 18s.

THIS is the conclusion of vol. vii. *bis* of André's great series of monographs, "Spécies des Hymenoptères," and completes the Cynipides, or gall flies. The previous portions have already been noticed in NATURE (vol. lxvii. pp. 124–5, December 11, 1902, and vol lxviii. p. 221, July 9, 1903), and the part now published completes the Cynipides, 5e tribu, Figitinæ; and also includes the Evaniides (divided into two tribes, Evaniinæ and Gasteruptioninæ), the Stephanides, Trigonalides, Agriotypides, general supplements, a "Catalogue méthodique et synonymique," extending from pp. 653 to 741 (double columns), and general indices.

The plan of the work is uniform throughout, and as the previous portions have already been discussed at considerable length, an extended notice is here unnecessary.

W. F. K.

The Gum-Bichromate Process. By J. Cruwys Richards. Pp. 119. (London: Iliffe and Sons, Ltd., n.d.) Price 2s. 6d. net.

THIS process of photographic printing is about fifty years old, but it is only during the last ten years or so that it has been adopted for practical purposes. When first introduced it was deliberately rejected, because it was not equal to the then known processes in reproducing the detail of the negative; latterly it has been taken up and very much appreciated by some of those who desire to be able to alter or "control" their photographic printing, and so obtain results that, while they can lay no claim to mechanical accuracy, more nearly please the æsthetic taste of the worker. At the present time there are more methods of photographic printing than there were a generation ago that are excellently adapted for the purposes of photography pure and simple; therefore the gum-bichromate process is still more than it was then a process for the specialist in the direction named. The author of this volume is well known as a successful worker of the method. He gives his own formulæ, and states clearly the practical details that he prefers to follow, but he also describes the methods of others. He is a warm advocate of "multiple printing"; that is, after coating the paper, exposing, developing with warm water aided with a brush or by other mechanical means, coating, exposing, and developing a second or even a third or more times, so gradually building up the picture with the maximum opportunity of "control." It will be obvious that every possibility of improvement in the hands of the skilful is a probability of error in the hands of the artistically ignorant, and that the process does not claim attention from a photographic point of view at all, but as enabling an artist to express his ideas with less trouble and perhaps with more accurate drawing than if he worked wholly by hand. The volume includes several reproductions of the author's works, some of them showing the print in its various stages of evolution.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Recent Changes in Vesuvius.

I BEG to enclose a somewhat free translation of a letter I have recently received from Prof. G. Mercalli, of Naples, concerning certain changes which have taken place in Vesuvius this year. During a visit to the mountain on August 14–16, I was able to approach quite near to the sources of the lava streams described by him, and also to examine the remarkable tunnels formed at certain places by the cooled surface of lava streams which had subsequently diminished in volume, or had even "run dry."

During the week preceding my visit, many incandescent bombs of pasty rock had been ejected from the crater at the summit, mostly in the direction of the side facing Pompeii, and these successively rolling down the ash-slope presented a beautiful spectacle at times. The lava streams proper often presented that curious double appearance, due to the fact that the colder and darker scoriæ, floating down the stream, keep to the more swiftly-moving current in mid-stream, and avoid the sides.

Yesternight (August 20) but one of the lava streams referred to by Prof. Mercalli was visible from Naples, the other having apparently ceased.

The explosions of Stromboli are occurring at intervals of about $3\frac{1}{2}$ minutes.

R. T. GÜNTHER.

R.M.S. *Oroya*, off Stromboli, August 21.

Lava Stream of May 27, 1905.

IN the months of April and May of this year Vesuvius began to show an increased activity, and in the crater, which was about 80 metres in depth, a small cone began to form; it increased rapidly, and by the middle of May had risen to a height of about 15 metres above the level of the enclosing crater.

From May 25 to May 27 violent explosions occurred, which were heard in all the villages on the mountain-side,

FIG. 1.—Source of lava stream of August 26, 1903. From a photograph by Prof. G. Mercalli, taken April 15, 1904.

and were accompanied by the ejection of much red-hot and liquid matter. These explosions ceased almost suddenly on the evening of May 27, and at about 6.45, a small lateral outlet, "A," burst through the north-west flank of the great cone at a height of about 1245 metres, and at the point where a seam in the mountain-side showed where the traces of the last eruption of August 26, 1903, still lingered.

A few hours after the first, a second outlet was formed, then a third, "B," both lower down, at an altitude of

FIG. 2.—Vesuvius as seen from the Observatory Ridge, May 29, 1905. From a photograph by Prof. G. Mercalli.

about 1180 metres, and both westward of the first, and nearer the station of the funicular railway.

For some weeks lava issued from these outlets and flowed down the mountain-side in two parallel streams, which from Naples had the appearance of two lines of fire running down the slope of the great cone; towards June 25 the current from "A" ceased, but the stream from "B" continued, and flows more actively than before.

On reaching the base of the great cone (800 metres), the lava piled itself up in the space between the cone and the hill formed by the lava-flow of 1895; a stream branched off, first toward Mount Somma, but afterwards in a south-south-west direction, and a small stream more fluid than the main body ran to within a short distance of the electric railway which plies between the observatory and the lower funicular station. Near the fumarole "B" a small heap of scoriæ (a driblet-cone), about 4–5 metres in height, has sprung up; but apart from the explosions attendant on its formation, and which only lasted a few days, there has been no disturbance in the regular flow of the great streams.

The line of white steam seen in Fig. 2 shows the position of the outlets and the course of the lava streams as seen from the observatory ridge; the black smoke issuing from the crater indicates the cloud of non-incandescent dust which was cast up after the partial falling in of the walls of the smaller cone on the summit.

We may perhaps attribute the frequency in these latter years of the lava streams from lateral outlets to the increased height of Vesuvius (now about 1330 metres), for the column of fluid lava, when inside the cone, is forced up to a higher level and exerts greater hydrostatic pressure on the sides of it, which are, moreover, much seamed. Formerly, when the mountain was lower, as, for instance, between the years 1840 and 1850, the lava streams generally flowed from the top.

The Millport Marine Station.

SINCE the efficiency of such an institution as a biological station is so largely dependent upon the completeness of its library, I do not think any apology need be offered for appealing to those readers of NATURE who are interested in marine biology for assistance in an endeavour to bring together for the use of those working at the Millport Marine Station as complete a collection as may be possible of works having any bearing on the fauna and flora of the European seas. The station already possesses a considerable proportion of the more important monographs, as well as a number of useful pamphlets; but there are still lacking many reference works of importance, and I am sure that copies of some of these will exist among the duplicates in many a naturalist's library. I would also urge the claims of the Millport Station upon the generosity of authors for separate copies of any papers they may publish; and in this connection it should be noted that the council of the association has recently agreed that all material intended for private research shall be supplied absolutely free of charge.

This occasion may also be utilised to point out some of the advantages which the Millport Marine Station offers to the research student. The fauna of the Clyde area is an extremely rich one, and the water in the vicinity of the station is of most remarkable purity, so that even quite delicate species can be readily kept alive in the tanks. A small steamer, the *Mermaid*, specially built for scientific research, is constantly at work during the summer months, and brings in daily an abundant supply of material. The tank-room, only part of which is open to the public, has recently been greatly extended, and now has facilities which are probably unsurpassed anywhere for the accommodation of invertebrates and the smaller vertebrates; the tanks are mostly of glazed fire-clay, and capitally adapted for observation and experiment. Besides a well-equipped private research room, there are seven screened compartments in the general laboratory affording ample accommodation for nine students, while a large class-room recently added has benches for forty-five students.

The station is lavishly equipped with apparatus of all kinds—for instance, the student will find here every facility for advanced physiological work. In fine, I think it may fairly be claimed that nowhere in the British Isles will the student find facilities for research on marine biology such as exist at Millport; and, indeed, I know of no marine station elsewhere which can, all things considered, offer greater advantages to the biologist. Lastly, it may be mentioned that although the fees are very low, there is never any difficulty in arranging for a free table.

S. PACE (Director).

Millport Marine Station, N.B.

THE TOTAL SOLAR ECLIPSE, AUGUST 30.

(1) THE SOLAR PHYSICS OBSERVATORY EXPEDITION.

Palma, August 26.

IN another four days the eclipse will be an event of the past, and we shall be packing up the great amount of material which we have been setting up with so much care since August 11. The greatest keenness has been displayed in every party told off for its particular duty, and I think that everyone will be glad when the eventful day arrives.

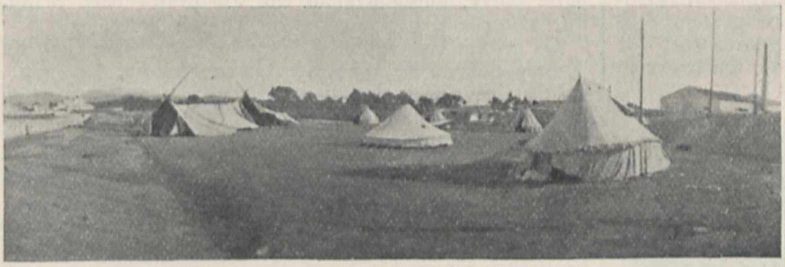

FIG. 1.—Our camping ground as seen from the south-east end. In the long tent on the left is the 76 ft. prismatic reflector, and all the other instruments are beyond it. Notice the poles for the discs in the right-hand corner.

We have settled down to routine work every day. Those in charge of instruments go to the camp at about 6.15, and work at the adjustments and small items so necessary for successful photographs. At nine o'clock the whole band of volunteers, now about 150 in number, arrives at the camp, and three drills are then gone through in fairly quick succession. The organisation of the division of labour at each instrument is now very satisfactory, and the various movements that have to be performed at stated times occur in clockwork fashion.

FIG. 2.—The camp as seen from the south-west end of the ground. The 3½-inch McClean equatorial in the foreground, 16 ft. coronagraph under tent on left, 76 ft. prismatic reflector under canvas on the right. All these instruments are housed with sails and spars from H.M.S. *Venus*.

As I have mentioned before, the whole work of the camp is organised according to signals given by the eclipse clock. There are, however, two further signals given from the angles subtended by the cusp at the centre of the dark room. These angles, which have been previously calculated, give us 16 seconds and 5 seconds respectively before the commencement of totality. The object of employing these times is not so much to assist the observers in the camp generally, as to warn the workers with the prismatic cameras, who begin making their exposures three seconds before the commencement of totality. Both Mr. Butler and myself utilise these two signals to begin our series of snap-shots for photographing the lower chromosphere.

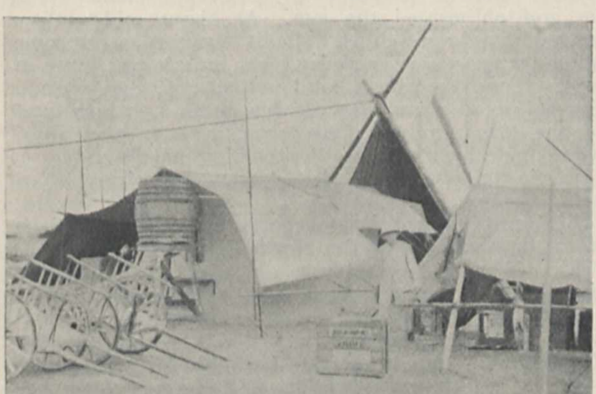

FIG. 3.—The north end of the 76 ft. prismatic reflector, showing the dark room with the wine-tub for water, the two handcarts loaned us, and on the right, under the small awning, the 3-prism 6-inch prismatic camera.

Undoubtedly the three minutes three seconds, the length of totality at this station, is a long time, and when the strong voices of the timekeepers are heard shouting out "163 seconds," "153 seconds more," &c., one somehow feels that one is not utilising to the fullest extent the time available.

With the prismatic camera, of which I am in charge, it is hoped to secure fourteen photographs. The three large 6-inch prisms of 60°, and the object-glass of the same diameter, form together a powerful weapon of research. The programme of work is to make four snap-shots at about the commencement of totality and five about the end. The remaining five plates will be exposed for intervals varying from 5 to 90 seconds, and it is hoped that the two long exposures on each side of mid-totality will add to our knowledge of the wave-lengths of the coronal rings. This prismatic camera is designed to give results suitable for determining accurate wave-length of the chromospheric and corona arcs; the image of the sun is therefore small, and the dispersion large.

The prismatic reflector of 76 feet focal length, in charge of Mr. Butler, provides a solar image of about 8 inches diameter, and, since the light is made to pass through one prism twice, the dispersion is not excessive. The large chromospheric arcs should, however, provide us with much matter for thought.

This latter instrument is practically ready for the eclipse, and a few words may here be said as regards the erection of it. The camera end itself forms part of the dark room of the camp, and is to the south of it. Just outside, but a little to the west of the north and south line, is the siderostat, which throws the solar rays on to the long-focus mirror situated to the south about 70 feet. This concave reflector throws the image towards the north, into the portion of the dark room in which is fitted a screen. An arrangement is adopted for inserting, during some periods of totality, a prism in front of the mirror. The light from the siderostat has thus to pass twice through the prism, giving a very useful spectrum. The large size of the image involves the use of very great photographic plates, and in this case plates 2 feet square and 2 feet by 1 foot will be used.

In order to keep out the light from the cloth tube connecting the mirror with the camera, sails have been erected on large spars, making the whole tube a very imposing structure.

Two new additions to eclipse drill have been introduced to render the organisation more perfect and flexible in exceptional circumstances, and both of these have been proved to be necessary. During one of the rehearsals the other day the eclipse clock stopped owing to the hand coming in contact with the dial over which it moves. Such an occurrence has never been known in our eclipse history before, and the timekeepers remained dumb after counting "163 seconds more." In future, a man with a stop-watch will stand with the timekeepers and keep a tally of the 10 seconds as they pass.

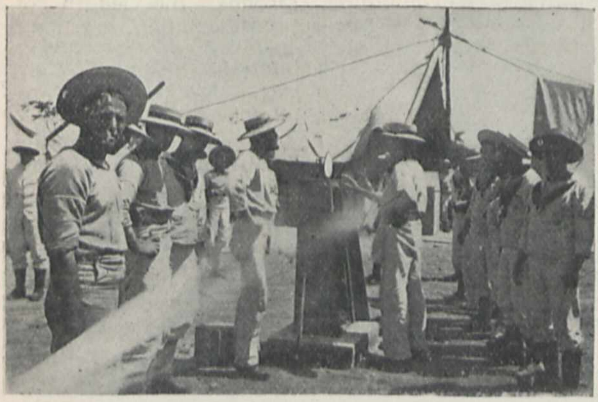

FIG. 4.—The timekeepers at work with the eclipse clock, and their audience.

The second innovation was prompted by the possible absence on the day of the eclipse of any one member of a group working an instrument. Unfortunately, I had to spend the whole of Saturday, August 26, in bed by the doctor's orders; but my instrument was very efficiently worked by the navigating officer, Lieut. Horne, who will make the cusp observations from my siderostat during the eclipse. In each party, then, the work of each member was changed, and drills were carried out under this scheme with success. I should like to take this opportunity of thanking most heartily both Staff-Surgeon Clift and Surgeon Jones, of H.M.S. *Venus*, for their very kind and efficient assistance on that occasion.

FIG. 5.—The cœlostat end of the 16 ft. coronagraph, which is under the tent on the right.

The camp at the present time practically fills the whole of the enclosed ground placed very generously at our service. Through the kindness of the local authorities, extra tents have been provided, and much material loaned in the way of wood for the shadow-band party, handcarts for the use of the men bringing water and provisions from the ship, &c.

To avoid the inconvenience of any dust arising from the road to the north of the camp, the same authorities will keep this well watered on the day of the eclipse, and for some days previous to it, and they have also arranged that the manufacturers' chimneys, which are very numerous here, shall not smoke during the time of the eclipse.

WILLIAM J. S. LOCKYER.

(2) REPORTS OF OBSERVATIONS.

Up to the time of writing very few details as to the actual scientific results obtained during the total eclipse of the sun on August 30 have arrived in this country; but it is very clear that the hopes expressed in these pages on August 24 have not been completely realised on account of the prevalence of cloud during totality at several stations.

Telegraphing from Castellon, Prof. Callendar states that, although the first and last contacts were observed in a clear sky, totality was entirely obscured by clouds. Good records of radiation and temperature were, however, secured. Similarly, Mr. Evershed, who had set up a very fine prismatic camera near to Burgos, says in a telegram to the Royal Society, "Thick clouds; no results." This forms a striking contrast to the reports of the Press correspondents, which state that all the observations at Burgos itself were successfully carried out during a temporary break in the clouds. A reproduction of a photograph of the corona, taken with a camera of 48 inches focal length by Mr. J. T. Pigg at Burgos, appeared in the *Daily News* for September 2.

At Palma, Majorca, the expedition from the Solar Physics Observatory, South Kensington, under the direction of Sir Norman Lockyer, and assisted by the officers and crew of H.M.S. *Venus*, were apparently only a little more successful, for as the crucial moment of totality arrived dense clouds came up and obliterated the sun. At about mid-totality, however, a break in the clouds occurred, and some photographs were secured which, it is hoped, may at least show the form and extent of the corona. Several good drawings of this feature, which was of the "maximum" type seen in 1871 and 1882, were made by the "disc" sketching parties.

At Saragossa, cirrus clouds prevented observations being made.

Encouraging but brief reports have been received from the observers at the North African stations.

Mr. Newall, at Guelma, appears to have been singularly fortunate, for he reports "superb weather conditions, observations successfully made," and states that he observed a brilliant corona of the "maximum" type having remarkably long streamers—one of which extended towards Mercury for more than three degrees—and unusually dark rays. Splendid prominences were also observed by him.

Sir William Christie's report from Sfax is not quite so sanguine, for he states that the sky was partially cloudy; nevertheless, photographs were secured with all instruments, and the eclipse was satisfactorily observed. A Reuter telegram from this station says that during the period of totality no clouds interfered with the observations.

At Assuan, where Prof. Turner set up his coronagraph and polariscopic apparatus, the atmospheric conditions were perfect, except for a slight haze, and the *Times* correspondent reports that eight photographs in polarised light were obtained and successful corona pictures were taken. Mr. Reynolds with his 120-feet reflector evidently experienced the great drawback common to all users of long-focus cameras, viz. bad atmospheric tremors, for the local fire brigade had to be requisitioned to flood the site in order to check the radiation from the heated ground.

Dr. J. Larmor sends us the following observations made by Mr. S. L. Walkden on the Orient steamer *Ortona*, situated on the central line of the eclipse in the Mediterranean near the Spanish coast. The observations contain a good naked-eye record of the eclipse, and agree with Dr. Larmor's impressions:—

"Rainbow colours visible on small cloud about 5° from sun about ½ minute to 1 minute before totality. Pulsation of light from strip of sun was observed by Mr. Campbell and myself as if the moon advanced by stages. (Probably another aspect of shadow-bands phenomenon.) No approach of shadow observed by myself, though keenly looked for; but found no one else who observed it except Mr. Campbell, who caught it in the sky not far from sun's limb at time of approach of totality. *Totality.*—Venus first noticed about one minute before totality, and Regulus as soon as totality complete. Mercury searched for with Zeiss field-glass and naked eye, but *not* caught after about 10 to 15 seconds' search. *Corona.*—Very fine and very detailed, so that general description difficult. *General impressions.*—(1) Some streamers seemed to cross, and were certainly not all radial. (2) Obvious extension seemed about two sun diameters. (3) Streamers distributed all round sun, but chiefly at left-top (45° from top) limb. Long thin streamer at left-left-bottom limb (67½° to left of bottom). *Prominences.*—Distributed more or less all round, but chief one observed at left-top corner. Height about ¼ of sun's radius; but this should be corrected for irradiation, which made the prominence appear to trespass into the moon's surface, exaggerating its size and producing general local glare. Colour of prominence was much less marked than expected, being merely of a violet or faintly rosy-pink hue. Shadow bands observed on deck at end of totality (looking down from boat deck). They 'rippled' along a little faster than could be easily followed by eye. They were parallel to the strip of the sun after totality, and travelled in direction of shadow. Dark strips about 6 to 8 inches wide, distance apart about 18 inches. During totality depth of darkness seemed practically independent of depth of our immersion in shadow. Clouds formed a good deal after ⅞ of sun's diameter had gone. *Lightness* of eclipse very marked, and in itself disappointing. Time by watch always plainly visible. Sky illumination greatest round horizon, and a yellow glow (like sunset) in points *opposite* to sun (about N. point). Coast lights were visible a few miles away, and one hill to N. appeared as if *perforated*, with the sky showing through. This was observed by one other passenger. Venus still visible nearly 5 minutes after end of totality. Whole black disc of moon was visible shortly before totality, say 5 to 10 seconds before."

According to a correspondent writing to the *Times*, some interesting observations of a simple character were made by the amateur astronomers on board the P. and O. mail steamer *Arcadia*, which for the time of the eclipse waited off the coast of Spain not far from Castellon. Members of the British Astronomical Association were on board, and organised themselves to watch various features of the phenomena. Mr. and Mrs. Johnson report that they saw the whole contour of the moon projected on the corona immediately after the first contact. Thermometric observations showed a fall from 90° to 72°.6 in the sun, and from 82°.4 to 72°.5 in the shade, temperature. Mr. Bacon, first officer of the *Arcadia*, made successful observations of the approach and of the recession of the moon's shadow from a point of vantage at the mast-head.

As regards the observations made by foreign astronomers, those located at Castellon, Burgos, Guelma, Sfax, and Assuan shared, of course, in the conditions enumerated above. M. Trépied, of the Algiers Observatory, was apparently very successful at Guelma, and obtained numerous photographs of the chromospheric spectrum and the corona. A fall of temperature of 5° C. (from 33° to 28°) was recorded, and Mercury, Venus, and Regulus were observed.

At Tripoli, Prof. Todd, of Amherst College Observatory, M. Liberd, of Paris, and Prof. Millosevich, of Rome, were favoured with a clear sky. Prof. Todd secured some 250 photographs of the corona with his automatic coronagraph. Very good observations of the shadow-bands are said to have been made at this station.

A disappointing feature of the eclipse was the failure to secure observations at both ends of the shadow's path. As mentioned before in these columns, arrangements had been made by the Lick Observatory to photograph the corona in Labrador and in Egypt with exactly similar coronagraphs. Mrs. Maunder, accompanying the Canadian party at Hamilton Inlet (Labrador), was also to use a coronagraph identical in scale with that used by Prof. Turner at Assuan. A Reuter telegram from St. John's, Newfoundland, announces, however, that the Lick observers experienced a total failure owing to clouds; a second message from a telegraph station on Hamilton Inlet stated that fine weather prevailed from 7 a.m. to 6 p.m. on the day of the eclipse, and that the phenomena were perfectly visible, and it was hoped that the Canadian party had been successful in making good observations. A later telegram, dated September 3, states, however, that the expedition was entirely unsuccessful, owing to the cloudy weather, and no photographs were secured.

A communication from Mr. J. Y. Buchanan, F.R.S., to the *Times* of September 5, contains some interesting notes of visual observations made during the period of totality at Torreblanca, a small village on the east coast of Spain. Having been present at the 1882 eclipse, when he assisted Sir Norman Lockyer at Sohag, on the Nile, and not having *seen* the whole of the phenomena, Mr. Buchanan only took with him an ordinary camera and a field-glass, so that he might devote all his attention to visual observations. His choice of Torreblanca, where, with the exception of the local railway employees, he seems to have been the sole observer, was justified, inasmuch as the eclipse took place in a blue sky. As the last vestige of sun disappeared behind the eastern limb of the moon a magnificent bunch of prominences, of a light violet hue, appeared at the same part of the limb; but these subsequently disappeared, and a careful search at mid-totality failed to reveal any prominences at all. A similar group, however, burst into view on the opposite limb just before the end of totality, thus indicating that the apparent diameter of the moon was sufficient to cover the whole of the prominence layer of the sun's limb at mid-totality.

The corona was clearly visible near to the western part of the moon's limb eight seconds before the advent of totality, and throughout totality it was very clearly defined. On an average it extended to rather more than one lunar diameter from the limb, but a streamer on the lower western limb was judged to extend to at least twice this distance. The whole corona had an appearance of movement, suggesting to Mr. Buchanan certain features which occur when a search-light illuminates the atmosphere.

Observations of the partial eclipse are of no great interest as compared with those made during totality, but a number of thermometric readings were recorded at numerous stations. Mr. Spencer Russell, in a communication to the *Standard* for September 2, gives a table of fifteen-minute observations of a wet and dry bulb thermometer, made at Epsom between 11.45 a.m. and 2 p.m. on the day of the eclipse. Whilst the wet bulb readings remained constant at 53° F., the dry bulb showed a minimum temperature of 54° F. between 12.45 and 1.30 p.m. Photographs of the partial eclipse were secured by Messrs. Spencer and Butler during a balloon journey from Wandsworth to Caen in Normandy.

An interesting record of a series of "pin-hole" images of the crescent sun reaches us from Sir Joseph Fayrer, F.R.S. Whilst sailing in a ten-ton boat having a large mainsail, he observed the partial eclipse under favourable conditions in Falmouth Bay. About 1 p.m. a slight breeze caused the sail to incline from the perpendicular, and a number of well defined crescent images were projected on to the whitened deck of the boat, and occasionally on to the water. An investigation showed that these images were formed by a series of eyelet holes, used for the balance reef, high up in the sail. The phenomenon was so vivid and the images so sharply defined as to appear worthy of record.

A correspondent to the *Daily Graphic* (September 2), the Rev. Frederick Ehlvers, rector of Shaftesbury, Dorset, records the remarkable phenomenon of an evening primrose unfolding itself during the eclipse as if evening had arrived. Observers at the Solar Physics Observatory, South Kensington, were prevented by clouds from seeing the eclipse, except for one or two breaks of short duration. About one minute before last contact, however, the sky suddenly became clear for a short distance around the sun, and brilliant sunshine prevailed as the last trace of the moon left the solar disc.

TECHNICAL EDUCATION IN NATAL.[1]

THE report of the commission appointed to inquire into technical education in Natal has just been received. It is signed by eleven out of twelve of the commissioners, and Mr. C. I. Mudie, superintendent of education, has forwarded a minority report.

The commission, under the presidency of Sir David Hunter, K.C.M.G., held eleven meetings and examined fifty witnesses; some of the members were also sent to Johannesburg to confer with the council and board of studies of the Transvaal Technical Institute. Delegates from the Orange River Colony also attended the conference.

The commission finds that Natal, with its European population of 97,109, has as yet but meagre provision for technical and higher education, and, indeed, states that boys who had received primary and secondary education in the colony were frequently found to be so deficient in general knowledge that they were not well qualified to enter upon technical education.

The result of inquiries as to the probability of youths availing themselves of instruction should it be placed within their grasp was decidedly encouraging, and the commission concludes, from the evidence and statistics, and from the fact that considerable sums are being expended by individuals in Natal on American correspondence classes and private tuition, that there is an urgent necessity for more adequate provision to equip the youth of the colony for the battle of life.

The resolutions of the conference held at Johannesburg point out that there is a present and immediate need for a full teaching university in South Africa, and that the colonies in which the university may not be situated should each have one or more colleges or institutes devoted to higher or technical education which should be recognised by the university council as integral parts of that teaching university, and that the university should grant diplomas in professional subjects, and degrees in arts and science, in the faculties of (1) education; (2) engineering, including mining; (3) agriculture; (4) law; and (5) medicine.

The recommendations of the commission are based upon the resolutions of the conference, and suggest that immediate steps should be taken by the Government to provide for higher education; that a council be appointed by Government to organise and control technical education in Natal which shall be independent of the education department, although that department should be represented on the council. It suggests that specialists be obtained as lecturers in (1) chemistry and metallurgy; (2) physics and electrotechnics; (3) natural science (botany, zoology, geology, physiology); (4) pure and applied mechanics; (5) modern history and literature; while other subjects would be taught by local part-time men.

It is suggested that Pietermaritzburg has first claim for this college, but that Durban also has claims, and the commission thinks that the foregoing lecturers should be peripatetic, in the first place teaching at Pietermaritzburg and Durban only, but as occasion required going farther afield.

While appearing to have somewhat wide views as to the subjects that should be taught—for twenty-six branches are mentioned in the list of subjects in which the commission finds there is a need for classes—the estimates of cost are strictly moderate, for the annual expenditure is taken at 6500*l.*, and the initial expenditure to provide the necessary equipment for engineering, chemical, physical, natural science, and other laboratories is estimated at about 2000*l.* It is true that no provision is made in this estimate for rent or capital expenditure on buildings, but we should think even without these the estimate was likely to be exceeded.

All institutions, however, must have a beginning, and those which start with the highest aspirations have a good chance of attaining some, if not all, of their objects. There can be no doubt that technical education should be conducted everywhere quite apart from the education department, and as much as possible under the guidance of men who are acquainted with some at least of the subjects that are being taught. Technical education, especially in the colonies, should be made accessible to everyone, and should more especially offer inducements to those who are working for their living to improve their knowledge of the sciences which underlie their handicrafts. If this be the first object in view, it will be evident that evening classes and evening laboratory work must be undertaken before any attempt is made to form day classes. It appears to be chiefly on this subject that Mr. Mudie dissented from the report of the commission, for he thinks the college at Pietersburg, which, as he says, covers a preparatory, a high school, and a college proper, should form the nucleus of a university college in Natal. It would not seem to be a desirable thing to commence operations in this way for many reasons, the principal of

[1] Colony of Natal. Report of the Technical Education Commission May, 1905. (Maritzburg: P. Davis and Sons, 1905.)

which is that artisans, clerks and others, for whom technical education is primarily provided, while wishing to learn, have in many cases left school so recently that they do not wish to return, and those of maturer age are not always quite certain whether their dignity will allow them to go to school again.

THE WOBURN EXPERIMENTAL FRUIT FARM.

THE fifth report on the Woburn Fruit Farm, by the Duke of Bedford and Mr. Spencer U. Pickering, F.R.S., contains a very useful summary of the results of ten years' experiments and observations on apple-trees. The conclusions arrived at are based on measurements of leaves, trees, and fruits, and also on weighings of the fruit. The average size of the leaf of the tree seems gradually to diminish with age, and there is a similar but less marked tendency in the fruit. The experiments indicate no advantage from heavy thinning of the fruit, for the size was not increased; hard pruning proved unprofitable, unpruned trees were three times more productive than those heavily pruned; summer pruning was found not to be desirable, and even moderate root pruning was found to injure the trees. Apple-trees transplanted at 2–3 years old were found to grow better than either younger or older plants.

A very curious result which for some time puzzled the experimenters was that carelessly planted trees, though weak at first, ultimately made more growth than those carefully planted. A satisfactory explanation has, however, been found. The roots of carelessly planted trees are so much injured that they make scarcely any growth; the result of this is that numerous new roots grow from dormant buds higher up the stem, and these new roots, not having suffered from transplantation, ultimately surpass in size the original roots of carefully planted trees.

The results obtained at the Woburn Fruit Farm are to some extent due to the particular soil—a moderately stiff clay—but it is probable that the conclusions arrived at would be found to hold good in many English orchards. It is, however, a very difficult thing to judge how far conclusions of the foregoing kind, based on a particular set of conditions, apply under different conditions, and the practical value of the long series of experiments and observations made at Woburn would be very greatly increased if similar experiments were conducted on a soil, or soils, of different character. In any action which the Board of Agriculture and Fisheries may take upon the report of the "Fruit" Committee, it is to be hoped that the important work of the Duke of Bedford and Mr. Pickering may be followed up and extended.

T. H. MIDDLETON.

NOTES.

To commemorate the meeting of the British Association in South Africa, a scheme has been formulated to found a British Association medal for South African students. This announcement was made by Prof. Darwin at the close of his presidential address at Johannesburg. A visit was paid to the Johannesburg Observatory on August 30, and the opportunity was taken of pointing out to Lord Selborne the suitability of the site for a fully-equipped observatory and the necessity for more astronomical work in the southern hemisphere. Referring to this suggestion in the course of his speech introducing Prof. Darwin as president of the association, Lord Selborne is reported by the *Times* correspondent to have said that "he greatly regretted he had been obliged to refuse the only request that the association had made to him—namely, to find funds for the establishment of a proper observatory in Johannesburg. He was obliged to say that all the revenue they at present possessed was required for the development of their material resources and means of communication; but where the Government was powerless, what a magnificent opportunity there was for a patriotic Transvaal. For a site in the purest atmosphere, 2000 feet above the highest observatory now existing, only 10,000*l.* was required. There they might establish a telescope which would help observers in the southern hemisphere to compete with the astronomers of the northern hemisphere. The site was there, and it was already occupied by a perfectly equipped meteorological observatory." All the papers on South African matters read during the meeting are to be published in a separate volume by the South African Association for the Advancement of Science. At the closing meeting, held on September 1, Prof. Ray Lankester was elected president of the association for 1906.

MR. J. W. DOUGLAS, one of the editors of the *Entomologist's Monthly Magazine,* died at Harlesden on August 28 in his ninety-first year.

THREE distinct earthquake shocks, the severest ever experienced in the district, were felt at Portsmouth, New Hampshire, on August 30, beginning at 5.40 p.m.

REUTER'S correspondent at Stockholm reports that Prof. Nathorst has received a letter in which Lieut. Bergendahl, who is a member of the Duc d'Orléans's Greenland Expedition, states that on July 27, as the expedition passed Cape Bismarck, unknown land was discovered. It appears that Cape Bismarck lies on a large island, and not on the mainland. The new land has been mapped as well as possible, and has received the name Terre de France. The expedition was unable to penetrate further north than 78° 16′ N. lat.

AT the annual meeting of the Academy of the Lincei, which was held on June 4 in the presence of the King and Queen of Italy, the president, Prof. Blaserna, announced the result of the competition for the three Royal prizes founded by the late King Humbert. In the section of normal and pathological physiology, the prize is awarded to Prof. Aristide Stefani, of Padua, for his published work dealing with the physiology of the heart and circulation, the non-acoustic functions of the labyrinth of the ear, and the serotherapeutic treatment of pneumonia. In the sections of archæology and of economic and social science, the judges reported that the competitors were not of sufficient merit to justify the award of the prizes. This is the first occasion on which so small a proportion of the prizes have been conferred, and it is proposed that in future the section of archæology shall embrace not only classical, but also Christian and mediæval archæology. Ministerial premiums intended to aid original work among teachers in secondary schools were awarded in the department of mathematical sciences to Prof. Ciani (50*l.*), Prof. Pirondini (38*l.*), and Prof. Chini (20*l.*). Out of the funds available from the Carpi prize, a sum of 32*l.* was awarded to Dr. P. Enriques for a thesis on the changes brought about in absorbed chlorophyll by the action of the liver, and the relation existing between the derivatives of chlorophyll produced in the organism and the genesis of the hæmatic pigments. In his address the vice-president, F. d'Ovidio, discussed in general terms the question "Art for Art's Sake," dealing more particularly with the influence exerted on national life and character by art and literature.

THE *Popular Science Monthly* (vol. lvii., No. 4) contains a suggestive article by Prof. John M. Coulter on the methods available for arousing public interest in scientific research. The results of scientific work usually reach the public through the medium of reporters to the newspapers and writers for the magazines; the material dealing with original research is, generally speaking, scant in amount, sensational in form, and wide of the mark. It is urged that men of science should, so far as possible, be their own interpreters, so that the misleading statements of the "middle man" may be avoided. Particularly, not only the facts of the investigation, but its general bearing should be made clear; it is this feature that the reporter always misses, and a "strategic movement is represented to the public as a dress parade." As a justification, it is contended that research will be shown to be practical, and a more ample endowment be secured for it. "The question of adequate support for research is the most serious one that confronts American science to-day." The appeal to American interest is utility, and it is necessary to show that practical results are reached most surely and most quickly from the vantage ground of pure science.

THE report of the commission appointed for the investigation of Mediterranean, or Malta, fever (part iii.), recently issued by the Royal Society, contains the important announcement that goats seem to be capable of transmitting the disease. The evidence supporting this conclusion is as follows:—On June 14 Dr. Zammit examined six goats, and found that the blood of five of them gave the agglutination reaction for Mediterranean fever. This was confirmed by Major Horrocks, R.A.M.C. Major Horrocks and Dr. Zammit then undertook the examination of eight different herds of goats, and in every herd examined an average of half the animals (from 7·6–75 per cent.) gave the agglutination reaction for Mediterranean fever. It was also found that one or more apparently healthy goats in every herd were excreting the specific organism of the disease—the *M. melitensis*—in their milk and urine, the number of the organism in the milk being very large. It would seem probable, therefore, that infected goat's milk may be the source of infection of man, particularly as monkeys may be artificially infected by feeding with material containing the specific organism, as has been detailed in a previous report. It is of interest that in Gibraltar, where the disease is also very prevalent, goats are almost the only source of the milk-supply.

THE report of the Government analyst of Trinidad for the year 1904–5 contains several points of general interest. Samples of water from the Carrera Convict Depôt have been examined to ascertain if a connection could be traced between the water supply and the prevalence of diarrhœa and dysentery among the prisoners. Very small proportions of lead, copper, and zinc were found to be present, and, in view of the fact that all attempts made during several years past to trace the epidemic to other causes have been unsuccessful, it appears possible that the metallic impurities named are responsible for the trouble. Before the question can be definitely decided, further investigation will be necessary. The aërated waters which are largely consumed in the colony were found to be usually contaminated with lead, owing to the use of an impure sulphuric acid in their manufacture, to an extent likely to prove dangerous. It is suggested that the use of liquefied carbon dioxide, such as is now imported into the colony in cylinders, would be a remedy for the difficulty. The adulteration of milk has very much decreased owing to the system adopted of suspending the licenses of sellers convicted of adulteration during the past year. Previously the Board of Health did not refuse the renewal of licenses, either temporarily or permanently, but only issued warnings.

THE fishes of Puget Sound form the subject of a paper by Messrs. Gilbert and Thompson in the *Proceedings of the U.S. Nat. Museum* (No. 1414). The paper is based on a collection made in 1903, which included two species regarded as new and six not previously recorded from the area in question.

THE opening article in the first part of the third volume of the quarterly issue of *Smithsonian Miscellaneous Contributions* is a translation of Dr. E. Mascha's valuable paper on the minute structure of the flight-feathers of birds, originally published in the *Zeitschrift für wissenschaftliche Zoologie*, and already noticed in our columns. Among the original communications, special reference may be made to one by Mr. F. W. True on the skull of an extinct sea-lion (Pontoleon) from the Miocene of Oregon, apparently the earliest known representative of this group of seals; to a second, by Mr. A. Mann, describing the extreme beauty of the surface sculpture in diatoms ("Diatoms, the Jewels of the Plant-World," it is called); and to a third, by Mr. C. A. White, on the ancestry of the North American pond-mussels of the family Unionidæ, in which it is concluded that all the living forms in this particular area are descended from fossil local types. It may be added that if we accept the views on nomenclature expressed in yet another article, the well known name Dromæus (for the emeu) has to give place to Dromiceius.

THE *Proceedings of the American Philosophical Society*, Philadelphia (xlix., No. 179), contains papers on the Filipino, on the Aborigines of Western Australia, on the osteology of sinopa, and on the marsupial fauna of the Santa Cruz beds. In an article on the oligodynamical action of copper foil on certain intestinal organisms, Mr. Kraemer concludes that intestinal bacteria such as the colon and typhoid bacilli are completely destroyed by placing clean copper foil in water containing them, and that certain of the lower animal and vegetable organisms possess a special sensitiveness to minute quantities of copper. The copper is probably in the form of a crystalloid rather than that of a colloid. It will be remembered that Dr. Moore, of the United States Department of Agriculture, has suggested the use of copper salts and of bright copper for the purification of water supplies. In another article Dr. Wiley discusses the effects of preservatives in food on metabolism, and expresses the opinion that boric acid and borates in any quantity upset digestion, and even in small doses, if given over a long period, have an unfavourable effect on health and digestion.

A PAPER by Dr. W. T. Calman, of the British Museum, on the Crustacea of the group Cumacea from the west coast of Ireland, published as No. 1, part iv., of Scientific Investigations, 1904, by the Irish Department of Agriculture and Technical Instruction, illustrates the importance of collecting on a thoroughly practical and effective system. During the entire cruise of H.M.S. *Challenger*, for instance, the whole collection of Cumacea was represented by no more than fifteen species, whereas Mr. E. Holt, the collector of the specimens submitted to Dr. Calman, obtained within a small area representatives of no less than forty-eight species, of which nine are regarded as new, one being so aberrant as to be assigned by its describer to a separate family group. Most of the specimens were collected by means of tow-nets attached to the back of a trawl in such a position as to capture any creatures disturbed by the ground-rope.

IN the report on the sea and inland fisheries of Ireland for 1902 and 1903, part iii., scientific investigations, Mr. E. W. L. Holt, the scientific adviser of the fisheries branch of the Board of Agriculture and Technical Instruction for Ireland, takes a broad view of the services which scientific investigations can render to practical fishery problems. Not only are such subjects as oyster culture, the artificial propagation of the Salmonidæ, and the mackerel fisheries dealt with, but the various appendices to the report constitute a most valuable addition to our knowledge of the invertebrate marine fauna of Ireland, more especially of the very interesting and little-known fauna occurring in the deeper water off the west coast. The most important paper, from a scientific point of view, is that contributed by Mr. Holt himself, in collaboration with Mr. W. M. Tattersall, on the schizopodous crustacea of the north-east Atlantic slope, in which a great number of new or little known species are fully described and figured. Other papers deserving special notice are Mr. G. P. Farran's account of the copepoda of the Atlantic slope, and the interesting contributions of the Misses Delap on the rearing of *Cyanea lamarcki* and on the plankton of Valencia Harbour from 1899 to 1901. The whole report, which treats of both sea- and fresh-water fisheries, is well illustrated with a large number of plates and diagrams excellently reproduced, and reflects great credit upon the department responsible for the scientific study of the Irish fisheries.

THE *Pioneer Mail* of July 28 published an account of the phenomenal storm of wind and rain which devastated a large portion of the province of Gujarat between July 22 and 24, owing to which it was estimated that about 10,000 people were rendered homeless. The storm seems to have been most severe at Ahmedabad, 310 miles north of Bombay. The average annual rainfall of that place is only about 33 inches; during the storm in question it was stated that fully 37 inches were measured in two days. We find from the Official *Indian Daily Weather Report* that the fall was over-stated, but that nevertheless it was quite abnormal; 14 inches fell in twenty-four hours ending 8h. a.m. July 23, and 12½ inches on the following day. The Government meteorological reporter states that the fall was due to a severe cyclonic storm passing over the head of the peninsula, and to the fact that when it entered Gujarat it was fed by strong winds from the Arabian Sea.

WE have received "British Rainfall, 1904," being the forty-fourth annual volume of this very useful publication, containing the carefully prepared results of observations taken at nearly 4000 stations. Dr. Mill states that every return undergoes critical examination before the results are published, a task that must strain the energies of himself and his small available staff to the utmost. While every page of this now somewhat voluminous work contains information of the highest value in connection with the distribution of rain over the British Isles, it is difficult to fix upon any particular portion calling for especial remark. One new feature is the publication of complete daily records for ten selected stations, and, as last year, attention has been given to a discussion of some of the wettest days, illustrated by special charts. There are also several interesting articles dealing with various branches of rainfall work, *e.g.* an analysis of the observations on the summit of Ben Nevis and at the base station at Fort William, for the years 1885–1903; for more complete details reference is made to an exhaustive discussion published by Mr. A. Watt in the *Journal of the Scottish Meteorological Society*. Another article deals with October rainfalls; this is generally the wettest month of the year over the greater part of England. In the present case, special reference is made to the comparatively dry Octobers of 1879, 1888, 1897, and 1904; with one exception, October, 1904, was the driest on record since the foundation of the British rainfall organisation. Another important article discusses the duration and average rate of rainfall in London since 1881. It shows *inter alia* that the rate of fall per hour is twice as great in July as in January.

WE are glad to be able to reproduce from the *Annuario* of the Messina Observatory for the year 1904 an illustration of that important Sicilian station, which, under the able superintendence of Prof. Rizzo, undertakes, in addition to the usual meteorological observations, valuable

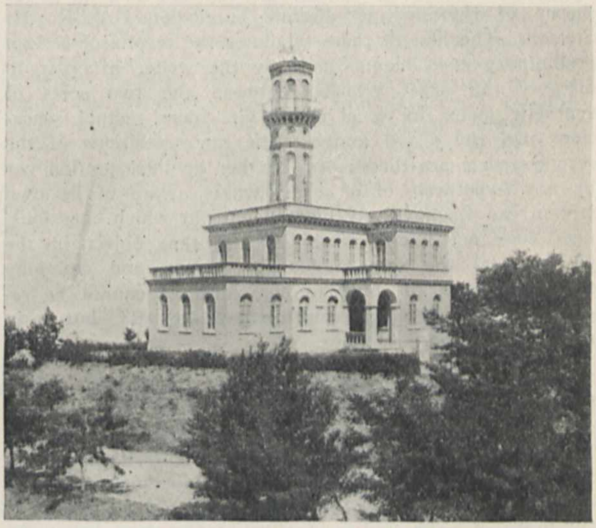

FIG. 1.—The Messina Observatory.

researches connected with solar and terrestrial physics. The institution has risen from modest beginnings in 1876, when, at the instigation of Prof. Manzi, it was attached to the Technical and Nautical Institute of that city. The importance of its work was soon recognised by the Central Meteorological Office at Rome, which supplied it with several instruments. The present edifice on the hill of Andria was completed in 1902, under the auspices of the Royal University of Studies at Messina, and occupies a position much better suited to its useful work; it is now removed from all disturbing influences, and we look forward with confidence to important results connected with the relation of magnetism to solar activity and to the movements of the ground, to which subjects Prof. Rizzo devotes special attention.

THE International Council for the Exploration of the Sea continues to issue its publications in rapid succession. Of the Bulletins, which embody the records of the work more especially entrusted to it, we have received those for the terminal expeditions in November, 1904, and February, 1905 (Conseil Permanent International pour l'Exploration de la Mer, Bulletin, 1904–5, Nos. 2 and 3). We note, as additions to the routine observations of the council, an extension of the surface observations made by merchant steamers on various routes, and a series of observations in February, 1905, made and communicated by the fishery branch of the Department of Agriculture and Technical Instruction for Ireland. It can serve no useful purpose to attempt the general discussion of the observations contained in these Bulletins as they appear; the general results can best be summarised at a later stage by the central authority, by whom the work will no doubt be undertaken. For the two dates concerned, a very marked feature of the observations in the English area is worth pointing out—the high salinity of the water at the entrance to the channel and to the west of Ireland. The origin of this salt water demands close investigation; it would seem to have come almost directly from the south, and in that event it is to be hoped that means of ascertaining whether Mediterranean water was present or not are available.

THE *Psychological Review* (article section) contains in its July number the following articles:—The synthetic factor in tactual space perception, T. H. Haines; consciousness and its object, F. Arnold; and a motor theory of rhythm and discrete succession (i.), R. H. Stetson. The first of these tabulates the results of certain preliminary experiments made by the writer in order to discover the exact relation between the two sorts of synthetic factor for local signs, viz. inner tactual sensations and the visual image. The main positions of the second article are these:—(1) Neither by introspection nor by any hypothesis of a consciousness aware of its own stream can we have any mental state in which consciousness does not have an object, and that object in the present; (2) the same holds for feeling and emotion; (3) the relation of thing to consciousness cannot be represented by any simple formulation like aRx, but is in reality much more complex.

THE July number of *Mind* contains an excellent article by Mr. R. F. Alfred Hoernlé on Pragmatism *v.* Absolutism, which is mainly occupied with a discussion of Mr. Bradley's views. The writer finds fault with Mr. Bradley's use of the criterion of non-contradiction, his neglect of epistemology in favour of metaphysics, his doctrine of "degrees of truth and reality," and his theory that "a self-consistent reality must *include* the appearances, and yet cannot be its appearances." Dr. Norman Smith, in a second article on the naturalism of Hume, deals sympathetically with Hume's treatment of ethics. He claims that "Hume may, indeed, be regarded, even more truly than Kant, as the father of all those subsequent philosophies that are based on an opposition between thought and feeling, truth and validity, actuality and worth." Other articles deal with Empiricism and the Absolute, Plato's view of the soul, and Symbolic Reasoning.

THE *Journal of the Anthropological Institute* (July–December, 1904) contains the Huxley lecture for 1904, presented by Dr. Deniker, the subject being "Les Six Races composant la Population actuelle de l'Europe." This is virtually a re-statement and a vindication of the racial division which was propounded by Dr. Deniker eight years ago in "Les Races européennes" (*Bull. Soc. d'Anthr.*, Paris, iv., 3), which the researches of later years have served to illustrate and confirm. To the Nordic, Ibero-Insular, and Western or Cevenole races (corresponding to the Northern, Mediterranean, and Central or Alpine races of other authors) are added three main races:—Eastern, brachycephalic, short and fair; Littoral or Atlanto-Mediterranean, mesocephalic, tall and dark; and Adriatic, brachycephalic, tall and dark. There are also four secondary races:—Sub-Nordic, brachycephalic, short and fair; Vistulan, brachycephalic, very short, fair or medium; North-Western, mesocephalic or brachycephalic, tall, medium or dark; and Sub-Adriatic, brachycephalic, and medium in stature and pigmentation. The maps of the average stature and pigmentation for Europe which accompany the paper are scarcely satisfactory. The cardinal principle laid down by Prof. Ripley, that the visual impression must, so far as possible, conform to the represented facts, has not been successfully followed, with the result that in the bewildering mass of detail no general impression can be gained by the eye without the assistance of the convention in the legend.

THE *Journal of the Franklin Institute* for August (clx., No. 2) contains papers of more or less interest, and covering most of the branches of science. Mr. Fuller discusses in a very complete manner the subject of sewage disposal and the pollution of shell-fish. A very full bibliography is appended to his paper.

WE have received from the Sytam Fittings Co., of Basinghall Buildings, Leeds, the catalogue of the company's system of filing, classifying, and indexing bottles, boxes, specimens, tubes, apparatus, &c. The company has applied the characteristics of the well known elastic or expansion series of bookcases to the purposes named, the specimen cabinets being built up of a number of interchangeable elements.

THE *Johns Hopkins Hospital Bulletin* for August (xvi., No. 173) contains an interesting account, by Dr. MacCallum, of the life and work of Marcello Malpighi, with full-plate portrait of this distinguished Italian anatomist of the seventeenth century. The concluding sentence of this article may be quoted:—"After all is considered the most enduring things in Malpighi's books are his perfect honesty, his extraordinary keenness and good sense in the interpretation of what he saw, and his ingenious objective methods of observation. What he saw could not have failed of being seen very soon by others, but we are filled with wonder that quite alone, with his 'quiet, eager mind,' he could have encompassed all, steadily searching out one thing after another throughout his forty years of restless activity."

WE have received the report of the second meeting of the South African Association for the Advancement of Science. It forms a handsome cloth-bound volume of 598 pages with 44 plates, and contains the forty-four papers read before the association printed in full. Summaries of the papers were published in NATURE (vol. lxx. p. 41) shortly after the meeting, and also the greater part of Mr. E. B. Sargant's address on the education of examiners (vol. lxx. p. 63). The presidential address by Sir Charles Metcalfe, and the sectional addresses by Mr. J. R. Williams on the metallurgy of the Rand, by Dr. G. S. Corstorphine on the history of stratigraphical investigation in South Africa, and by Sir Percy Girouard on improvements in rolling stock, are of permanent value, and the subjects and names of the authors of the papers make the volume an important addition to scientific literature, and show what a large amount of valuable scientific work is being done in South Africa. The illustrations are excellent. The coloured plates accompanying Dr. L. G. Irving's paper on miners' phthisis are admirably reproduced, as also are the photomicrographs of blue ground illustrating the paper by Mr. H. Kynaston and Mr. A. L. Hall on the geological features of the diamond pipes of the Pretoria district. This paper is of special interest. In the Premier pipe a remarkable bar of purple quartzite, locally known as floating reef, occurs. It appears to be a mass of Waterberg sandstone that has dropped into the pipe. The blue ground is considered to be a serpentinised peridotite breccia with a specific gravity of 2·757. That of the Kimberley blue is 2·734.

OUR ASTRONOMICAL COLUMN.

DISCOVERY OF A NOVA.—A telegram from the Kiel Centralstelle, dated September 1, announces the discovery of a new star, by Mrs. Fleming at Harvard, on August 12. Its position, referred to the equinox of 1900, is given as follows:—

$$\text{R.A.} = 284^\circ\ 2' = 18\text{h. } 56{\cdot}1\text{m.}$$
$$\text{Dec.} = -4^\circ\ 34',$$

and, although the magnitude is not mentioned, the Nova is said to be fading rapidly.

The position given above is near to that of λ Aquilæ, the Nova apparently forming the apex of an equilateral

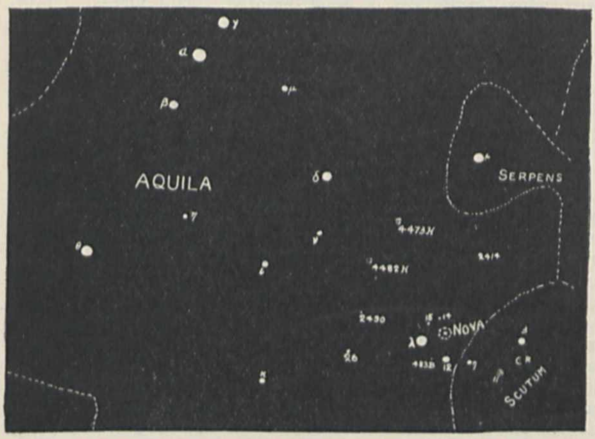

FIG. 1.—Chart of region about Nova discovered by Mrs. Fleming, August, 1905.

triangle which is completed by λ and 12 Aquilæ. The accompanying chart of the surrounding region shows the approximate position of the object.

A later telegram from Prof. Pickering gives the value R.A. = 18h. 57m. 8s. as being more correct for the right ascension of this object.

WATER VAPOUR IN THE MARTIAN ATMOSPHERE.—In Bulletin No. 17 of the Lowell Observatory, Mr. Lowell describes a new spectroscopic method for testing the presence of water vapour in the atmosphere of Mars, and Mr. Slipher discusses the results obtained from an experimental trial of the method. The principles involved are as follows:—Cosmically considered, the earth's atmosphere is at rest as regards a terrestrial observer, whilst the Arean atmosphere partakes of the planet's motion relative to the earth. This relative motion should be reflected in the solar spectrum, as obtained on a spectrogram of Mars, by a displacement of the lines due to the selective absorption common to both atmospheres. But in the terrestrial atmosphere water vapour accounts for a great deal of this absorption; therefore, if water vapour also exists in the Martian atmosphere the lines due to it should show a displacement, or at least a broadening, of such lines as those in the α band of the solar spectrum, or, with small dispersion, an extension on one side or the other of the band itself. The spectrum of the sunlight reflected by the moon, the approach or recession of which is negligible, is taken as the comparison spectrum, in which the earth's atmospheric absorption appears alone.

Mr. Slipher obtained several spectrograms of Mars and of the moon, the exposures being made when the respective bodies were at the same altitude. An examination of the α band and of the water vapour lines near D in both spectra seemed to indicate a slight shift, but the measurements made were uncertain and discordant, and no definite conclusion could be arrived at. So far as selective absorption is concerned, the spectrum of Mars seems to be the same as that of the equally high moon. Similar experiments on the planet Venus, using direct sunlight for the comparison spectrum, were equally inconclusive.

REAL PATHS OF LYRID METEORS.—The real paths of forty April meteors, recorded during the period 1889–1903 by different observers, are given by Mr. Denning in the *Observatory* (August). Many of the objects observed were Lyrids, and Mr. Denning emphasises the importance of this shower and its contemporaries, and, further, gives a daily ephemeris for the Lyrid radiant, based on his own observations of 703 meteors (186 Lyrids) during the years 1873–1904. This ephemeris covers the period April 15–April 25, but its author is doubtful of the radiant's activity on April 15, 16, and 25. On April 15 the computed position is $\alpha = 263\frac{1}{2}^\circ$, $\delta = 33^\circ$, and the latter value is constant. The right ascension, however, increases at the uniform rate of one and a quarter degrees per day.

OBSERVATIONS OF SATELLITES.—In No. 4035 of the *Astronomische Nachrichten* Dr. C. W. Wirtz publishes the results of a series of observations of various satellites made with the 49 cm. (about $19\frac{1}{2}$-inch) refractor of the Strassburg Observatory during 1902, 1903, 1904, and 1905. The results are given in a tabulated form, showing the differences between the calculated and observed position angles and distances. Dealing with Neptune's satellite, Dr. Wirtz found that it exhibits a marked variation of apparent brightness according to its position in its orbit. In longitude 40° (or position angle 60°) it is brightest, in longitude 240° (*i.e.* position angle 180°) it is least bright. Saturn's satellites, iii.–viii. inclusive, are also dealt with, the positions with regard to the planet and then to each other being given.

THE BRITISH ASSOCIATION.

SECTION G.

ENGINEERING.

OPENING ADDRESS BY COLONEL SIR C. SCOTT MONCRIEFF, K.C.S.I., K.C.M.G., R.E., LL.D., PRESIDENT OF THE SECTION.

SCIENCE has been defined as the medium through which the knowledge of the few can be rendered available to the many; and among the first to avail himself of this knowledge is the engineer. He has created a young science, the offspring, as it were, of the older sciences, for without them engineering could have no existence.

The astronomer, gazing through long ages at the heavens and laying down the courses of the stars, has taught the engineer where to find his place on the earth's surface.

The geologist has taught him where he may find the stones and the minerals which he requires, where he may count on firm rock beneath the soil to build on, where he may be certain he will find none.

The chemist has taught him of the subtle gases and fluids which fill all space, and has shown him how they may be transformed and transfused for his purposes.

The botanist has taught him the properties of all trees and plants, "from the cedar tree that is in Lebanon even unto the hyssop that springeth out of the wall."

And all this knowledge would be as nothing to the engineer had he not reaped the fruits of that most severe of all pure and noble sciences—the science of numbers and dimensions, of lines and curves and spaces, of surfaces and solids—the science of mathematics.

Were I to attempt in the course of a single address to touch on all the many branches of engineering, I could do no more than repeat a number of platitudes, which you know at least as well as I do. I think, then, that it will be better to select one branch, a branch on which comparatively little has been written, which has, I understand, a special interest for South Africa, and which has occupied the best years of my life in India, Southern Europe, Central Asia, and Egypt—I mean the science of irrigation. My subject is water—living, life-giving water. It can surely never be a dry subject; but we all know that with the best text to preach on the preacher may be as dry as dust.

Irrigation: What it Means.

Irrigation may be defined as the artificial application of water to land for the purposes of agriculture. It is, then, precisely the opposite of drainage, which is the artificial removal of water from lands which have become saturated, to the detriment of agriculture. A drain, like a river, goes on increasing as affluents join it. An irrigation channel goes on diminishing as water is drawn off it. Later on I shall show you how good irrigation should always be accompanied by drainage.

In lands where there is abundant rainfall, and where it falls at the right season of the year for the crop which it is intended to raise, there is evidently no need of irrigation. But it often happens that the soil and the climate are adapted for the cultivation of a more valuable crop than that which is actually raised, because the rain does not fall just when it is wanted, and there we must take to artificial measures.

In other lands there is so little rain that it is practically valueless for agriculture, and there are but two alternatives—irrigation or desert. It is in countries like these that irrigation has its highest triumph; nor are such lands always to be pitied or despised. The rainfall in Cairo is on an average 1·4 inches per annum, yet lands purely agricultural are sold in the neighbourhood as high as 150*l.* an acre.

This denotes a fertility perhaps unequalled in the case of any cultivation depending on rain alone, and this in spite of the fact that the Egyptian cultivator is in many respects very backward. The explanation is not far to seek. All rivers in flood carry along much more than water. Some carry alluvial matter. Some carry fine sand. Generally the deposit is a mixture of the two. I have never heard of any river that approached the Nile in the fertilising nature of the matter borne on its annual floods; with the result that the plains of Egypt have gone on through all ages, with the very minimum of help from foreign manures, yielding magnificent crops and never losing their fertility. Other rivers bring down little but barren sand, and any means of keeping it off the fields should be employed.

Primitive Means of Irrigation.

The earliest and simplest form of irrigation is effected by raising water from a lake, river, or well, and pouring it over the land. The water may be raised by any mechanical power, from the brawny arms of the peasant to the newest pattern of pump. The earliest Egyptian sculptures show water being raised by a bucket attached to one end of a long pole, turning on an axis with a heavy counterpoise at the other end. In Egypt this is termed a *shadoof*, and to this day, all along the Nile banks, from morning to night brown-skinned peasants may be seen watering their fields in precisely this way. Tier above tier they ply their work so as to raise water 15 or 16 feet on to their land. By this simple contrivance it is not possible to keep more than about 4 acres watered by one *shadoof*, so you may imagine what an army is required to irrigate a large surface. Another method, largely used by the natives of Northern India, is the shallow bucket suspended between two strings, held by men who thus bale up the water. A step higher is the water-wheel, with buckets or pots on an endless chain around it, worked by one or a pair of bullocks. This is a very ordinary method of raising the water throughout the East, where the water-wheel is of the rudest wooden construction and the pots are of rough earthenware. Yet another method of water-raising is very common in India from wells where the spring level may be as deep as 100 feet or more. A large leathern bag is let down the well by a rope passing over a pulley and raised by a pair of bullocks, which haul the bag up as they run down a slope the depth of the well. An industrious farmer with a good well and three pairs of good bullocks can keep as much as 12 acres irrigated in Northern India, although the average is much less there. The average cost of a masonry well in India varies from 20*l.* to 40*l.*, according to the depth required. But it is obvious that in many places the geological features of the country are such that well-sinking is impracticable. The most favourable conditions are found in the broad alluvial plains of a deltaic river, the subsoil of which may be counted on as containing a constant supply of water.

Pumps and Windmills.

All these are the primitive water-raising contrivances of the East. Egypt has of late been more in touch with Western civilisation, and since its cotton and sugar-cane crops yield from 6*l.* to 8*l.* or even 10*l.* per acre, the well-to-do farmer can easily afford a centrifugal pump worked by steam power. Of these there are now many hundreds, fixed or portable, working on the Nile banks of Egypt. Where wind can be counted on the windmill is a very useful and cheap means of raising water. But everything depends on the force and the trustworthiness of the wind. In the dry Western States of America wind power is largely used for pumping. It is found that this power is of little use if its velocity is not at least six miles per hour. (The mean force of the wind throughout the whole United States is eight miles per hour.) Every windmill, moreover, should discharge its water into a tank. It is evident that irrigation cannot go on without cessation day and night, and it may be that the mill is pumping its best just when irrigation is least wanted. The water should, therefore, be stored till required. In America it is found that pumping by wind power is about two-thirds of the cost of steam power. With a reservoir 5 to 15 acres may be kept irrigated by a windmill. Without a reservoir 3 acres is as much as should be counted on. Windmills attached to wells from 30 to 150 feet deep cost from 30*l.* to 70*l.*

Artesian Wells.

Up to now the artesian well cannot be counted on as of great value for irrigation. In the State of California there are said to be 8097 artesian wells, of a mean depth of 210 feet, discharge 0·12 cubic feet per second, and original cost on an average 50*l.* Thirteen acres per well is a large outturn.

In Algeria the French have bored more than 800 artesian wells, with a mean depth of 142 feet, and they are said to irrigate 50,000 acres. But these are scattered over a large area. Otherwise, the gathering ground would probably yield a much smaller supply to each well than it now does. In Queensland artesian wells are largely used for the water supply of cattle stations, but not for irrigation.

Well Irrigation.

It is evident that where water has to be raised on to the field there is an outlay of human or mechanical power which may be saved if it can be brought to flow over the fields by gravitation. But there is one practical advantage in irrigating with the water raised from one's own well or from a river. It is in the farmer's own hands. He can work his pump and flood his lands when he thinks best. He is independent of his neighbours, and can have no disputes with them as to when he may be able to get water and when it may be denied to him. In Eastern countries, where corruption is rife among the lower subordinates of government, the farmer who sticks to his well knows that he will not require to bribe anyone; and so it is that in India about 13 millions of acres, or 30 per cent. of the whole annual irrigation, is effected by wells. Government may see fit to make advances to enable the farmer to find his water and to purchase the machinery for raising it; or joint-stock companies may be formed with the same object. Beyond this all is in the hands of the landowner himself.

Canal Irrigation.

Irrigation on a large scale is best effected by diverting water from a river or lake into an artificial channel, and thence on to the fields. If the water surface of a river has a slope of 2 feet per mile, and a canal be drawn from it with a surface slope of 1 foot per mile, it is evident that at the end of a mile the water in the canal will be 1 foot higher than that in the river; and if the water in the river is 10 feet below the plain, at the end of 10 miles the water in the canal will be flush with the plain, and henceforth irrigation can be effected by simple gravitation.

When there is no question of fertilising deposit, and only pure water is to be had, the most favourable condition of irrigation is where the canal or the river has its source of supply in a great lake. For, be the rainfall ever so heavy, the water surface in the lake will not rise very much, nor will it greatly sink at the end of a long drought. Where there is no moderating lake, a river fed from a glacier has a precious source of supply. The hotter the weather, the more rapidly will the ice melt, and this is just when irrigation is most wanted.

Elsewhere, if crops are to be raised and the rain cannot be counted on, nor well irrigation be practised, water storage becomes necessary, and it is with the help of water storage that in most countries irrigation is carried on.

Water Storage.

To one who has not given the subject attention, surprise is often expressed at the large volume of water that has to be stored to water an acre of land. In the case of rice irrigation in India, it is found that the storage of a million cubic feet does not suffice for more than from 6 to 8 acres. For the irrigation of wheat about one-third this quantity is enough. It would never pay to excavate on a level plain a hollow large enough to hold a million cubic feet of water. It is invariably done by throwing a dam across the bed of a river or a valley and ponding up the water behind it. Many points have here to be considered: the length of dam necessary, its height, the material of which it is to be constructed, the area and the value of the land that must be submerged, the area of the land that may be watered. The limits of the height of a dam are from about 150 to 15 feet. If the slope of the valley is great it may be that the volume which can be ponded up with a dam of even 150 feet is inconsiderable, and the cost may be prohibitory. On the other hand, if the country is very flat, it may be that a dam of only 20 feet high may require to be of quite an inordinate length, and compensation for the area of land to be submerged may become a very large item in the estimate. I have known of districts so flat that in order to irrigate an acre more than an acre must be drowned. This looks ridiculous, but is not really so, for the yield of an irrigated acre may be eight or ten times that of an unirrigated one; and after the storage reservoir has been emptied it is often possible to raise a good crop on the saturated bed.

The advantage of a deep reservoir is, however, very great, for the evaporation is in proportion to the area of the surface, and if two reservoirs contain the same volume of water, and the depth of one is double that of the other, the loss by evaporation from the shallow one will be double that of the deep one. In India, from time immemorial, it has been the practice to store water for irrigation, and there are many thousands of reservoirs, from the great artificial lakes holding as much as 5000 or 6000 millions of cubic feet, down to the humble village tank holding not a million. There are few of which the dam exceeds 80 feet in height, and such are nearly always built of masonry or concrete. For these it is absolutely necessary to have sound rock foundations. If the dam is to be of earth, the quality of the soil must be carefully seen to, and there should be a central core of puddle resting on rock and rising to the maximum height of water surface. If the dam is of masonry, there may perhaps be no harm done should the water spill over the top. If it is of earth, this must never happen, and a waste weir must be provided, if possible cut out of rock or built of the best masonry, and large enough to discharge the greatest possible flood. More accidents occur to reservoirs through the want of sufficient waste weirs or their faulty construction than from any other cause.

As important as the waste weir are the outlet sluices through which the water is conveyed for the irrigation of the fields. If possible they should be arranged to serve at the same time as scouring sluices to carry off the deposit that accumulates at the bottom of the reservoir. For, unless provided with very powerful scouring sluices, sooner or later the bed of the reservoir will become silted up, and the space available for water storage will keep diminishing. As this happens in India, it is usual to go on raising the embankment (for it does not pay to dig out the deposit), and so the life of a reservoir may be prolonged for many years. Ultimately it is abandoned, as it is cheaper to make a new reservoir altogether than to dig out the old one.

Italian Irrigation.

For the study of high-class irrigation there is probably no school so good as is to be found in the plains of Piedmont and Lombardy. Every variety of condition is to be found here. The engineering works are of a very high class, and from long generations of experience the farmer knows how best to use his water.

The great river Po has its rise in the foothills to the west of Piedmont. It is not fed from glaciers, but by rain and snow. It carries with it a considerable fertilising matter. Its temperature is higher than that of glacial water—a point to which much importance is attached for the very valuable meadow irrigation of winter. From the left bank of the Po, a few miles below Turin, the great Cavour Canal takes its rise, cutting right across the whole drainage of the country. It has a full-supply discharge of 3800 cubic feet per second; but it is only from October to May that it carries anything like this volume. In summer the discharge does not exceed 2200 cubic feet per second, which would greatly cripple the value of the work were it not that the glaciers of the Alps are melting then, and the great torrents of the Dora Baltea and Sesia can be counted on for a volume exceeding 6000 cubic feet per second.

Lombardy is in no respects worse off than Piedmont for the means of irrigation; and its canals have the advantage of being drawn from the lakes Maggiore and Como, exercising a moderating influence on the Ticino and Adda rivers, which is sadly wanted on the Dora Baltea. The Naviglio Grande of Lombardy is drawn from the left bank of the Ticino, and is used largely for navigation, as well as irrigation. It discharges between 3000 and 4000 cubic feet per second, and nowhere is irrigation probably carried on with less expense. From between Lake Maggiore and the head of the Naviglio Grande a great new canal, the Villoresi, has been constructed during the last few years with head sluices capable of admitting 6700 cubic feet per second, of which, however, 4200 cubic feet have to be passed on to the Naviglio Grande. Like the Cavour Canal, the Villoresi crosses all the drainage coming down from the foothills to the north. This must have entailed the construction of very costly works.

Irrigation in Northern India.

It is in India that irrigation on the largest scale is to be found. The great plains of Northern India are peculiarly well adapted for irrigation, which is a matter of life and death to a teeming population all too well accustomed to a failure of the rain supply.

The Ganges, the Jumna, and the great rivers of the Punjab have all been largely utilised for feeding irrigation canals. The greatest of these, derived from the river Chenab, and discharging from 10,500 to 3000 cubic feet per second, was begun in 1889, with the view of carrying water into a tract entirely desert and unpopulated. It was opened on a small scale in 1892, was then enlarged, and ten years after it irrigated in one year 1,829,000 acres, supporting a population of 800,000 inhabitants, colonists from more congested parts of India.

The Ganges Canal, opened in 1854, at a time when there was not a mile of railway, and hardly a steam engine within a thousand miles, has a length of about 9900 miles, including distributing channels. It was supplemented in 1878 by a lower canal, drawn from the same river 130 miles further down, and these two canals now irrigate between them 1,700,000 acres annually. On all these canals are engineering works of a very high class. The original Ganges Canal, with a width of bed of 200 feet, a depth of 10 feet, and a maximum discharge of 10,000 cubic feet per second, had to cross four great torrents before it could attain to the watershed of the country, after which it could begin to irrigate. Two of these torrents are passed over the canal by broad super-passages. Over one of them the canal is carried in a majestic aqueduct of fifteen arches, each of 50 feet span; and the fourth torrent, the most difficult of all to deal with, crosses the canal at the same level, a row of forty-seven floodgates, each 10 feet wide, allowing the torrent to pass through and out of the canal.

Elsewhere there are rivers in India, rising in districts subject to certain heavy periodical rainfall, and carrying their waters on to distant plains of very uncertain rainfall. At a small expense channels can sometimes be constructed drawing off from the flooded river water sufficient thoroughly to saturate the soil, and render it fit to be ploughed up and sown with wheat or barley, which do not require frequent watering. The canal soon dries up, and the sown crop must take its chance; but a timely shower of rain may come in to help it, or well irrigation may mature the crop. These, which are known in India as inundation canals, are of high value.

Southern India.

In Southern India there are three great rivers, drawing their supply from the line of hills called the Ghats, running parallel to and near the western coast, and after a long course discharging into the Bay of Bengal on the east coast. Against the Ghats beats the whole fury of the tropical S.W. monsoon, and these rivers for a few months are in high flood. As they approach the sea they spread out in the usual deltaic form. Dams have been built across the apex of these deltas, from which canals have been drawn, and the flood waters are easily diverted over the fields, raising a rice crop of untold value in a land where drought and famine are too common. But for the other months of the year these rivers contain very little water, and there is now a proposition for supplementing them with very large reservoirs.

A very bold and successful piece of irrigation engineering was carried out a few years ago in South India, which deserves notice. A river named the Periyar took its rise in the Ghats, and descended to the sea on the west coast, where there was no means of utilising the water, and a good deal of money had periodically to be spent in controlling its furious floods. A dam has now been built across its course, and a tunnel has been made through the mountains, enabling the reservoir to be discharged into a system of canals to the east, where there is a vast plain much in need of water.

In the native State of Mysore, in Southern India, there are on the register about 40,000 irrigation reservoirs (or tanks, as they are called), or about three to every four square miles, and the nature of the country is such that hundreds may be found in the basin of one river—small tanks in the upper branches and larger ones in the lower, as the valley widens out—and these require constant watchful attention. From time to time tropical rainstorms sweep over the country. If then even a small tank has been neglected, and rats and porcupines have been allowed to burrow in the dam, the flood may burst through it, and sweep on and over the dam of the next village, lower down. One dam may then burst after another, like a pack of cards, and terrible loss occurs.

In this State of Mysore a very remarkable irrigation reservoir is now under construction at a place called Mari Kanave. Nature seems here to have formed an ideal site for a reservoir, so that it is almost irresistible for the engineer to do his part, even although irrigation is not so badly wanted here as elsewhere. The comparatively narrow neck of a valley containing 2075 square miles is being closed by a masonry dam 142 feet high. The reservoir thus formed will contain 30,000 million cubic feet of water, but it is not considered that it will fill more than once in thirty years. Nor is there irrigable land requiring so great a volume of water. Much less would be sufficient, so such a high dam is not needed; but the construction of a waste weir to prevent the submergence of a lower dam would require such heavy excavation through one of the limiting hills that it is cheaper to raise the dam and utilise a natural hollow in the hillside for a waste weir.

Irrigation in Egypt.

No lecture on irrigation would be complete without describing what has been done in Egypt. You are generally familiar with the shape of that famous little country. Egypt proper extends northwards from a point in the Nile about 780 miles above Cairo—a long valley, never eight miles wide, sometimes not half a mile. East and west of this lies a country broken into hills and valleys, wild crags, level stretches, but everywhere absolutely sterile, dry sand and rock, at such a level that the Nile flood has never reached it to cover its nakedness with fertile deposit. A few miles north of Cairo the river bifurcates, and its two branches flow each for about 130 miles to the sea. As you are probably aware, with rivers in a deltaic state the tendency is for the slope of the country to be away from the river, and not towards it. In the Nile Valley the river banks are higher than the more distant lands. From an early period embankments were formed along each side of the river, high enough not to be topped by the highest flood. At right angles to these river embankments others were constructed, dividing the whole valley into a series of oblongs, surrounded on three sides by embankments, on the fourth by the desert heights. These oblong areas vary from about 50,000 to 3000 acres. I have said the slope of the valley is away from the river. It is easy, then, when the Nile is low, to cut short deep canals in the river banks, which fill as the river rises and carry the precious mud-charged water into these great flats. There the water remains for a month or more, some three or four feet deep, depositing its mud, and then at the end of the flood it may either be run off direct into the receding river, or cuts may be made in the cross embankments and the water passed off one flat after another, and finally rejoin the river. This takes place in November, when the river is rapidly falling. Whenever the flats are firm enough to allow a man to walk over them with a pair of bullocks, the mud is roughly turned over with a wooden plough, or even the branch of a tree, and wheat or barley is immediately sown. So soaked is the soil after the flood that the seed germinates, sprouts, and ripens in April without a drop of rain or any more irrigation, except what, perhaps, the owner may give from a shallow well dug in the field. In this manner was Egypt irrigated up to about a century ago. The high river banks which the flood could not cover were irrigated directly from the river, the water being raised as I have already described.

The Barrage.

With the last century, however, appeared a very striking figure in Egyptian history, Muhammed Ali Pasha, who came from Turkey a plain captain of infantry, and before many years had made himself master of the country, yielding only a very nominal respect to his suzerain lord, the Sultan at Constantinople.

Muhammed Ali soon recognised that with this flood system of irrigation only one cereal crop was raised in the year, while with such a climate and such a soil, with a teeming population and with the markets of Europe so near, something far more valuable might be raised. Cotton and sugar-cane would fetch far higher prices; but they could only be grown at a season when the Nile is low, and they must be watered at all seasons. The water-surface at low Nile is about 25 feet below the flood-surface, or more than 20 feet below the level of the country. A canal, then, running 12 feet deep in the flood would have its bed 13 feet above the low-water surface. Muhammed Ali ordered the canals in Lower Egypt to be deepened; but this was an enormous labour, and as they were badly laid out and graded they became full of mud during the flood and required to be dug out afresh. Muhammed Ali was then advised to raise the water-surface by erecting a dam (or, as the French called it, a *barrage*) across the apex of the delta, twelve miles north of Cairo, and the result was a very costly and imposing work, which it took long years and untold wealth to construct, and which was no sooner finished than it was condemned as useless.

Egyptian Irrigation since the English Occupation.

With the English occupation in 1883 came some English engineers from India, who, supported by the strong arm of Lord Cromer, soon changed the situation. The first object of their attention was the *barrage* at the head of the delta, which was made thoroughly sound in six years and capable of holding up 15 feet of water. Three great canals were taken from above it, from which a network of branches are taken, irrigating the province to the left of the western, or Rosetta branch of the river, the two provinces between the branches, and the two to the right of the eastern, or Damietta branch.

In Upper Egypt, with one very important exception (the Ibrahimieh Canal, which is a perennial one), the early flood system of irrigation, yielding one crop a year, prevailed until very recently, but it was immensely improved after the British occupation by the addition of a great number of masonry head sluices, aqueducts, escape weirs, &c., on which some 800,000*l.* was spent. With the completion of these works, and of a complete system of drainage, to be alluded to further on, it may be considered that the irrigation system of Egypt was put on a very satisfactory basis. There was not much more left to do, unless the volume of water at disposal could be increased.

Probably no large river in the world is so regular as the Nile in its periods of low supply and of flood. It rises steadily in June, July, and August. Then it begins to go down, at first rapidly, then slowly, till the following June. It is never a month before its time, never a month behind. It is subject to no exceptional floods from June to June. Where it enters Egypt the difference between maximum and minimum Nile is about 25 feet. If it rises 3½ feet higher the country is in danger of serious flooding. If in former days its rise was 6 feet short of the average there existed a great risk that the floods would not cover the extensive flats of Upper Egypt, and thus the ground would remain as hard as stone, and sowing in November would be impossible. Fortunately the good work of the last twenty years very much diminishes this danger.

The Assuan Dam and Reservoir.

In average years the volume of water flowing past Cairo in September is from thirty-five to forty times the volume in June. By far the greater part of this flood flows out to the sea useless. How to catch and store this supply for use the following May and June was a problem early pressed on the English engineers in Egypt.

During the time of the highest flood the Nile carries along with it an immense amount of alluvial matter, and when it was first proposed to store the flood-water the danger seemed to be that the reservoir would in a few years be filled with deposit, as those I have described in India. Fortunately it was found that after November the water was fairly clear, and that if a commencement were made even as late as that there would still be water enough capable of being stored to do enormous benefit to the irrigation.

A site for a great dam was discovered at Assuan, 600 miles south of Cairo, where a dyke of granite rock crosses the valley of the river, occasioning what is known as the First Cataract. On this ridge of granite a stupendous work has now been created. A great wall of granite 6400 feet long has been thrown across the valley, 23 feet thick at the crest, 82 feet at the base. Its height above the rock-bed of the river is 130 feet. This great wall or dam holds up a depth of 66 feet of water, which forms a lake of more than 100 miles in length up the Nile Valley, containing 38,000 million cubic feet of water.

The dam is pierced with 180 sluices, or openings, through which the whole Nile flood, about 360,000 cubic feet per second, is discharged. A flight of four locks, each 260×30 feet, allows of free navigation past the dam. The foundation-stone of this great work was laid in February 1899, and it was completed in less than four years. At the same time a very important dam of the pattern of the barrage north of Cairo was built across the Nile at Assiut, just below the head of the Ibrahimieh Canal, not with the object of storing water, but to enable a requisite supply at all times to be sent down that canal.

The chief use of the great Assuan reservoir is to enable perennial irrigation, such as exists in Lower Egypt, to be substituted in Upper Egypt for the basin system of watering the land only through the Nile flood; that is, to enable two crops to be grown instead of one every year, and to enable cotton and sugar-cane to take the place of wheat and barley. But a great deal more had to be done in order to obtain the full beneficial result of the work. About 450,000 acres of basin irrigation are now being adapted for perennial irrigation. Many new canals have had to be dug, others to be deepened. Many new masonry works have had to be built. It is probable the works will be finished in 1908. There will then have been spent on the great dam at Assuan, the minor one at Assiut, and the new canals of distribution in Upper Egypt about six and a half millions sterling. For this sum the increase of land rental will be about 2,637,000*l.*, and its sale value will be increased by about 26,570,000*l.*

Drainage.

In the great irrigation systems which I have been describing, for a long time little or no attention was paid to drainage. It was taken for granted that the water would be absorbed or evaporated, and get away somehow without doing any harm. This may hold good for high-lying lands, but alongside of these are low-lying lands into which the irrigation water from above will percolate and produce waterlogging and marsh. Along with the irrigation channel should be constructed the drainage channel, and Sir W. Willcocks, than whom there is no better authority on this subject, recommends that the capacity of the drain should be one-third that of the canal. The two should be kept carefully apart—the canal following the ridges, the drain following the hollows of the country, and one in no case obstructing the other. This subject of drainage early occupied the attention of the English engineers in Egypt. In the last twenty years many hundred miles of drains have been excavated, some as large as 50 feet width of bed and 10 feet deep.

Irrigation in America.

If it is to Italy that we should look for highly finished irrigation works and careful water distribution, and to India and Egypt for widespreading tracts of watered land, it is to America that we naturally look for rapid progress and bold engineering. In the Western States of America there is a rainfall of less than 20 inches per annum, the consequence of which is a very rapid development of irrigation works. In 1889 the irrigation of these Western States amounted to 3,564,416 acres. In 1900 it amounted to 7,539,545 acres. Now it is at least 10,000,000 acres. The land in these States sells from 10*s.* to 1*l.* per acre if unirrigated. With irrigation the same land fetches 8*l.* 10*s.* per acre. The works are often rude and of a temporary nature, the extensive use of timber striking a foreigner from the Old World. Some of the American canals are on a large scale. The Idaho Company's canal discharges 2585 cubic feet, the Turlock Canal in California 1500 cubic feet, and the North Colorado Canal 2400 cubic feet per second. These canals have all been constructed by corporations or societies, in no case by Government. On an average it has cost about 32*s.* per acre to bring the water on to the land, and a water-rate is charged of from 2*l.* 8*s.* to 4*l.* per acre, the farmer paying in addition a rate of from 2*s.* to 10*s.* per acre annually for maintenance. Distributary channels of less than 5 feet wide cost less than 100*l.*, up to 10 feet wide about 150*l.* per mile.

The Introduction of Irrigation into a Country.

It is evident that there are many serious considerations to be taken into account before entering on any large project for irrigation. Statistics must be carefully collected of rainfall, of the sources of water supply available, and of the amount of that rainfall which it is possible to store and utilise. The water should be analysed if there is any danger of its being brackish. Its temperature should be ascertained. It should be considered what will be the effect of pouring water on the soil, for it is not always an unmixed benefit. A dry climate may be changed into a moist, and fever and ague may follow. In India there are large tracts of heavy black soil, which with the ordinary rainfall produce excellent crops nine years out of ten, and where irrigation would rather do harm than good. But in the tenth year the rains fail, and without artificial irrigation the soil will yield nothing. So terrible may be the misery caused by that tenth year of drought that even then it might pay a Government to enter on a scheme of irrigation. But it is evident that it might not pay a joint-stock company.

In all cases it is of the first importance to establish by law the principle that all rivers or streams above a certain size are national property, to be utilised for the good of the nation. Even where there is no immediate intention of constructing irrigation works it is well to establish this principle. Otherwise vested rights may be allowed to spring up, which it may be necessary in after years to buy out at a heavy cost.

Modes of Distributing and Assessing Water.

Where the river is too inconsiderable to be proclaimed as national property, and where there is no question of spreading the water broadcast over the land, but of bestowing it with minute accuracy over small areas to rear valuable plants, such as fruit-trees, it may be very well left to local societies or to syndicates of farmers to manage their own affairs. Where irrigation is on a larger scale, and its administration is a matter of national importance, the control of the water requires the closest consideration, especially if, as is usually the case, the area which may be irrigated exceeds the volume of water available to irrigate it, and where the water is delivered to the fields by gravitation without the labour of raising it. It must be decided on what principle the farmer's right to the water is to be determined. Is he to obtain water in proportion to the area of his land which is irrigable? If part of the irrigable land is not yet cultivated, is some of the supply to be reserved for such land? Is he to pay in proportion to the area actually watered each crop, or to the area which he might water if he chose? Where the slope of the land is sufficient to allow the water to flow freely out of a sluice into the field channel, it is not difficult to measure the water discharged. Modules have been invented for this purpose, and the owner of the field may be required to pay for so many cubic feet of water delivered. The Government or the association owning the canal will then have nothing to do with the way in which the water is employed, and self-interest will force the farmer to exercise economy in flooding his land. But even then precautions must be taken to prevent him from keeping his sluice open when it should be shut.

In Italy and in America water is generally charged by the module; but in many cases, where the country is very flat, the water cannot fall with a free drop out of the sluice, and, as far as I know, no satisfactory module has yet been invented for delivering a constant discharge through a sluice when the head of water in the channel of supply is subject to variation. These are the conditions prevailing in the plains of Northern India, where there is a yearly area of canal irrigation of about six millions of acres. The cultivator pays not in proportion to the volume of water he uses, but on the area he waters every crop, the rate being higher or lower according as the nature of the crop demands more or less water.

The procedure of charging for water is, then, as follows: When the crop is nearly ripe the canal watchman, with the village accountant and the farmers interested, go over the fields with a Government official. The watchman points out a field which he says has been watered. The accountant, who has a map and field-book of the village, states the number and the area of the field and its cultivator. These are recorded along with the nature of the crop watered. If the cultivator denies that he has received water, evidence is heard and the case is settled. A bill is then made out for each cultivator, and the amount is recovered with the taxes.

This system is perfectly understood, and works fairly well in practice. But it is not a satisfactory one. It holds out no inducement to the cultivator to economise water, and it leaves the door open to a great deal of corruption among the canal watchmen and the subordinate revenue officials.

Government Control of Water Supply.

Where the subject agricultural population is unfitted for representative government it is best that the Government should construct and manage the irrigation, on rules carefully considered and rigorously enforced, through the agency of officers absolutely above suspicion of corruption or unfair dealing. Such is the condition in Egypt and in the British possessions in India. Objections to it are evident enough. Officials are apt to be formal and inelastic, and they are often far removed from any close touch with the cultivating classes. But they are impartial and just, and I know of no other system that has not still greater defects.

Even if the agricultural classes in India were much better educated than they are, it would still be best that the control of the irrigation should rest with the Government. By common consent it is the Government alone that rules the army. Now the irrigation works form a great army, of which the first duty is to fight the grim demon of famine. Their control ought, therefore, to rest with the Government; but the conditions are very different when the agricultural classes are well educated and well fitted to manage their own affairs.

Irrigation is too new and experimental in America for us to look there for a well-devised scheme of water control. The laws and rules on the subject vary in different States, and are often contradictory. It is better to look at the system evolved after long years in North Italy.

The Italian System.

I have already alluded to the great Cavour Canal in Piedmont. This fine work was constructed by a syndicate of English and French capitalists, to whom the Government gave a concession in 1862. Circumstances to which I need not allude ruined this company, and the Government, who already had acquired possession of many other irrigation works in Piedmont, took over the whole Cavour Canal in 1874, a property valued at above four millions sterling, and ever since the Government has administered it.

The chief interest of this administration centres on the Irrigation Association West of the Sesia,[1] an association that owes its existence to the great Count Cavour. It takes over from the Government the control of all the irrigation effected by the Cavour and other minor canals within a great triangle lying between the left bank of the Po and the right bank of the Sesia. The association purchases from the Government from 1250 to 1300 cubic feet per second. In addition to this it has the control of all the water belonging to private canals and private rights, which it purchases at a fixed rate. Altogether it distributes about 2275 cubic feet per second, and irrigates therewith about 141,000 acres, of which rice is the most important crop. The association has 14,000 members, and controls 9600 miles of distributary channels. In each parish is a council, or, as it is called, a *consorzio*, composed of all landowners who take water. Each *consorzio* elects one or two deputies, who form a sort of water-parliament. The deputies are elected for three years, and receive no salary. The assembly of deputies elects three committees—the direction-general, the committee of surveillance, and the council of arbitration. The first of these committees has to direct the whole distribution of the waters, to see to the conduct of the *employés*, &c. The committee of surveillance has to see that the direction-general does its duty. The council of arbitration, which consists of three members, has most important duties. To it may be referred every question connected with water-rates, all disputes between members of the association or between the association and its servants, all cases of breaches of rule or of discipline. It may punish by fines any member of the association found at fault, and the sentences it imposes are recognised as obligatory, and the offender's property may be sold up to carry them into effect. An appeal may be made within fifteen days from the decisions of this council of arbitration to the ordinary law courts, but so popular is the council that, as a matter of fact, such appeals are never made.

To effect the distribution of the water the area irrigated is divided into districts, in each of which there is an overseer in charge and a staff of guards to see to the opening and closing of the modules which deliver the water into the minor watercourses. In the November of each year each parish sends in to the direction-general an indent of the number of acres of each description of

1 See Mr. Elwood Mead's "Report on Irrigation in Northern Italy," printed for the Department of Agriculture, Washington, 1904.

crop proposed to be watered in the following year. If the water is available the direction-general allots to each parish the number of modules necessary for this irrigation; but it may quite well happen that the parish may demand more than can be supplied, and may have to substitute a crop like wheat, requiring little water, for rice, which requires a great deal.

The Government executes and pays for all repairs on the main canals. It further executes, at the cost of the Irrigation Association, all repairs on the minor canals. The association, then, has no engineers in its employ, but a large staff of irrigators. The irrigation module employed in Piedmont is supposed to deliver 2·047 cubic feet per second. The Association West of the Sesia buys from the Government what water it requires at a rate fixed at 800 liras per module, or 15*l.* 12*s.* 7*d.* per cubic foot per second per annum.

The association distributes the water by module to each district, and the district by module to each parish. Inside the parish each farmer pays, according to the area he waters, a sum to cover all the cost of the maintenance of the irrigation system, and his share of the sum which the association has to pay to the Government. This sum varies from year to year according as the working expenses of the year increase or diminish.

I have already mentioned the recently constructed Villoresi Canal in Lombardy. This canal belongs to a company, to whom the Government has given large concessions. This company sells its water wholesale to four districts, each having its own secondary canal, the cubic metre per second, or 35·31 cubic feet per second, being the unit employed. These districts, again, retail the water to groups of farmers termed *comizios,* whose lands are watered by the same distributary channels, their unit being the litre, or 0·035 cubic foot, per second. Within the *comizio* the farmer pays according to the number of hours per week that he has had the full discharge of the module.

I have thought it worth while to describe at some length the systems employed on these Italian canals, for the Italian farmers set a very high example, in the loyal way in which they submit to regulations which there must at times be a great temptation to break. A sluice surreptitiously opened during a dark night, and allowed to run for six hours, may quite possibly double the value of the crop which it waters. It is not an easy matter to distribute water fairly and justly between a number of farms at different levels, dependent on different water-courses, cultivating different crops. But in Piedmont this is done with such success that an appeal from the council of arbitration to the ordinary law courts is unheard of. It is thought apparently as discreditable to appropriate an unfair supply of water as to steal a neighbour's horse, as discreditable to tamper with the lock of the water module as with the lock of a neighbour's barn.

Mr. Schuyler's Views as to Government Control.

Where such a high spirit of honour prevails I do not see why syndicates of farmers should not construct and maintain a good system of irrigation. Nevertheless, I believe it is better that Government should take the initiative in laying out and constructing the canals and secondary channels at least. A recent American author, Mr. James Dix Schuyler, has put on record: "That storage reservoirs are a necessary and indispensable adjunct to irrigation development, as well as to the utilisation of power, requires no argument to prove. That they will become more and more necessary to our Western civilisation is equally sure and certain; but the signs of the times seem to point to the inevitable necessity of Governmental control in their construction, ownership, and administration."

This opinion should not be disregarded. Sir W. Willcocks has truly remarked: "If private enterprise cannot succeed in irrigation works of magnitude in America, it will surely not succeed in any other country in this world." What its chances may be in South Africa I leave to my hearers to say. It is not a subject on which a stranger can form an opinion.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY A. C. HADDON, SC.D., F.R.S., PRESIDENT OF THE SECTION.

THERE are various ways in which man can study himself, and it is clearly impossible for me to attempt to give an exposition of all the aims and methods of the anthropological sciences; I propose, therefore, to limit myself to a general view of South African ethnology, incidentally referring to a few of the problems that strike a European observer as needing further elucidation. It seems somewhat presumptuous in one who is now for the first time visiting this continent to venture to address a South African audience on local ethnology, but I share this disability with practically all students of anthropology at home, and my excuse lies in the desire that I may be able to point out to you some of the directions in which the information of anthropologists is deficient, with the hope that this may be remedied in the immediate future.

Men are naturally apt to take an exclusive interest in their immediate concerns, and even anthropologists are liable to fall into the danger of studying men's thoughts and deeds by themselves, without taking sufficient account of the outside influences that affect mankind.

In the sister science of zoology, it is possible to study animals as machines which are either at rest or in motion: when they are thus studied individually, the subjects are termed anatomy and physiology; when they are studied comparatively, they are known as comparative anatomy or morphology and comparative physiology. The study of the genesis of the machine is embryology, and palæontologists, as it were, turn over the scrap-heap. All these sciences can deal with animals irrespective of their environment, and perhaps for intensive study such a limitation is temporarily desirable, but during the period of greatest specialisation there have always been some who have followed in the footsteps of the field naturalist, and to-day we are witnessing a combination of the two lines of study.

Biology has ceased to be a mixture of necrology and physiology; it seeks to obtain a survey of all the conditions of existence, and to trace the effects of the environment on the organism, of the organism on the environment, and of organism upon organism. Much detailed work will always be necessary, and we shall never be able to do without isolated laboratory work; but the day is past when the amassing of detailed information will satisfy the demands of science. The leaders, at all events, will view the subject as a whole, and so direct individual labour that the hewers of wood and drawers of water, as it were, shall not mechanically amass material of which no immediate use can be made, but they will be so directed that all their energies can be exercised in solving definite problems or in filling up gaps in our information, with knowledge which is of real importance.

This tendency, which I have indicated as affecting the science of zoology, is merely one phase of an attitude of mind that is influencing many departments of thought. There are psychologists and theologians who deem it worth while to find out what other people think and believe. Arm-chair philosophers are awakening to the fact that their studies have hitherto been confined almost exclusively to the most highly specialised conditions, and that in order to comprehend these fully it is necessary to study the less and the yet less specialised conditions; for it is only possible to gain the true history of mind or belief by a combination of the observational with the comparative method. A considerable amount of information has already been acquired, but in most departments of human thought and belief vastly more information is needed, and hitherto the trustworthiness of a great deal that has been published is not above suspicion.

The comparative or evolutionary historian also needs trustworthy facts concerning the social condition of varied peoples in all stages of culture. The documentary records of history are too imperfect to enable the whole story to be unravelled, so recourse must be had to a study of analogous conditions elsewhere for side-lights which will cast illuminating beams into the dark corners of ancient history. When the historian seriously turns his attention to the mass of data accumulated in books of travel, in records of expeditions, or the assorted material in the memoirs of students, he will doubtless be surprised to find how much there is that will be of service to him.

Sociologists have not neglected this field, but they need more information and more exhaustive and precise analyses of existing conditions. The available material is of such importance and interest, that the pleasure of the reader is apt to dull his critical faculty; as a matter of fact, the social conditions of extremely few peoples are accurately known, and sooner or later—generally sooner—the student finds his authorities failing him from lack of thoroughness.

I have alluded to the subjects of psychology, theology, history, and sociology, because they all overlap that area over which the anthropologist prowls. Indeed it is our work to collect, sift, and arrange the facts which may be utilised by our colleagues in these other branches of inquiry, and to this extent the ethnologist is also a psychologist, a theologian, a historian, and a sociologist.

Similarly the anthropographer provides material for the biologist on the one hand, and for the geographer on the other.

As a general rule those who have investigated any given people in the field have alluded to the general features of the country they inhabit, so that usually it is possible to gain some conception of them in their natural surroundings. Thus, to a certain extent, materials are available for tracing that interaction between life and environment and between organisms themselves, to which the term Œcology is now frequently applied, but we still need to have this interdependence more recognised in such branches of inquiry as descriptive sociology or religion.

Just as the arts and crafts of a people are influenced by their environment, so is their social life similarly affected, and their religion reflects the stage of social culture to which they have attained; for it must never be overlooked that the religious conceptions of a people cannot be thoroughly understood apart from their social, cultural, and physical conditions.

This may appear a trite remark, but I would like to emphasise the fact that very careful and detailed studies of definite or limited areas are urgently needed, rather than a general description of a number of peoples which does not exhaust any one of them—in a word, what we now need is thoroughness.

Three main groups of indigenous peoples inhabit South Africa—the Bushmen, the Hottentots, and various Bantu tribes; in more northerly parts of the continent there are the Negrilloes, commonly spoken of as Pygmies, the Negroes proper, and Hamitic peoples, not to speak of Arab and Semitic elements.

Kattea.

Before proceeding further I must here make allusion to an obscure race who may possibly be the true aborigines of Africa south of the Zambesi. These are the Kattea—or Vaalpens, as they are nicknamed by the Boers, on account of the dusty colour their abdomen acquires from the habit of creeping into their holes in the ground—who live in the steppe region of the North Transvaal, as far as the Limpopo. As their complexion is almost a pitch-black, and their stature only about 1·220 m. (4 ft.), they are quite distinct from their tall Bantu neighbours and from the yellowish Bushmen. The "Dogs," or "Vultures," as the Zulus call them, are the "lowest of the low," being undoubtedly cannibals and often making a meal of their own aged and infirm, which the Bushmen never do. Their habitations are holes in the ground, rock shelters, and lately a few hovels. They have no arts or industries, nor even any weapons except those obtained in exchange for ostrich feathers, skins, or ivory. Whether they have any religious ideas it is impossible to say, all intercourse being restricted to barter carried on in a gesture language, for nobody has ever yet mastered their tongue, all that is known of their language being that it is absolutely distinct from that of both the Bushman and the Bantu. There are no tribes, merely little family groups of from thirty to fifty individuals, each of which is presided over by a headman, whose functions are acquired, not by heredity, but by personal qualities. I have compiled this account of this most interesting people from Prof. A. H. Keane's book, "The Boer States," in the hope that a serious effort will be made to investigate what appears to be the most primitive race of all mankind. So little information is available concerning the Kattea that it is impossible to say anything about their racial affinities.

Perhaps these are the people referred to by Stow (p. 40), and possibly allied to these are the dwarfs on the Nosop River mentioned by Anderson; these were 1·125 m. (4 ft. 4 in.) or less in height, of a reddish-brown colour, with no forehead and a projecting mouth; Anderson's Masara Bushmen repudiated any suggestion of relationship with them, saying they were "monkeys, not men."

Bushmen.

The San, or Bushmen (Bosjesman of colonial annals), may, with the possible exception of the Kattea, be regarded as the most primitive of the present inhabitants of South Africa; according to most authors, there is no decisive evidence that there was an earlier aboriginal population, although M. G. Bertin informs us that Bushman tales always speak of previous inhabitants.

The main physical characteristics of the Bushmen are a yellow skin, and very short, black, woolly hair, which becomes rolled up into little knots; although of quite short stature, with an average height of 1·529 m. (5 ft. 0¼ in.), or, according to Schinz, 1·570 m. (5 ft. 1¾ in.), they are above the pygmy limit of 1·450 m. (4 ft. 9 in.). The very small skull is not particularly narrow, being what is termed sub-dolichocephalic, with an index of about 75, and it is markedly low in the crown; the face is straight, with prominent cheekbones and a bulging forehead; the nose is extremely broad—indeed, the Bushmen are the most platyrrhine of all mankind; the ear has an unusual form, and is without the lobe. Their hands and feet are remarkably small.

Being nomadic hunters the Bushmen could only attain to the rudiments of material culture. The dwellings were portable, mat-covered, dome-shaped huts, but they often lived in caves; the Zulus say "their village is where they kill game; they consume the whole of it and go away." Clothing consisted solely of a small skin; for weapons they had small bows and poisoned arrows. Their only implement was a perforated rounded stone into which a stick was inserted; this was used for digging up roots. A very little coarse pottery was occasionally made. Although with a great dearth of personal ornaments, they had a fair amount of pictorial skill, and were fond of decorating their rock shelters with spirited coloured representations of men and animals. They frequently cut off the terminal joint of a little finger. They never were cannibals. Cairns of stones were erected over graves. Although they are generally credited with being vindictive, passionate, and cruel, they were as a matter of fact always friendly and hospitable to strangers until dispossessed of their hunting grounds. They did not fight one another, but were an unselfish, merry, cheerful race with an intense love of freedom.

A great mass of unworked material exists for the elucidation of the religious ideas, legends, customs, and so forth, of the Bushmen, in the voluminous native texts, filling eighty-four volumes, to the collection of which the late Dr. Bleek devoted his laborious life. This wonderful collection of the folklore of one of the most interesting of peoples still remains inaccessible to students in the Grey Library in Cape Town. A more enlightened policy in the past would have enabled Dr. Bleek to publish his own material; now the task is complicated by the great difficulty of finding competent translators and of securing the services of trustworthy natives who know their own folklore. The time during which this labour can be adequately accomplished is fleeting rapidly, and once more the Government must be urged to complete and publish the life-work of this devoted scholar.

The Mañanja natives, who live south of Lake Shirwa, assert that formerly there lived on the upper plateau of the mountain mass of Mlanje a people they call Arungu, or "gods," who from their description must have been Bushmen. Relics of Bushman occupation have been found in the neighbourhood of Lakes Nyassa and Tanganyika.

West of the Arangi plateau in German East Africa, between the steppes occupied by the Wanyamwezi and the Masai, live the Wasandawi, a settled hunting people who, according to Baumann, are very different from the surrounding Bantu peoples, and who are allied to the more primitive, wandering, hunting Wanege, or Watindiga, of the steppes near Usukuma. They use the bow and poisoned arrow. Their language, radically distinct from Bantu, is full of those strange click sounds which are characteristic of Bushman speech; but Sir Harry Johnston says that he does not know if any actual relationship has been pointed out in the vocabulary, and he distinctly states that the Sandawi are not particularly like the Bushmen in their physique, but more resemble the Nandi; and Virchow declares there is no relationship between the Wasandawi and the Hottentot in skull-form. Until further evidence is collected, one can only say that there may have been a Bushman people here who have become greatly modified by intermixture with other races. Sir Harry Johnston thinks that possibly traces of these people still exist among the flat-faced, dwarfish Doko, who live to the north of Lake Stephanie, and he is inclined to think that traces of them occur also among the Andorobo and Elgunono.

If the foregoing evidence should prove to be trustworthy, it would seem that at a very early time the Bushmen occupied the hunting grounds of tropical East Africa, perhaps even to the confines of Abyssinia. They gradually passed southwards, keeping along the more open grass lands of the eastern mountainous zone, where they could still preserve their hunting method of life, until, at the dawn of history, they roamed over all the territory south of the Zambesi, with the exception of the eastern seaboard.

Negrilloes.

Material does not at present exist for an exhaustive discussion of the exact relationship between the Bushmen and the Negrilloes of the Equatorial forests. On the whole I am inclined to agree with Sir Harry Johnston, who says: "I can see no physical features other than dwarfishness which are obviously peculiar to both Bushmen and Congo Pygmies. On the contrary, in the large and often protuberant eyes, the broad flat nose with its exaggerated alæ, the long upper lip and but slight degree of eversion of the inner mucous surface of the lips, the abundant hair on head and body, relative absence of wrinkles, of steatopygy, and of high protruding cheekbones, the Congo dwarf differs markedly from the Hottentot-Bushman type." Shrubsall had previously stated: "For the present I can only say that the data seem to me too insufficient to enable the affinities of the various pygmy races to be clearly demonstrated, or to allow of much significance being attached to any apparent resemblance." Deniker also directs attention to the physical characters that distinguish those two types, and he concludes that "nothing justifies their unification."

Hottentots.

The skin of the Hottentots, or Khoikhoi, as they style themselves, is of a brownish-yellow, with a tinge of grey, sometimes of red; the hair is very similar to that of the Bushmen; the average stature is 1·604 m. (5 ft. 3 in.); the head is small and distinctly dolichocephalic (74), the jaws prognathic, cheekbones prominent, and chin small. Shrubsall, who has investigated the osteological evidence, says no hard-and-fast line can be drawn from craniological evidence between Hottentots and Bushmen on the one hand and Negroid races on the other, various transitional forms being found; but Bushman characteristics undoubtedly predominate in the true Hottentots.

The Hottentots were grouped in clans, each with its hereditary chief, whose authority, however, was very limited. Several clans were loosely united to form tribes. Their principal property consisted of horned cattle and sheep; the former were very skilfully trained. The dwellings were portable, mat-covered, dome-shaped huts. For weapons they had a feeble bow with poisoned arrows, but they also had assegais and knobkerries or clubbed sticks used as missiles; coarse pottery was made. They were often described as mild and amiable.

The Hottentot migration from the eastern mountainous zone took place very much later than that of the Bushmen, and it seems to have been due mainly to the pressure from behind of the waxing Bantu peoples. These pastoral nomads took a south-westerly course across the savanna country, and if the tsetse fly had the same distribution then as now they probably, more or less, followed the right bank of the Zambesi, then struck across to the Kunene north of the desert land, and worked their way down the west coast and along the southern shore of the continent.

What is now Cape Colony was inhabited solely by Bushmen and Hottentots at the time of the arrival of the Europeans. As the latter expanded they drove the aborigines before them, but in the meantime mongrel peoples had arisen, mainly of Boer-Hottentot parentage, who also were forced to migrate. Those of the Cape Hottentots who were not exterminated or enslaved drifted north and found in Bushman Land an asylum from their pursuers. The north-east division of the Hottentots comprises the Koranna, or Goraqua; they were an important people, despite the fact that they had no permanent home. They migrated along the Orange River—one section went up the right bank of the Harts and the other went up the Vaal until they were deflected by the Bechuana. When the Boers in 1858 were engaged with the Basuto, the Koranna devastated the Orange Free State, but were themselves ultimately destroyed. The original home of the Griqua was in the neighbourhood of the Olifant River; in the middle of the eighteenth century the colonists settled in the land, and as a result the Griqua-Bastards retreated to the east under the leadership of the talented Adam and Cornelius Kok. They adopted the name Griqua in place of the earlier one of Bastard; one split founded Griqua Town in Griqualand West, but the other went further east and eventually settled east of the Drakensberg, between Natal and Basutoland, and occupied the country devastated by Chaka's wars. Here rose the chief town, Kokstadt, in Griqualand East, where a few Griqua still live. The interesting little nation of the Bastards, descendants of unions between Europeans, mostly Boers, and Hottentot women, now mixes very little with other peoples. They were forced in 1868 to leave their home in Great Bushmanland owing to the ravages of Bushmen and Koranna, and finally, after various wanderings and vicissitudes, they settled as four communities in Great Namaqualand, in German territory. Namaqualand is too infertile to attract colonists, and thus it forms an asylum for expatriated Hottentots as well as for the Namaqua division of the Hottentots, the original inhabitants of the country.

True Negroes.

One of the most primitive populations of Africa is that of the true, or West Africa, Negroes. At present this element is mainly confined to the Sudan and the Guinea Coast.

The main physical characteristics of the true Negro are: "black" skin, woolly hair, tall stature, averaging about 1·730 m. (5 ft. 8 in.), moderate dolichocephaly, with an average cephalic index of 74–75. Flat, broad nose, thick and often everted lips, frequent prognathism.

West African culture contains some characteristic features. The natives build gable-roofed huts; their weapons include spears with socketed heads, bows tapering at each end with bowstrings of vegetable products, swords and plaited shields, but no clubs or slings. Among the musical instruments are wooden drums and a peculiar form of guitar, in which each string has its own support. Clothing is of bark-cloth and palm-fibre, and there is a notable preponderance of vegetable ornaments. Circumcision is common and the knocking out of the upper incisors. With regard to religion, there is a great development of fetishism and incipient polytheistic systems. Colonel Ellis has proved in a masterly manner the gradual evolution of religion from west to east along the Guinea Coast, and this is associated with an analogous progress in the laws of descent and succession to property, and in the rise of government. He further suggests that differences in the physical character of each country in question have played a great part in this progressive evolution. Here also are to be found secret societies, masks and representations of human figures. The ordeal by poison is employed, chiefly for the discovery of witchcraft; anthropophagy occurs. The domestic animals are the dog, goat, pig, and hen. Cattle are absent owing to the tsetse fly. The plants originally cultivated were beans, gourds, bananas, and perhaps earth-nuts. Coiled basketry and head-rests are absent.

That branch of the true Negro stock which spake the mother-tongue of the Bantu languages some 3000 years ago (according to Sir Harry Johnston's estimate) spread over the area of what is now Uganda and British East Africa. In the Nile valley these people probably mixed with Negrilloes, and possibly with the most northerly representatives of the Bushmen in the high lands to the east. Here also they came into contact with Hamitic peoples coming down from the north, and their amalgamation constituted a new breed of Negro—the Bantu. We have already seen what are some of the more important physical characteristics of the Negro, Negrillo, and Bushman stocks; it only remains to note in what particulars they were modified by the new blood.

Hamites.

The Hamites are to be regarded as the true indigenous element in North Africa, from Morocco to Somaliland. Two main divisions of this stock are generally recognised: (1) the Northern or Western Hamites (or Mediterranean race of some authors), of which the purest examples are perhaps to be found among the Berbers; and (2) the Eastern Hamites or Ethiopians. These two groups shade into each other, and everywhere a Negro admixture has taken place to a variable extent since very early times. The Hamites are characterised by a skin-colour that varies considerably, being white in the west and various shades of coffee-brown, red-brown, or chocolate in the east; the hair is naturally straight or curly, but usually frizzly in the east. The stature is medium or tall, averaging about 1·670 m. (5 ft. 5¾ in.) to about 1·708 m. (5 ft. 7¼ in.); the head is sub-dolichocephalic (75–78); the face is elongated and the profile not prognathous; the nose prominent, thin, straight or aquiline, with narrow nostrils; lips thin or slightly tumid, never everted.

Bantu.

Roughly speaking, the whole of Africa south of the equator, with the exception of the dwindling Bushman and Hottentot elements, is inhabited by Bantu-speaking peoples, who are extremely heterogeneous, but who exhibit sufficient similarities in physical and cultural characteristics to warrant their being grouped together: the true Negro may be regarded as a race; the Bantu are mixed peoples.

It will be noticed that as a rule the Bantu approach the Hamites in those physical characters in which they differ from the true Negroes, and owing to the fact that the physical characters of Semites in the main resemble those of Hamites, any Semitic mixture that may have taken place will tend in the same direction as that of the Hamitic. The diversity in the physical characters of the Bantu is due to the different proportions of mixture of all the races of Africa. What we now require is a thorough investigation of these several elements in as pure a state as possible, and then by studying the various main groups of Bantu peoples their relative amount of racial mixture can be determined.

The physical characteristics of the Bantu vary very considerably. The skin colour is said to range from yellowish-brown to dull slatey-brown, a dark chocolate colour being the prevalent hue. The character of the hair calls for no special remark, as it is so uniformly of the ordinary Negro type. The stature ranges from an average of about 1·640 m. (5 ft. 4½ in.) to about 1·715 m. (5 ft. 7½ in.). Uniformity rather than diversity of head-form would seem to be the great characteristic of the African black races, but a broad-headed element makes itself felt in the population of the forest zone and of some of the upper waters of the Nile Valley. It appears that the broadening of the head is due to mixture with the brachycephalic Negrillo stock, for, whereas the dolichocephals are mainly of tall stature, some of the brachycephals, especially the Aduma of the Ogowe, with a cephalic index of 80·8, are quite short, 1·594 m. (5 ft. 2¾ in.). The character of the nose is often very useful in discriminating between races in a mixed population, but it has not yet been sufficiently studied in Africa, where it will probably prove of considerable value, especially in the determination of the amount of Hamitic or Semitic blood. The results already obtained in Uganda are most promising. Steatopygy is not notable among men; fatty deposits are well developed among women, but nothing approaching the extent characteristic of the Hottentots and Bushmen.

It appears that the Bantu peoples may be roughly divided according to culture into two groups: a western zone, which skirts the West African region and extends through Angola and German West Africa into Cape Colony; and an eastern zone. (1) The western Bantu zone is characterised by beehive huts, the absence of circumcision, and the presence of wooden shields (plain or covered with cane-work) in its northern portion, though skin shields occur to the south. (2) In the eastern Bantu zone the huts are cylindrical, with a separate conical roof.

Certain characteristics are typical of the Bantu culture. The natives live in rounded huts with pointed roofs; their weapons comprise spears, in which the head is fastened into the shaft by a spike, bows of equal thickness along their length, with bowstrings of animal products, clubs and skin shields, but slings are usually absent; the clothing is of skin and leather, and there is a predominance of animal ornaments; knocking out the lower incisors is general, circumcision is common, though among the Kafir tribes it seems to be dying out; ancestor-worship is the prevalent form of religion, fetishism and polytheism are undeveloped; masks and representations of human figures are rare, and there are no secret societies; anthropophagy is sporadic and usually temporary; the domestic animals include the dog, goat, and sheep, and cattle are found wherever possible; coiled basketry is made, and head-rests are a characteristic feature.

M. A. de Préville has drawn a broad line of distinction between the religion of the pastoral Bantu tribes and that of the hunters of the forest belt. The cattle-raisers of the small pastures recognise that the rain and necessary moisture depend on an invisible and supreme power whom they invoke in his location in the sky. His intermediaries are the rain-makers, he has no human form, neither are there idols in the pantheon. In Central Africa there is more than sufficient rain, but rain is of little importance to the hunter. What he requires is to find game, to be able to capture it and to avoid danger; the "medicine-men" are not rain-makers, but makers of talismans, amulets, philtres, and charms to attract the game and to ensure its capture. The mysterious depths of the forest, in the impenetrable thickets of which death may lurk at each step, and the isolation which results in social disorganisation, incline the hunter to superstitious terrors. Pasturage is governed by natural impersonal forces, but hunting is individual and personal. Further, associated with the mobile pastoral life of the Bantu is the patriarchal system of family life, respect and veneration for old age, and the autocracy of the chief; no wonder, then, that ancestor-worship has developed, or that it is the chief factor in the religious life of these people.

As I have previously indicated, there is evidence of the former extension to the north of the Hottentots and the Bushmen, they having gradually been pressed first southwards and then into the steppes and deserts of South Africa by the southerly drifting of the Bantu.

The mixture of Hamite with Negro, which gave rise to the primitive Bantu stock, may have originated somewhere to the east or north-east of the Victoria Nyanza. A factor of great importance in the evolution of the Bantu is to be found in the great diversity of climate and soil in Equatorial East Africa. It is a country of small plateaux separated by gorges, or low-lying lands. The small plateaux are suitable for pasturage, but their extent is limited; thus they fell to the lot of the more vigorous people, while the conquered had to content themselves with low country, and were obliged to hunt or cultivate the land. In these healthy highlands the people multiplied, and migration became necessary; the stronger and better-organised groups retained their flocks and migrated in a southerly direction, keeping to the savannas and open country, the line of least resistance being indicated by the relative social feebleness of the peoples to the south. In the small plateaux a nomadic life is impossible for the herders: there being at most a seasonal change of pasturage, this prevents the possession of large herds and necessitates a certain amount of tillage; further, it would seem that this mode of life tends to develop military organisation and a tribal system.

No materials at present exist for any attempt at a history of this stage of the Bantu expansion, but from what we know of the great folk-wanderings in South Africa during the first half of the nineteenth century, we can form some estimate of what may have happened earlier in Equatorial Africa.

Lichtenstein lived among the Bechuanas in 1805, and from that date begins our knowledge of the Bantu peoples. Dr. G. M. Theal, the learned historian of South Africa, Dr. K. Barthel and Mr. G. W. Stow, whose valuable book has just appeared, have made most careful studies of folk-wanderings in South Africa, based upon the records of the explorers of the past hundred years; we scarcely have trustworthy accounts of the movements of the various tribes for a longer period, and oral traditions of the natives, though in the main correct, require careful handling. The nature of the country is such that it affords more than ordinary facilities for migrations, and the absence of great geographical barriers prevents ethnical differentiation.

The Bantu peoples of Southern Africa may conveniently be classified in three main groups:—

(1) The eastern tribes, composed of the Zulu-Xosa.

(2) The interior tribes, consisting of the Bechuana, Basuto, Mashona, &c.

(3) The western tribes, such as the Ovampo and Ovaherero.

(1) The Zulu-Xosa are respectively the northern and southern branches of a migration down the east coast, that, according to some authorities, took place about the fifteenth century. The Amaxosa (Kosa, or Kafirs) never overstepped the Drakensberg range, but there have been northerly and, more especially, southerly movements: the Amaxosa, for example, extended, about 1800, as far as Kaaimans River, Mossel Bay, but in 1835 they were pressed back by the colonists to the Great Fish River.

The Amazulu have occupied the east coast, north of the Tugela, for a long period, and allied tribes extend as far as the Zambesi; indeed, it may be said that a complete chain of Zulu peoples stretches up to the neighbourhood of the equator, the more open country in which they live giving greater opportunities for expansion. The wonderful rise to power of Chaka (1783–1828) caused great movements of peoples to take place. The Amangwane (who drove the Amahlubi before them) and other groups fled southward to escape from the tyranny of this great warrior. The conquerors applied to these scattered remnants of tribes the contemptuous term "Fingu," or homeless fugitives, and turned them into slaves and cattle-tenders. The Matabele, to the number of some 60,000 individuals, separated from the parent stock about 1817, under the leadership of the terrible Moselekatze (Umsilikatzi), whose fame as an exterminator of men ranks second only to that of Chaka; they crossed the Drakensberg and went north-west through the Transvaal, scattering the settled Bechuana peoples. They were attacked by the Boers, who defeated them with terrible slaughter, from which only forty warriors escaped. They withdrew to the Zambesi, but were driven south by the tsetse fly. They encountered the Makalaka and destroyed their villages, drove out the Mashona to the north-east, and settled in Mashonaland.

(2) The great central region of the South African plateau, roughly known as Bechuanaland, was very early occupied by Bantu peoples coming from the north, who displaced or reduced to servitude the indigenous Bushmen. As Prof. Keane points out, the Bechuana must have crossed the Zambesi from the north at a very early date, because of all the south Bantu groups they alone have preserved the totemic system. Among the first to arrive, according to him, appear to have been the industrious Mashona and Makalaka. For three hundred years, according to native tradition, the Makalaka owned the land between the Limpopo and the Zambesi, and then came the Barotse, who are allied to the Congo Bantu, and conquered them. A section of the latter founded a powerful so-called Barotse (Marotse) empire on the Middle Zambesi above the Victoria Falls. At the beginning of the nineteenth century a Bahurutse dynasty ruled over the Bechuana; as these people expanded they broke off into clans, and extended between the Orange River and the Zambesi, and from the Kathlamba, or Drakensberg chain, to the Kalahari Desert.

The densely populated country west of the Drakensberg now known as Basutoland was subjected to great devastation as a result of Chaka's tyranny. In 1822 a tribe fleeing from the Zulus set up the first of these disturbances, and the attacked became the attackers in their turn. One horde, the Mantati, achieved great notoriety, and are credited with having wiped out twenty-eight tribes; they were eventually defeated by the Bangwaketsi and scattered by the Griqua. The Makololo, a small group of the Mantati (who lived on the upper waters of the Orange River), led by Sebituane, in 1823 aimed at reaching the district of the Chobe and Zambesi, where he had heard that it was always spring. After conquering the Bakwena, Bahurutse, and other kindred tribes and increasing their forces from the conquered peoples, they crossed the Zambesi and the uplands stretching to the Kafukwe, and settled in those fertile pasture lands about 1835. Disturbed by the Matabele, Sebituane passed through the Barotse Valley, followed by the Matabele and the Batoka, a tribe of the Barotse. He put the former to flight and subjugated the latter. Thus Sebituane led his people a journey of more than 2000 miles to reach their Promised Land. Under Sekeletu, Sebituane's successor, the State began to fall to pieces, and after his death the Barotse revolted, and practically exterminated the Makololo. The rehabilitated Barotse empire comprises an area of some 250,000 square miles between the Chobe and Kafukwe affluents of the Zambesi. Prof. Keane directs attention to the instructive fact that though the Makololo have perished from among the number of South African tribes, their short rule (1835–1870) was long enough to impose their language upon the Barotse, and to this day, about the Middle Zambesi, where the Makololo have disappeared, their speech remains the common medium of intercourse throughout the Barotse empire. The consolidation of the Basuto under the astute Moshesh is an instructive episode in the history of the South African races. The Bamangwato are the most important branch of the independent Bechuana peoples, who have made considerable progress under the wise guidance of the enlightened Khama; they are an industrious people, and have exceptional skill in working iron.

According to Mr. G. W. Stow there were three main migrations of the interior, or middle, Bantu, or Bachoana as he terms them: (i.) The pioneer tribes of the southward migration into the ancient Bushman hunting grounds were the Leghoya, Bakalahari, and those who intermarried with the Bushmen to form the Balala and Bachoana Bushmen; (ii.) the tribes of the second period of the Bachoana migration were the Batlapin and Barolong; (iii.) the great Bakuena or Bakone tribes were the most civilised of the Bantu peoples: they consisted of the Bahurutse, Batlaru, Bamangwato, Batauana, Bangwaketse, and the Bakuena, who were the wealthiest and most advanced of all until they were reduced by the Mantati and destroyed by the Matabele.

(3) Turning for a moment to German South-West Africa we find the Bastards to the south, and north of them the Haukoin or Mountain Damara, who are now practically a pariah people, subject to the Hottentots, Bastards, Ovaherero, and the white man. It is possible that these are of Negro rather than of Bantu origin; in mode of life, save for their talent for agriculture, they are Bushmen; in their speech they are Hottentots, but their colour is darker than that of their neighbours. Somewhere from Eastern South Africa, about a hundred years ago, came the Ovaherero, or the Merry People, who, like the rest of the Bantu, are warlike cattle-breeders, with wandering proclivities, but they are not agriculturists. When they arrived in the Kaoko district they drove the Haukoin to the south, together with the Toppnaers (Aunin) and Bushmen. To the north of the Ovaherero are the agricultural Ovampo.

—

Speaking generally, the direction of ethnic migration in South Africa has been southerly in the south-east: the sea blocked an eastern expansion and the Drakensberg a western; only the Matabele went westward of this range to the north. In the central district the Bahurutse or Bechuana parent stock dispersed in various directions; most of the movements were towards the north, but the Mantati and Basuto went south-east. In the west the Cape Hottentots always retreated from the colonists towards the north; the Bastards and other tribes followed the same direction, the causes, as Barthel points out, being obvious: to the east is the Kalahari, on the west is the sea, from the south came the pressure of the Boers. Finally, right across South Africa we have, from west to east, the Koranna, Griqua, and Boer wanderings in the south; and in the north, from east to west, the wanderings of the Hottentots, Ovaherero, and of the Boer emigrants from the Transvaal.

South Africa has thus been a whirlpool of moving humanity. In this brief summary I have been able to indicate only the main streams of movement: there have been innumerable cross-currents which add complexity to this bewildering history, and much patient work is necessary before all these complications can be unravelled and their meaning explained.

When one takes a bird's-eye view of the ethnology of South Africa, certain main sociological facts loom out amongst all the wealth of varied detail.

The earliest inhabitants of whom we have any definite information were the dwarf Bushmen, who undoubtedly represent a primitive variety of mankind. In a land abounding with game they devoted themselves entirely to the chase, supplementing their diet with fruit and roots. This mode of life necessitates nomadic habits, the absence of property entails the impossibility of gaining wealth, and thereby relieving part of the population from the daily need of procuring food; this absence of leisure precludes the elaboration of the arts of life. A common effect of the nomadic hunting life is the breaking-up of the community into small groups; the boys can soon catch their own game, hence individualism triumphs and parental authority is apt to be limited. Social control is likely to be feeble unless the religious sentiment is developed, and certainly social organisation will be very weak. In an open country abounding with game the case is somewhat different, and there is reason to believe that in early days the Bushmen were divided into a number of large tribes, occupying tolerably well-defined tracts of country, each being under the jurisdiction of a paramount chief. The tribes were subdivided into groups under captains. They showed great attachment and loyalty to their chiefs, and exhibited a passionate love for their country. For hundreds of years these poor people have been harried and their hunting grounds taken away from them, and hence we must not judge the race by the miserable anarchic remnant that still persists in waste places. Nomad hunters do not progress far in civilisation by their own efforts, nor are they readily amenable to enforced processes of civilisation. Invariably they are pushed on one side or exterminated by peoples higher in the social scale.

When the written history of South Africa begins we find the Bushmen already being encroached upon by tbe Hottentots, who themselves sprang from a very early cross of Bantu with Bushmen. Culturally, as well as physically, they may be regarded as a blend of these two stocks. They combined the cattle-rearing habits of the Bantu with the aversion from tillage of the soil characteristic of the hunter; they became nomadic herders, who were stronger than the Bushmen, but who themselves could not withstand the Bantu when they came in contact with them, and they too were driven to less favourable lands and became enslaved by the invaders. All gradations of mixture took place until lusty uncontaminated Bantu folk forced their way into the most desirable districts. Still less could the Hottentots prevail against the colonists; their improvidence was increased by alcohol, and their indifference to the possession of land, due to their inherent love of wandering, completed their ruin.

The Bantu were cattle-rearers who practised agriculture. The former industry probably was transmitted from their Hamitic forefathers, who were herdsmen on the grassy uplands of north-eastern Africa, while the latter aptitude was probably due in part to their Negro ancestry. This duality of occupation led to variability in mode of life. In some places the land invited the population towards husbandry, in others the physical conditions were more suited to a pastoral life, and thus we find the settled Baronga on the one hand and the wandering Ovaherero on the other. The Bantu peoples easily adopt changes of custom; under the leadership of a warlike chief they become warlike and cruel, a common characteristic of pastoral peoples, while it is recorded that many of the Matabele, taken prisoners by the Barotse, settled down peacefully to agriculture. The history of the prolific Bantu peoples on the whole indicates that they were as loosely attached to the soil as were the Ancient Germans, and like the latter, at the slightest provocation, they would abandon their country and seek another home. This readiness to migrate is the direct effect of a pastoral life, and along with this legacy of unrest their Hamitic ancestors transmitted a social organisation which lent itself to discipline. These were the materials, so to speak, ready to hand when organisers should appear. Nor have such been lacking, for such names as Dingiswayo, Chaka, Dingan, Moselekatze, Lobengula, Moshesh, Sebituane, Cetewayo, and others are writ large in the annals of South Africa; and the statesman Khama is an example of what civilisation can do to direct this executive ability into proper channels.

Archaeology.

The archæology of South Africa is now attracting considerable local interest, and we may confidently expect that new discoveries will soon enable us to gain some insight into the dense obscurity of the past. It cannot be too strongly insisted upon that the methods of the archæologist should be primarily those of the geologist. Accurate mapping of deposits or localisation of finds is absolutely necessary. The workmanship of an implement is of little evidential value: the material of which it is made may be refractory, the skill of the maker may be imperfect, or he may be satisfied with producing an implement just sufficient for his immediate need; and there is always a chance that any implement may be simply a reject. The early generalisation of implements in England into two groups, Palæolithic and Neolithic, expressed a fact of prime importance, but now the classification has extended. It is obvious that the shapely palæoliths of the older gravels could not have been the first attempts at implement-making by our forefathers, and the presumed hiatus between the two epochs has been bridged over by evidence from sites on the European mainland. Our knowledge is increasing apace and an orderly sequence is emerging, but there are many interesting variations, and even apparent setbacks, in the evolution of industrial or artistic skill. In a word, sequence and technique must not be confounded, and our first business should be to establish the former on a firm basis; but, as I have just remarked, this can be accomplished only by adhering rigidly to the stratigraphical methods of the geologist. It would probably be to the interest of South African archæology if the terms "Eolithic," "Palæolithic," and "Neolithic" were dropped, at all events for the present, and it might prove advantageous if provisional terms were employed, which could later on be either ratified or abandoned, as the consensus of local archæological opinion should decide.

In certain lands of the Old World, north of the Equator, there was a progressive evolution from the Stone Ages, through a copper and a bronze age, to that of iron; but the stone-workers of South Africa appear to have been introduced to iron-smelting without having passed through the earlier metal phases, since the occurrence of copper implements is too limited to warrant the belief that it represents a definite phase of culture. The similarity of the processes employed in working iron by the different tribes of Africa, south of the equator, indicates that the culture was introduced from without, a conclusion which is supported by the universal use of the double bellows—a similar instrument is in use in India and in the East Indian Archipelago. Some ethnologists hold that Africa owes to India its iron industry and other elements of culture, as well as the introduction of the ox, pig, and fowl. At all events, we shall probably not be far wrong if we assign a fair degree of antiquity to the knowledge of iron in tropical and southern Africa.

The characteristic metal of South Africa is gold, and its abundance has had a profound effect on the country, although, strange to say, it was not employed by any of the native races on their own initiative. We cannot tell when it was first discovered or by whom, but the hundreds of ruins scattered over a large extent of country, and the very extensive ancient workings, testify to the importance and the long continuance of this industry; for there can be no doubt that the builders of these wonderful remains came to this country mainly for the sake of its goldfields, though there must also have been an important trade in ivory, and incidentally in other local produce. Positive demonstration is as yet lacking concerning the nationality of the first gold-workers. This much is certain: they must have come to South Africa originally for some other product, since the aborigines did not work the metal, and it is most probable their quest was for ivory, and it was these hunters and traders who discovered the surface gold. Further, the discoverers must have come from a country where quarrying and metal-smelting were practised, and this implies the organisation of labour, for in early times, as history abundantly proves, mining was always undertaken by means of forced labour. The gold-workers, who probably came from Southern Arabia, belonged to a much higher social order than any of the peoples with whom they came in contact, and with their discipline in war and their industrial training they were able to subdue the Bantu inhabitants over immense tracts between the Zambesi and the Limpopo, to reduce them to slavery, to organise the working of the gold mines, and to establish a chain of forts and a system of communication with the coast. This occupation of the country by foreigners was purely for purposes of exploitation, and when, for reasons at present unknown to us, their hold weakened on the land, the whole enterprise fell to pieces, and the foreigners departed, they left indelible marks of their former presence on the face of the country, but in native industries and customs there is virtually no trace remaining of the rule of the more civilised Semitic overlord. The natives seem, as it were, to have awakened from a nightmare and straightway to have forgotten the hideous dream. Possibly this history may have been repeated more than once.

It is greatly to be deplored that in the past irresponsible prospectors have been permitted to rifle the ancient ruins for gold, with the result that not only have very numerous specimens of archæological interest been cast into the melting-pot, but at the same time collateral evidence has been destroyed, and thus valuable data lost to science. Even now the situation is not without its dangers, for the recently awakened interest in the ruins, and appreciation of their historical value, may lead to unconsidered zeal in excavation. After all, there is no especial hurry; what is perishable has long ago decayed, and so long as the ruins are sealed up by the rubbish that preserves them, no great harm can accrue, but in a few hours, by careless excavation, may be destroyed more archæological evidence than in centuries of neglect. Therefore it would be advisable for those in authority to consider carefully whether it is wise to lay bare new sites, unless proper examination and preservation can be ensured. The number of the ruins in Rhodesia is so great, and the area within which they occur so enormous, that it would be a very large undertaking for the Government systematically to investigate and permanently to conserve them all. Perhaps it would be possible to entrust some of this work to properly constituted local authorities, assisting them by grants and special facilities, but care would have to be taken to ensure the thorough carrying out of the work. Records of work done should be published, and the specimens preserved in authorised museums only. It is desirable also that every ruin should be scheduled under an Ancient Monuments Protection Act, and that an Inspector or Curator of Ancient Monuments should be appointed, who would be responsible for the excavation and preservation of all the monuments. To a less extent these remarks apply also to other parts of South Africa. All relics of the past, such, for example, as the pictographs in the rock-shelters of the Bushmen, should be jealously preserved and guarded from intentional or unwitting injury.

I trust my South African colleagues will forgive me if I have appeared too much in the character of a mentor. I have endeavoured to present a general view of the anthropological situation in South Africa, without burdening my remarks with details, and at the same time I have made bold to publish some of the conclusions which this survey has suggested; but there are other points on which I feel constrained to touch.

Recently Sir Richard Temple delivered an Address on "The Practical Value of Anthropology," in the course of which he said: "We often talk in Greater Britain of a 'good' magistrate or a 'sympathetic' judge, meaning thereby that these officials determine the matters before them with insight; that is, with a working anthropological knowledge of those with whom they have to deal. . . . It is, indeed, everything to him to acquire the habit of useful anthropological study before he commences, and to be able to avail himself practically and intelligently of the facts gleaned, and the inferences drawn therefrom, by those who have gone before him. . . . Take the universally delicate questions of revenue and taxation, and consider how very much the successful administration of either depends on a minute acquaintance with the means, habits, customs, manners, institutions, traditions, prejudices, and character of the population. In the making of laws too close a knowledge of the persons to be subjected to them cannot be possessed, and, however wise the laws so made may be, their object can be only too easily frustrated if the rules they authorise are not themselves framed with an equally great knowledge, and they in their turn can be made to be of no avail unless an intimate acquaintance with the population is brought to bear on their administration. For the administrator an extensive knowledge of those in his charge is an attainment, not only essential to his own success, but beneficial in the highest degree to the country he dwells in, provided it is used with discernment. And discernment is best acquired by the 'anthropological habit.' . . . . The habit of intelligently examining the peoples among whom his business is cast cannot be overrated by the merchant wishing continuously to widen it to profit; but the man who has been obliged to acquire this kind of knowledge without any previous training in observation is heavily handicapped in comparison with him who has acquired the habit of right observation, and, what is of much more importance, has been put in the way of rightly interpreting his observations in his youth."

In referring to civil-servants, missionaries, merchants, or soldiers, Sir Richard Temple went on to say: "Sympathy is one of the chief factors in successful dealings of any kind with human beings, and sympathy can only come with knowledge. And not only does sympathy come of knowledge, but it is knowledge that begets sympathy. In a long experience of alien races, and of those who have had to govern and deal with them, all whom I have known to dislike the aliens about them, or to be unsympathetic, have been those that have been ignorant of them; and I have never yet come across a man who really knew an alien race that had not, unless actuated by race-jealousy, a strong bond of sympathy with them. Familiarity breeds contempt, but it is knowledge that breeds respect, and it is all the same whether the race be black, white, yellow, or red, or whether it be cultured or ignorant, civilised or semi-civilised, or downright savage."

I have quoted at length from Sir Richard Temple, as the words of an administrator of his success and experience must carry far greater weight than anything I could say. I can, however, add my personal testimony to the truth of these remarks, as I have seen Britons administering native races on these lines in British New Guinea and in Sarawak, and I doubt not that I shall now have the opportunity of a similar experience in South Africa.

In this connection I ought to refer to what has been already done in South Africa by the Government. In the year 1880 the Government of Cape Colony, confronted by the problem of dealing with the natives, appointed a Commission to inquire into the native laws and customs which obtained in the territories annexed to the Colony, especially those relating to marriage and land-tenure, and to suggest legislation, as well as to report on the advisability of introducing some system of local self-government in the native territories annexed to the Colony. The example was shortly afterwards followed by the Government of Natal, which had native problems of its own. These two Commissions collected and published a considerable amount of evidence, valuable not only for the immediate purpose in view, but also for the purposes of science. Before the late war came to a close the Anthropological Institute of Great Britain and Ireland and the Folklore Society addressed to Mr. Chamberlain, then Colonial Secretary, a memorial praying that on the conclusion of peace a similar Commission should be issued to inquire into the customs and institutions of the native tribes in the Transvaal and the Orange River Colony, and, with a view to the accomplishment of more directly scientific ends, praying that at least one anthropologist of eminence unconnected with South Africa should be included in the Commission. The prayer of the memorialists was bluntly refused. When, however, in the course of re-organisation of the administration, a conference was held at Bloemfontein in 1902 of the Ministers of the various colonies, protectorates, and territories, to discuss native affairs, they found themselves, in the words of Sir Godfrey Lagden, "much confused because the laws and the conditions of all the colonies were different." This was exactly what the memorialists had told Mr. Chamberlain. So the conference determined on the appointment of a Commission of Inquiry, which was issued in due course by Lord Milner in September, 1903, and reported on January 30 last. The evidence taken by this Commission, as well as that taken by the previous Commissions, is of a very valuable character. But, like those Commissions, its object was exclusively administrative. Consequently the evidence is only incidentally of ethnological interest, and it by no means covers the whole ground. The social life and marriage laws are to a great extent laid before the reader, but there is no attempt to distinguish accurately between one tribe and another; the native institutions are discussed only so far as they have a practical bearing on administrative questions. There is no attempt to penetrate to the underlying ideas and beliefs, and the vast domain of religion lies for the most part outside the ken of the Commissioners. Admirable, therefore, as is the work done by these Commissions, it is but a small part of what must be undertaken if an accurate account of the natives of South Africa is to be obtained and preserved for scientific use, and as an historical record. What is wanted is that the Government should undertake this enterprise in the same way as the Governments of the United States, Germany, the Netherlands, and other countries investigate their native races, or, failing this obvious duty of a Government, that adequate assistance should be given to societies or individuals who may be prepared to take the matter in hand.

Unfortunately it is not unnecessary to insist on the need there is for us to consider seriously what at any particular time is most worth investigating, and not to let ourselves drift into any casual piece of work. Let us apply that simple test to South Africa, and ask ourselves, What most needs doing in anthropological research in South Africa?

So long as actual wanton destruction is not taking place, local archæological investigation can wait. I do not mean to suggest that those who have the opportunity should not devote themselves to this important subject; many can do good work in archæology who have neither opportunity nor inclination for other branches of anthropology, and the British South Africa Company has shown and probably will continue to show a real interest in this work. But our first and immediate duty is to save for science the data that are vanishing; this should be the watchword of the present day.

Observations in South African anthropography are lamentably deficient. Although scattered up and down in books of travel and in missionary records there are descriptions of individuals, and in some cases a few salient features of a tribe are noted, yet we have few precise descriptions of communities that are of value for comparative purposes. Anthropometrical data are everywhere wanting; very few natives have been measured, and the measurements that have been made are insufficient both as regards those actually taken and the number of individuals measured. The interesting subject of comparative physiology is unworked. We have no observations in experimental psychology, and very few trustworthy data in observational psychology. Here, then, is a large field of inquiry.

I am not competent to speak concerning linguistics, but from what I have read I gather that a very great deal yet remains to be done, at all events in phonetics, grammar, and comparative philology.

In general ethnology a considerable amount of scattered work has been done, but no one tribe has been investigated with scientific thoroughness; the best piece of work hitherto accomplished in this direction is the admirable memoir on the Baronga by the missionary H. A. Junod, which leaves little to be desired. It would be well worth while for students to make exhaustive studies of limited groups of people, tracing all the ramifications of their genealogies in the comprehensive method adopted by Dr. Rivers for the Torres Straits Islanders and for the Todas; this method is indispensable if it is desired to obtain a true conception of the social structure of a people, their social and religious duties, the kinship relationships, and other information of statistical and sociological value. Other fruitful lines of inquiry are the significance of the form and ornamentation of objects and the symbolism (if there is any) of the decorative art, a subject which, as far as I am aware, is absolutely untouched. Even the toys and games are worth investigation. Hardest but most important of all, there is that intricate complexus of action and belief which is comprised under the term "religion." This needs the most delicate and sympathetic treatment, although too often it has been ruthlessly examined by those who were more prone to seek the ape and the tiger and vain imaginings in the so-called "superstitious" practices of these poor folk. They are laggards along the road which our more favoured ancestors have trod, but they all have their faces set in the same direction as our own, towards that goal to which we ourselves are striving. To induce natives to unbosom themselves of all that they hold secret and sacred and to confess their ideals and inspirations requires more than an ordinary endowment of patience, tact, and brotherly kindness; without these qualities very little can be gathered, and the finer side of native thought and feeling will for ever remain a sealed book to the European. In referring to this subject it should not be overlooked that the best account we have of the religion of the Zulu-Xosa peoples is due to the labours of Bishop Callaway. The number of native texts, including folk-tales, published by him are especially valuable, as they throw light from all sides upon the native mind, and it is greatly to be regretted that he lacked the pecuniary and other encouragement that was necessary for the completion of his labours. The most urgent of all the foregoing lines of inquiry are the most elusive; these are the ideas, beliefs, and institutions of the people, which are far less stable than are their physical characteristics.

These are some of the lines of research that await the investigator. The field is large, but the opportunities are fleeting. The Kattea, Bushmen, and Hottentots are doomed, and new social conditions are modifying the Bantu peoples. Here again we must apply the test question, Which of these peoples most needs investigation? The answer again is obvious. Those that will disappear first. All over South Africa this work is pressing. For some tribes it is too late. It would be a memorable result of the meeting of the British Association in South Africa if it should lead to an exhaustive study of those most interesting people, the Kattea, the Bushmen, and the Hottentots. They represent very primitive varieties of mankind, but their numbers are rapidly diminishing, and, as races, they have no chance of perpetuity. What judgment will posterity pass upon us if, while we have the opportunity, we do not do our best to save the memory of these primitive folk from oblivion?

A Short Bibliography of Books on the Ethnology of South Africa.

Ankermann, B. . Kulturkreise und Kulturschichten in Afrika. *Zeitschrift für Ethnologie*, vol. xxxviii. Berlin, 1905.
Arbousset, T., and Daumas, F. Narrative of an Exploratory Tour to the North-east of the Colony of the Cape of Good Hope. (Translated by J. C. Brown.) Cape Town, 1846; London, 1852.
Barthel, K. . . . Völkerbewegungen auf der Südhälfte des Afrikanischen Kontinents. "Mitt. Vereins für Erdkunde zu Leipzig" (1893), 1894.
Bleek, W. H. I. . Reynard the Fox in South Africa; or, Hottentot Fables and Tales. London, 1864.
,, Report concerning Bushman Researches. Printed by order of the House of Assembly. Cape Town, 1873.
,, Second Report. A brief account of Bushman Folklore and other Texts. Cape Town, 1875.
Callaway, H. . . Nursery Tales, Traditions, and Histories of the Zulus. London, 1868.
,, The Religious System of the Amazulu. London, 1870.
Casalis, F. . . . The Basutos. London, 1861.
Fritsch, G. . . . Die Eingeborenen Süd-Afrikas (with Atlas). Breslau, 1872.
Hahn, T. . . . Tsuni-Goam, the Supreme Being of the Khoi-Khoi. London, 1881.
Johnston, H. . . British Central Africa. London, 1897.
,, The Uganda Protectorate. London, 1902.
Junod, H. A. . . Les Chants et les Contes des Ba-Ronga. Lausanne, 1897.
,, Les Ba Ronga. Neuchatel, 1898.
Keane, A. H. . . Man: Past and Present. Cambridge, 1899.
,, The Boer States. London, 1900.
Kidd, D. . . . . The Essential Kafir (with an interesting but incomplete Bibliography). London, 1904.
Kolben, P. . . . The Present State of the Cape of Good Hope. London, 1731.
Leslie, D. . . . Among the Zulus and Amatongas. Second edition. Edinburgh and London, 1875.
Livingstone, D. . Missionary Travels and Researches in South Africa. London, 1857.
Lloyd, L. C. . . A Short Account of Bushman Material. Third Report presented to both Houses of Parliament; Cape Town. London, 1899.
Maclean, J. . . . A Compendium of Kafir Laws and Customs. Cape Town, 1866.
Moffatt, R. . . . Missionary Labours and Scenes in Southern Africa. London, 1842.
Préville, A. de . . Le Continent Africain. "La Science Sociale," tomes v., vi. Paris, 1888.
Stow, G. W. . . The Native Races of South Africa. London, 1905.
Theal, G. M. . . Kaffir Folk-Lore. London, 1882.
,, The History of South Africa. (5 vols.) London, 1888-1900.
,, The Beginning of South African History. London, 1902.
Wood, J. G. . . The Natural History of Man. London, 1868.
Wangermann . . Ein Reise-Jahr in Süd-Afrika. Berlin, 1868.

Basutoland Records. In three vols., 1833-1852; 1853-1861; 1862-1868.
Folk-lore Journal. Vol. i. 1879; Vol. ii. 1880. Cape Town.
Report and Proceedings, with Appendices, of the Government Commission on Native Laws and Customs (1881-82). Cape Town, 1883.
The Natives of South Africa: their Economic and Social Condition. Edited by the South African Native Races Committee. London, 1901.
Report and Proceedings of the South African Intercolonial Commission on Native Affairs, 1903-05. Cape Town, 1905. (Report, 1 vol. Minutes of Evidence, 5 vols.)

The foregoing list of books is manifestly very incomplete. A considerable amount of information concerning the natives will be found in numerous books by missionaries, travellers, and sportsmen.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. E. G. BAWDEN has entrusted Mr. Edgar Speyer "with a sum in cash and securities of about 100,000*l.* to be applied to purposes of charity and benevolence, and for the advancement of knowledge, especially in aid of human suffering." After careful consideration, this sum has been apportioned for various good purposes in the form of capital to be vested in trustees, and to be known in each case as the "Bawden Fund." The largest allotment is in aid of advanced university education and research, and for this purpose a gift of 16,000*l.* is made to complete the sum of 200,000*l.* required to bring about the incorporation of University College in the University of London.

THOUGH the corporation of the Massachusetts Institute of Technology has taken action in connection with the proposed alliance of the Institute with Harvard University, the faculty and alumni have expressed their disapproval of the scheme. Before the proposed agreement can be consummated there will be necessary at least three decisions by the Supreme Judicial Court upon the grave legal questions involved, action by the Harvard authorities, and possibly further consideration by the corporation of the institute and an appeal for legislative sanction. A league has therefore been organised "to oppose the plan of alliance under consideration, or any other plan which may impair the self-government of the institute, and to secure for the past students a proper share in its administration."

PROF. W. HALLOCK, professor of physics in Columbia University, New York City, writes to say that the proposal of the Emperor of Germany for the temporary interchange of professors with America, referred to in NATURE of July 20 (p. 285), had nothing to do with the courses arranged at that university, as they were planned three years ago, when Prof. Hallock took charge of the department of physics. The lecturers are not exchanged; they are appointed as "non-resident lecturers" for the year, and receive an honorarium for their courses. The visiting lecturers at Columbia University for the year 1906-7 are Prof. Lummer, of Breslau, and Dr. J. Larmor, F.R.S.

A COPY of the prospectus of the Redruth School of Mines for 1905-6 has been received. Situated in the centre of the Cornish mining district, the school is devoted wholly to instruction in mining and allied subjects essential to the training of mining engineers, assayers, and mine-surveyors. Practical work in mining is carried on at the

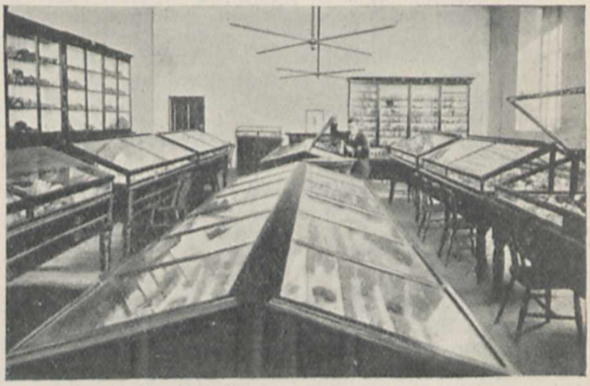

FIG. 1.—The Hunt Museum, Redruth School of Mines.

Basset mines and at other mines in the vicinity under the supervision of the school instructor. Success in examinations in particular subjects held at the school by the Board of Education, the City and Guilds of London Institute, and the County Council of Cornwall forms part of the requirements for a school certificate. One wing of the school building is occupied by a large mineral gallery erected in memory of the late Mr. Robert Hunt, F.R.S., keeper of the mining records. This museum, which contains a very valuable collection, offers great facilities for mineralogical study.

CORRESPONDENCE between the Bengal Government, the Government of India, and the Secretary of State for India upon the subject of the establishment of a school of mines in India, extending over the period from May 21, 1904, to August 3, 1905, has been published. On the advice of a strong committee, the proposal adopted is to provide a curriculum of mining instruction at the Sibpur Engineering College, Calcutta, with practical instruction in the mining districts. A professor of mining engineering is to be appointed in England at a salary of 750 rupees to 1000 rupees a month. The scheme also contemplates the temporary appointment for five years of a peripatetic mining instructor and a native assistant, who will be called upon to give free instruction in the mining districts. The whole scheme involves an initial expenditure of 8500 rupees on the equipment of Sibpur College, and an annual recurring expenditure of 16,000 rupees in connection with that college, and of 15,000 rupees for peripatetic instruction in the mining districts. For a scheme so promising in economic benefit to India, the outlay appears extremely moderate.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 8.—"The Elastic Properties of Steel at High Temperatures." By Prof. B. **Hopkinson** and F. **Rogers.** Communicated by Prof. Ewing, F.R.S.

In the experiments described in this paper, the elastic properties of steel and iron have been investigated at higher temperatures, ranging up to 800° C., and for stresses greatly below that required to rupture the material. The authors have found that as the temperature rises the stress-strain relations undergo a remarkable change, which may best be expressed by saying that what is variously called the "time-effect," or "elastische nachwirkung," or "creeping," increases greatly with the temperature. Steel, at high temperatures, behaves like indiarubber or glass; if it is stressed for a time, and the stress removed, it does not at once recover, but after the immediate elastic recovery there is a slow contraction perceptible for many minutes. Such "creeping" can be detected at the ordinary temperature, but at a red heat it attains a different order of magnitude, becoming (in its total amount) a substantial fraction of the whole deformation.

This phenomenon is analogous to residual charge in glass and other dielectrics; the stress corresponding to the electric force, and the strain to the electric displacement. Whether the law of linear superposition of the effects of stresses—closely followed in the electrical analogy—is true for hot steel or iron, is an interesting question which the apparatus used was hardly sufficiently delicate to answer.

The magnitude of this effect in steel may best be gauged by comparing it with other cases of the same kind, *e.g.* with the slow recovery of a glass fibre after twisting; if such a fibre be twisted through a considerable angle for several hours, it will recover all but one-fiftieth of the twist within two or three seconds of the removal of the stress. The remaining slow "creep," amounting to one-fiftieth of the whole deformation, corresponds to the slow return of the steel. In indiarubber, in certain circumstances, 10 per cent. of the strain disappears in time after the removal of the stress. But in steel, at 600° C., the proportion is about 15 per cent.

Another effect of "creeping," such as the authors have observed, is to make the determination of Young's modulus a matter of some uncertainty. Thus the extension of the bar at 600° C. produced by a given load varies 15 per cent. or more, according to the time of application of the load. When, however, the load is applied for a very short time, say of the order of one or two seconds, the strain produced seems to approach to a definite limiting value which is the instantaneous extension or contraction of the bar observed in the experiments when the load is applied or removed. It seems reasonable to define Young's modulus for a metal in this state, as the stress divided by this limiting instantaneous strain. It is then independent of the manner of loading, and is a definite physical constant; otherwise not.

"On the Refractive Index of Gaseous Fluorine." By C. **Cuthbertson** and E. B. R. **Prideaux.** Communicated by Sir William Ramsay, K.C.B., F.R.S.

The authors have determined the refractive index of gaseous fluorine for sodium light by means of Jamin's refractometer. Five experiments gave values for the refractivity $(\mu-1)$ 10^6 of 195, 177, 192, 194, and $198\frac{1}{2}$. The discrepancy exhibited by the second experiment can be accounted for, and it is believed that the mean of the other four experiments, 195, is within 2 or 3 per cent. of the true value.

In a recent paper (*Phil. Trans.*, A, vol. cciv. p. 323), one of the authors has attempted to show that the refractivities of the different members of the same chemical group are related in the ratios of small integers; and it was observed that, if this coincidence were not due to chance, the refractivity of fluorine should bear to that of chlorine the ratio of 1 to 4, which those of neon, oxygen, and nitrogen bear to argon, sulphur, and phosphorus respectively. This prediction has been verified. The refractivity of chlorine for sodium light is 768, or 192×4; and that now found for fluorine is 195, a discrepancy of $1\frac{1}{2}$ per cent., which is well within the limits of error of the experiment.

PARIS.

Academy of Sciences, August 28.—M. Troost in the chair.—The ultra-violet spectra of the reversing layer during the total eclipse of May 28, 1900: H. **Deslandres.** An account of the apparatus employed, and a short list of the principal lines of titanium, vanadium, and chromium observed.—On a differential equation of the fourth order: Gaston **Darboux.**—On transcendental numbers: Ed. **Maillet.**—Researches on irradiation: Adrien **Guébhard.**—On a method suitable for the study of a luminous phenomenon varying in intensity with the time. Application to the determination of the instantaneous velocity of a rotating mirror and to the study of the Hertzian spark: A. **Turpain.** The arrangement is a modification of the Foucault experiment for the determination of the velocity of light. The receiving eye-piece is replaced by a photographic plate, and the spark is placed between the rotating and fixed mirrors. The measurement of the distance on the negative between the two images, the one caused by the light travelling directly and the other by reflection from the fixed mirror, and of the distances apart of the portions of the apparatus, gives an accurate determination of the velocity of the mirror, the velocity of light being taken as known. The method has been also applied to the study of the spark given by a Hertzian excitor and resonator, but the description of this part of the work is reserved for a later communication.—A new group of protophytic parasites, Eccrinides: L. **Léger** and O. **Duboscq.**—A contribution to the cytological study of the Cyanophyceæ: A. **Guilliermond.**—*Sterigmatocystis nigra* and oxalic acid: P. G. **Charpentier.** This mould, when cultivated in Raulin's fluid, never secretes oxalic acid before spore formation takes place, but sporulation acts only indirectly in causing the secretion, this being caused by the exhaustion of the medium.

CONTENTS.

PAGE