develop their work in the direction of applied science. A large body—I cannot say how many—of outsiders who are well-wishers of these universities is of opinion that they should, and there is an idea abroad that they are suffering financially now from having neglected this side of education in the past. There was, for example, a leading article in the *Times* of May 25 in the course of which the writer suggests that they may have suffered through having a false reputation for being very wealthy bodies, and he adds :—" Or is it perchance, because the modern millionaire, being a man of his age and an Englishman to boot, has no great belief in the economic value of knowledge as such, and no great confidence in the capacity of our ancient universities to adapt themselves to the needs of the coming time? " Now, so far as the chemical manufacturers of this country are concerned, I can say with some personal experiences of my own that they certainly have shown no great belief hitherto in the economic value of scientific knowledge, as they now know to their own cost. But if, to make a purely hypothetical conjecture, some beneficent millionaire were to test the capacity of our old universities for undertaking this kind of work, and were to offer adequate means for the purpose, I feel pretty confident, from what I know of the spirit which dominates their governing bodies, that such an offer would be accepted both at Cambridge and here at Oxford with few dissentients. If such a departure were placed within their power, I think that that great public which glories in the past achievements of these universities would rejoice in their new development. And I will further add that the creation of chairs of applied science would react upon and strengthen the teaching of all those sciences which are in any way connected with industrial productiveness.

Of course, this is all hypothesis—the most nebulous of hypotheses. We all know, unfortunately, that the financial resources of the universities have been, and are, inadequate for the purpose of enabling them to meet the requirements of modern scientific education, either in the way of staff, accommodation, or equipment. It can be said, and justly said, that so long as these universities are without the means of developing their schools of pure physical science to an extent worthy of their reputation, it is useless to talk about developing the teaching of applied science. So it may be. But I remind you that we are still in the region of hypothesis, and the captious critic might retort by saying that they have not done even as much as they might, and could, have done for the proper development of scientific teaching with the means already at their disposal—that they are still overweighted by ancient tradition, and that their internal scientific forces are still feeble as compared with the preponderating forces of the advocates of the older culture. There is no time, even if I knew enough about the inner mechanism of university administration, to discuss this aspect of the question, but if you want to know an American view of the case—a strong view!—I would invite attention to an address by Prof. Victor Alderson, Dean of the Armour Institute of Technology, delivered before the Chicago Literary Club in October last year, an abstract of which was published in NATURE of February 12.

The question of the recognition of applied science by our old universities must, as I said, be faced—the time is at hand for them to consider seriously whether it is desirable that they should cater for the training of those who are destined to be the founders and upholders of our national prosperity. The longer this question is shelved the smaller will grow the chances of their being able to participate in the work. At present we in this country are not up to the German level so far as concerns the higher technical training of industrial leaders. Our universities, in other words, have not yet had to encounter the full force of competition with newer institutions of the rank of the technical high schools. We have but very few, if any, schools of this status here now, but if I read the signs of the times correctly, the differentiation between the old and the new education—which has already become well marked—is bound with the progress of science to become more and more strongly pronounced. Our newer universities—especially those in large manufacturing centres—will be driven more and more into the teaching of applied science, and our polytechnics and technical colleges will perforce have to raise their educational standard. The effect cannot but be to cause the older universities to become of smaller importance in the general scheme of national education as time goes on. That is why I have taken advantage of the opportunity which has been placed in my hands for raising this note of alarm, because even if nothing practical results from this meeting, it may at any rate be useful to let it be known that many of us desire to see the most ancient and the most renowned of our educational foundations doing more for the education of a nation the prosperity of which is so largely dependent on productive industry.

Whether as the outcome of the lectures delivered and the conferences held during this meeting the attitude of the universities towards applied science undergoes modification or not, the ventilation of opinions cannot but be of advantage in many ways. If, for example, it is made manifest that the current of national thought is moving slowly—alas! very slowly—towards the recognition of science as the main factor of industrial progress, it may help to emphasise the necessity for strengthening and developing the teaching of pure science. If the beneficent millionaires are not forthcoming for the purpose of endowing applied science, there is, at any rate, ample scope for their beneficence in the endowment of pure science in our old universities. A school of active science workers would—to use a quasi-scientific expression found in the pages of many writers of fiction—" galvanise into life " the science teaching of the schools. If you can only help to mould the public mind into the belief that science is a living reality veiling truths of inestimable value to humanity from every point of view, moral, social and material—truths that are to be wrested only by conscientious, laborious and persistent *research*—you will be assisting a great cause. If you will proclaim this doctrine from the house-tops and assist in sweeping away that dust heap of formal text-book knowledge which passes for science in our examination rooms you will be doing something towards raising the general level of opinion in this country. We need it badly! Think of all the creative intellectual power running to waste—the unrealised assets in the way of originality of thought which Great Britain might have at her disposal if the brain power of her teachers and students were only diverted into the right channels. The old universities, by virtue of their prestige, their traditions, and their past achievements, have still a powerful hold upon the public mind. They must open their doors still more widely to science if they wish to retain their hold. If their means are at present insufficient to enable them to meet the requirements of the age, they can still forward the national cause by upholding the dignity of science, by insisting upon originality of thought as an essential qualification for its successful teaching, and by helping to dispel the notion that it undergoes degradation by being applied to human welfare. It must be realised, and it cannot be realised too soon, that the peaceful campaign of industrial competition requires leaders well trained in scientific method, and not crammed with mere formal book learning—men as alert in mind and resourceful in meeting difficulties, as upright in principle, as keen in enthusiasm, as far-seeing in imagination, and with as intimate a knowledge of human nature as the statesmen, warriors, divines, lawyers, and schoolmasters which these old universities have given to their country. The victory of the future is with that nation which enables her children to approximate more closely towards Tennyson's ideal :—

". . . the crowning race
Of those that eye to eye shall look
On knowledge : under whose command
Is Earth and Earth's ; and in their hand
Is Nature like an open book."

IRRIGATION WORKS.

INDIA.

IN a recent number of the *Revue générale des Sciences* is an article on irrigation in India which is interesting as showing the impression made on the mind of a foreigner after an inspection of the great works that have been carried out under the British administration for mitigating the

effects of famines and improving the condition of agriculture. In a report published a few years ago by Mr. Deakin, the Minister of Water Supply in Victoria, under the title of "Irrigated India," Mr. Deakin stated that, in his opinion, after an inspection of the irrigation works in Italy, Egypt and America, he was satisfied that there was no canal system in the world that could hold comparison with that of India, and expressed his surprise that so little was known of it. The area of land irrigated in India by canals amounts to about 30 millions of acres, six times that of Egypt, and nearly double that of the whole of the rest of the world. M. Chailley Bert, the writer of the article under notice, after spending considerable time in inspecting the various irrigation works, seems to have come to very much the same conclusion. He expresses his opinion that, after the principles of the general administration of the country, and the conduct of the English in India, there is nothing of more interest and more worthy of observation than the system of irrigation, the methods pursued in carrying out the works, and the results that are obtained.

From all time there has existed a close relation in India between famine and irrigation. The ancient rulers of India have left everywhere traces of the great works which they had carried out for overcoming the want of rain and providing against the constant recurrence of famines; and since the English administration irrigation has been forced to the front by the terrible famines which periodically visit a portion of this vast territory, in every instance caused by deficient rainfall, which sometimes lasts for two or three consecutive years. The great famine of 1837 in Bengal led to the project of the Ganges Canal, which has now 5500 miles of main canals and branches; that of 1853 to the works at Madras; that of 1859 to the works in the north-west. The famine which desolated Orissa and the north of India in 1864, when a million of the inhabitants lost their lives by starvation notwithstanding the expenditure of 1½ millions of pounds in combating the famine, and also more than 3 millions in works of irrigation, resulted in the policy of systematically carrying out extraordinary public works by which it was contemplated to spend half a million a year in developing irrigation for the purpose of preventing the recurrence of these terrible disasters. During the terrible famine of 1876, for which a large relief fund was raised, 5¾ millions of lives were lost, although the Indian Government expended 11 millions in relief.

The rainfall of India is very various, amounting to 200 inches in a year in some districts, while in others the fall does not amount to more than from 2 to 10 inches; and over a vast area the land is dry and sterile, except where the rivers have been canalised, or the rain coming from the mountains has been caught and stored in reservoirs.

The peasants inhabiting these districts are described as being utterly improvident, and population goes on increasing at an enormous rate. The dry and unfertile years find them without any resources, and when famine comes untold misery ensues, and the population is decimated by starvation and death.

A vivid description is given by M. Chailley Bert of the irrigation works undertaken for the relief of the inhabitants in the great famine of 1901 in the Presidency of Bombay. Here five camps were established where provision was made for 10,000 people who were engaged in the construction of a reservoir. To this camp came a mass of people of all ages and conditions, old men, women, and children, besides the actual work people, driven from their homes by misery and starvation. To deal with this multitude a complete system of feeding and hospital requirements, sanitation and the care of children had to be provided, while all the able-bodied were organised into an army of workers. The writer says that no description can correctly give an idea of the complete system of organisation and order of this installation, and he seemed to be greatly impressed with the fact that the whole management was carried out by native functionaries under the direction of a single English engineer, with the occasional visits of the collector of the district and his assistants.

It is pointed out in the article that irrigation, besides providing a means of meeting the sterility due to the absence of rain, adds very greatly to the fertility of the land, in some cases doubling, and in others increasing the yield fourfold, and increasing the value of the land from 2*l.* or 3*l.* an acre to ten or twelve times that amount. Irrigation also permits the cultivation of the more valuable crops, such as rice, wheat, sugar cane, and indigo, and it also leads to other works which assist in the mitigation of famines, such as roads and railways for the conveyance of the produce of the irrigated lands.

The Indian Government has already expended upwards of 23 millions sterling on irrigation works, providing water for 13 millions of acres at an average cost of 35*s.* an acre.

SOUTH AFRICA.

At the meeting of the South African Science Association held in May last, amongst other subjects discussed, the most important in the interests of the country was that relating to irrigation, which Sir Charles Metcalfe described as the most prominent question of the day. In a paper read by Mr. Westhofen, the author stated that, owing to the insufficiency and uncertainty in the distribution of the rainfall, it was absolutely necessary that irrigation should be resorted to if the country is ever to be made a self-supporting one. Thousands of square miles of the most fertile land are lying waste owing to the want of this most essential adjunct to agriculture. The institution of a proper system of irrigation has hitherto been hindered by want of capital, want of experience, and ignorance of the best methods of storing water and applying it to the greatest advantage. Irrigation is no new thing in Africa. In Rhodesia there exist the remains of ancient works, and for miles and miles may be seen the traces of skilfully engineered irrigation canals. No information exists as to who carried out these works. In a rude way the natives of the Zambesi at the present day obtain from two to three crops off their land by employing a simple system of irrigation. As an example of what might be done, and as a public object lesson, a large reservoir containing 1000 million gallons of water was constructed by Mr. Rhodes at Matapos, the water in which is held up by an earthwork dam 100 feet high.

While thousands of acres of fertile land are lying waste in Africa for want of irrigation, food to the value of 2½ millions of pounds is imported through Cape Town.

Before an efficient system of irrigation can be organised, legislation is required to define the water rights. Sir W. Willcocks, in his report on the subject, suggested that all rivers and streams should be proclaimed as public domain and become the property of the nation.

The forestry of the country was also dealt with in a paper by Mr. D E. Hutchins, who showed that while at one time there is evidence that Africa was a well-wooded country, the forests of to-day consist generally of nothing but stunted evergreen trees confined to sheltered kloofs. There are now, however, Government forests worked systematically by the Forest Department, but so scarce is the supply that the imports of commercial timber amount to half a million pounds. It was stated that the special sleeper plantations established by the Cape Government Railways cost 60,000*l.*, and that in twenty-five years they were estimated to bring in a revenue of 100,000*l.* a year. There is no doubt that the encouragement of the growth of forests will have a material effect in conserving the rainfall of the country.

NEW MEXICO.

In the report issued by the New Mexico College of Agriculture for April, an account is given of the experiments carried out for pumping water for irrigation from wells. New Mexico has a genial climate and fertile soil, but the amount of rainfall is light, averaging not more than from 8 to 16 inches a year. Irrigation, therefore, becomes a necessity. It was with a view to demonstrate the practicability of providing such a supply of water from the underflow that the experimental work was undertaken. The strata consist of sand and gravel, with occasional layers of clay. The Rio Grande Valley is underlaid with gravel beds sufficiently thick to procure from them an ample supply of water at a depth of from 20 to 80 feet. There are two methods of obtaining water from the underground supply. One by sinking a well down to the water-level, and then forcing perforated pipes to some depth below this. The experimental station well was sunk 48 feet deep, with six-

inch pipes driven 21½ feet below this. The other method is by driving tubes varying from 3 to 6 inches diameter down from the surface some distance into the water-bearing surface. With tube wells as small as 3 inches in diameter, the perforated portion at the lower end is driven with the pipe, but with larger tubes the open pipe is first sunk, and the strainer or perforated part lowered inside; the tube is then jacked up until the perforated tube is exposed. The pipes are sunk by means of a sand bucket, which consists of a cylinder 3 to 5 feet long, the diameter being a little smaller than that of the tube, provided with a plunger and valve at the bottom. The cylinder is forced into the ground, and then the plunger is driven down to the bottom, and when drawn up sucks the sand and small stones into it. It is then raised to the surface and emptied. In some cases pressure has to be exerted by means of weights or levers to force the bucket down, and it is continually turned round by means of clamps. In favourable ground it will sink at the rate of 1 foot a minute. Owing to the quantity of fine sand in suspension in the water, centrifugal pumps for lifting the water were found to answer best. Where wells are used the suction pipe draws from the water at the bottom, but with tube wells the suction pipe is attached to the top of the tube.

FORESTRY IN THE UNITED STATES.

THE bulletins, professional and hydrographical papers, which form part of the serial publications of the United States Geological Survey, treat of a variety of subjects, among which forestry figures conspicuously. Five beautifully illustrated volumes, accompanied by carefully prepared and coloured maps, have recently been received. The statistics and information collected from various sources by well-trained experts and specialists are put forth in a very plain and comprehensive manner.

The first paper is by Mr. Henry Gannett, and treats of the forests of Oregon. It deals very concisely with the composition and character of the different forests and woodlands in the State. At the outset a land classification table is given, which shows total area, merchantable timber area, open country, burned, cut, and barren areas.

As the author remarks, "the most startling feature shown by the land classification map of this State, is the extent of the burned areas." A point worthy of note, to which the author directs attention, is that "the burns are greatest and most frequent in the most moist and heavily timbered parts of the State, and are smaller and fewer where the rainfall is less and where the timber is lighter," the reason being that the density and abundance of the undergrowth forms excellent fuel for the fire, and vastly increases its heat and destructiveness. Of the total timbered areas, not less than 18 per cent. has been thus destroyed. This represents a total of 54,000 million feet in the State, with an estimated value of 54 million dollars, which the author very truly remarks is too much to lose through carelessness. However, as the region of the fire area is well watered, reafforestation appears to be progressing favourably, especially where the burns have not been extensive; but, where many square miles have been involved, the lack of seed has retarded the process considerably. The dangerous fire season is autumn, when most things are dry. However, the magnitude of such devastations appears to have been worse prior to and during the days of early settlement—from 1843 to 1870. The rest of the paper consists of extremely valuable notes accompanied by tables which give a classification of the lands together with the amount and classification of timber for each county in the State. There is no extraneous matter brought in—each sentence is pithy and to the point. The text, accompanied as it is by illustrations and maps, gives as perfect an idea of the character and stand of the timber of Oregon as can well be conceived.

The next professional paper (No. 2) of the series is by the same author. It deals with a revision of the estimates of the standing timber and its distribution in the State of Washington. These forests consist mainly of red fir (*Pseudotsuga taxifolia*), mingled with spruce, hemlock, and cedar. They are the densest, heaviest, and most continuous in the States, with the exception of the red wood forests of California. The author's general description is followed by a summary of the standing timber in Washington, after which each county is taken up separately and in detail.

The revised estimate shows an increase over that given in a former report; this is due to the inclusion of species which have now come into use, and also such species as are of known value though at present not utilised.

The next report (No. 3) of the series is by Mr. Fred G. Plummer. It deals with the forest conditions in that part of the Cascade Range lying between the Mount Rainier and Washington Forest Reserve. The land classification map which accompanies this report covers 2,800,000 acres, but after deducting the naturally timberless areas, such as arid lands, lakes, and glaciers, also the area destroyed by fire (8 per cent.) and logging (1·64 per cent.), there remains an area of 2,292,820 acres which can be called timber lands. After dealing with general matters, the author gives a list of trees and shrubs of central Washington, which is followed by a very useful and instructive table showing the distribution of species by zones of altitude. Then comes a detailed record of the amount of vegetable growth supported by an acre of average soil of the Cascade Mountains. The defects and diseases of timber trees, also the market prices of lumber, receive due attention. The bulk of the report is taken up with detailed descriptions of the various watershed areas. At the end of the paper irrigation, grazing, and mineral springs are reported upon. The author's remarks on irrigation are interesting, as they show what can be done in the way of reclaiming and utilising arid tracts for agricultural purposes.

Report No. 4 of the series deals with the conditions of the Olympic Forest Reserve, Washington, and has been prepared from field notes taken by Messrs. Arthur Dodwell and Theodore F. Rixon. It deals first with topographical matters, agricultural lands, stand of timber, timber trees, forest fires, mining, roads, &c. The principal part of the report gives a detailed description of the various townships contained in the forest reserve. There is much useful information regarding the accessibility of the forests and the facilities of timber transport, which are matters of considerable importance.

The forest conditions in the northern part of Sierra Nevada, by John B. Leiberg, form the fifth paper of the series. This report deals with the topographical features of the region examined, along with the extent and composition of the forest and woodland. The distribution of the various coniferous trees and forest type presented by each receive adequate attention from a sylvicultural point of view. The topographical, agricultural, and sylvicultural aspects of the various river basins are then taken up and described in detail.

In addition to the above, three volumes on forestry, each consisting of several papers, have already been published in former annual reports of the United States Geological Survey.

We have only been able to sketch in the briefest outline the scope and significance of the above works, which represent several years of painstaking and accurate investigation. The undertaking shows that the great importance of the forest is now duly recognised in America, although not so many years have elapsed since forestry was a comparatively unknown science in that country.

In the days of early settlement axe and fire were indiscriminately employed to the great destruction of the forest, and in later days, when timber was required for structural purposes, lumbering operations were so diligently and recklessly pursued in the most accessible forests that in a short time they were depleted of all but the most worthless material. He who wants a vivid description of this state of affairs need only refer to Prof. Heinrich Mayr's work, "Die Waldungen von Nord America," which contains a great amount of information and good advice as regards the conservation of the North American forests. We are glad to see such advice has now been accepted. The good work already done by the Geological Survey will form a basis upon which future schemes of management for the conservation of the forests of North America may be built.