district of Egypt, and the primitive tools and methods employed at the mines were described.

Egypt was also noted for having produced the first mining map in the world, a map showing a gold mining region of the time of Seti I. or Rameses II. (1350 to 1330 B.C.).

The influence of silver and lead on the development of primitive culture was shown to be insignificant, the latter metal only becoming of importance during the supremacy of the Romans, in connection with their elaborate systems for the supply and distribution of water and in the construction of baths.

As regards iron, the belief that the first iron generally known to man was either of meteoric origin or telluric native iron was not supported by any substantial evidence. Nor was such origin necessary, as iron ores are so easily reducible that they can be converted into metallic iron in an ordinary charcoal fire. They are, in fact, reduced to metal at a considerably lower temperature than the ores of copper.

The earliest iron smelting in Europe was traced to the upper waters of the Danubian tributaries, the ancient Noricum, but in still earlier times iron was extracted from its ores in the region on the south-east of the Euxine, in Ferghana and other localities in Asia. In Africa, so far as metallurgical evidence may be depended on, the extraction of iron from its ores was carried on at a remote date. That this early African iron smelting was known in Egypt is well shown by a bas-relief on a stone now in the Egyptian collection in Florence.

THE BORDERLAND BETWEEN ELECTRICITY AND OTHER SCIENCES.[1]

THERE are applications of electricity that give work to many men, applications which employ much plant and apparatus, and on which large sums of money are spent, about which we have heard very little or nothing in the institution. Again, we hear little, if anything, about what is occurring on what I may term the borderland between electricity and the other sciences. In this borderland or fringe a large number of scientific workers are quietly at work, and what is to-day a laboratory experiment may to-morrow form the basis of a large industry. Finally, we should have an opportunity of discussing the many details in the design and operation of electrical plant and apparatus, the importance of which cannot be overestimated.

Wireless Telegraphy and Telephony.—Corresponding to each spark at the transmitter of a wireless telegraphy plant, a train of oscillations is received, and these trains of oscillations are rectified by the detector, and in general are passed through a telephone as an indicator. At each spark a click is heard in the telephone, so that with 600 sparks a second the diaphragm is attracted 600 times, producing a somewhat musical note.

Herein lies one of the great advantages of high-spark frequency.

There seems no doubt that the combination of the human ear and a telephone is much more sensitive for high-frequency notes than for low. In some tests I have made, using an alternating current to determine the minimum power required to produce an audible signal in a telephone receiver at different frequencies, I found in one case that the power was reduced from 430 micro-microwatts at 300 frequency to 7·7 micro-microwatts at 900 frequency. At higher frequencies it increased again.

[1] From the presidential address delivered to the Institution of Electrical Engineers on November 14 by Mr. W. Duddell, F.R.S.

Due to atmospheric causes, there is generally audible in the telephone receiver clicks and noises commonly spoken of as atmospherics or strays. With high-spark frequencies the human ear easily distinguishes the musical note from these atmospherics; this enables the operators to read through a large amount of extraneous interference. The elimination or compensation of these atmospherics is one of the most important outstanding problems in wireless telegraphy.

When operating with continuous waves practically no note is heard in the receiver telephone unless the currents are chopped up into rapidly recurring groups of waves either at the transmitter (tone sender) or at the receiving end (ticker).

In order to make a permanent record of the signals, and to allow of high-speed working, the rectified current from the detector may be passed through a galvanometer or a relay, and here we come to one of the difficult problems which requires solution, namely the construction of a relay or recording instrument which will make a record of the very small received currents at high speeds. The Einthoven or string galvanometer, which is at present used for this purpose, is delicate and gives a photographic record.

Although the difficulties may be minimised, I do not feel at this moment that the photographic method of recording, with the attendant chemicals, and the necessity of handling moist slip, can be looked upon as the final solution from the point of view of commercial telegraphy.

The problem of constructing a relay for this purpose is a very difficult one. The mean current strength of the signals, after rectification by a high-resistance detector, is of the order of $\frac{1}{10}$ to $\frac{1}{100}$ of a microampere, and the amount of power available to work the instrument is only of the order of a few micro-microwatts. For high-speed reception the number of contacts to be made and broken per second may be anything up to fifty. The problem before our instrument-makers is to construct a relay or recorder which will operate with a power not exceeding a few micro-microwatts at the rate of fifty signals per second.

Of the sister science, namely wireless telephony, there is not so much to relate. A certain amount of progress has been made, but the details of the methods used have not been made public. The principle is simple. Given continuous oscillations or a spark frequency above the limits of audibility, you may vary the antenna current, and hence the radiation by means of a microphone, in the same way as a continuous current is varied by the microphone in ordinary telephony. As the radiation varies according to the modulation of the current by the voice the received current will be varied in the same manner and the voice will be reproduced. The difficulties are mainly in the transmitter. First, we require a perfectly steady source of continuous oscillations, and secondly a microphone capable of modulating the large powers required to transmit any distance. Over short distances of a few miles there are no difficulties. It is only when we come to distances of fifty to 100 miles that the engineering problems become troublesome. In view of the progress that is being made in the high-frequency alternator, and of how much more easy it is to modify the power given out by an alternator, it will not be surprising if, as soon as high-frequency alternators are in use, wireless telephony over comparatively long distance becomes a working possibility.

Electrochemistry and Electrometallurgy. — The amount of power installed for chemical and metallurgical purposes is very large indeed. Exact data are wanting, but it seems probable that the power employed in these processes in Norway and at Niagara may already reach 1,000,000 kw. One of the necessities of our industry, namely copper, is largely purified by electrical means. Aluminium, calcium carbide, carborundum, sodium, and potassium are wholly prepared electrically. The only hydroelectric stations of any size that have been built in this country are used for electrochemical purposes. The production of aluminium alone at Loch Leven absorbs some 30,000 kw.

The production of disinfectants electrolytically is being worked on a small scale. In Poplar the formation of a solution of chlorine in water by means of electrolysis is in practical use. Although one cannot anticipate very large powers being required for this purpose, yet if the demand for electrolytic disinfectants all over the country was the same as in Poplar, it would require about 2,000,000 units per annum, all of which could be supplied at such times as would help to level up the load curve.

Electromedical apparatus.—The design of induction coils for the production of X-rays has advanced a long way of late years, and some of the latest pieces of apparatus for the production of the discharge through the X-ray tube involve considerable ingenuity and engineering design. The discharge must be undirectional and at a high pressure, say, 50,000 volts or more. One method to obtain this is to step up by means of an E.H.T. transformer and to rectify the secondary current. Another method of working to obtain practically instantaneous photographs consists in switching the primary of the transformer straight on to the direct-current mains, when the current rush instantly blows the fuses. This interruption of the current produces one powerful discharge on the secondary, which, passing through the X-ray tube, suffices for the photograph. I do not know how the supply companies view this method of operation, because the rush of current must be pretty considerable, as the apparatus is not constructed on a particularly small scale. The transformer weighs about half a ton.

Electricity and Chemistry.—We are all of us acquainted with the brush discharge, yet how much do we know of its mechanism? In our high-tension machinery we are mainly occupied with trying to get rid of it and its injurious effects. Yet it has its uses. Nearly all the information in our proceedings deals with the negative question, namely how to avoid it.

Now the brush discharge has a peculiar property of producing that modification of oxygen known as ozone, which is without doubt a strong sterilising agent, and which may in the future have considerable applications. A modification of the conditions of the production of the discharge will cause the formation of oxides of nitrogen instead of oxides of oxygen. Oxides of nitrogen are of great commercial importance, and their production by electrical means will probably be one of the most important industrial applications of electricity.

Already in Norway between 100,000 and 120,000 kw. are employed working day and night for this purpose, and it is stated that this power will shortly be increased to nearly 250,000 kw. The main object of fixing the atmospheric nitrogen is to form a substance to replace Chile saltpetre. The demand for this is yearly growing at an increasing rate.

Last year about 125,000 tons of nitrate were imported into this country. To produce the equivalent amount of fixed nitrogen per annum would, on the basis of Norwegian plants, require about 150,000 kw.

At the moment I believe that the cost of electrical power is the chief stumbling-block to the introduction of the manufacture on a large scale in this country.

Electricity and Sound.—I do not know of many researches on the efficiency of the telephone receiver, yet the question is really a practical one and of considerable importance. the telephone receiver may be looked upon as an alternating-current motor. It receives electrical energy, which it converts into the mechanical form in the motion of its diaphragm, which energy is transmitted to the air as sound waves. There is no special difficulty in measuring the electrical energy supplied to the telephone receiver to a moderate degree of accuracy. The amount of this energy that is transmitted to the diaphragm is much more difficult to estimate. The real difficulty is the determination of the amount of energy of the sound waves. If we possessed any apparatus by means of which we could measure energy of sound waves we could not only determine the efficiency of the telephone receiver, but the apparatus would have many other useful applications. It is curious to think that up to the present we have no unit or standard of sound. We cannot specify its strength or intensity. Even the comparison of two sounds by the ear is very inaccurate; nowhere near as accurate as the comparison of two lights by means of the eye. This want of standards and methods of measurement is, I believe, one of the causes that has retarded progress in the science of sound. Can electricity, the handmaid of all the other sciences, help in this direction?

Electricity and Radiation.—Much work is quietly going on, of which we in the institution hear nothing, to try to unravel completely the mechanism of the transfer of electricity through gases. There is much to be hoped for along these lines. The elaborate glass apparatus, the vacuum tubes, the mercury, the liquid air, &c., which are being used in the research make the experiments look most unpromising from the practical engineer's point of view. Yet some progress is being made in electric lighting by means of the passage of electricity through gases. Many members will remember the vacuum tube, 176 ft. long, which was used to light the courtyard of the Savoy Hotel. That tube, I believe, contained nitrogen, and according to the tests of Prof. Fleming, gave an efficiency of 0·56 candle per watt. About a year ago I saw a tube, not such a long tube, filled with the rare gas neon, obtained from the residues in the manufacture of liquid air. This tube gave a most beautiful rose-coloured light. If this rare gas were obtainable in sufficient quantities we might have a rival to the flame arc. I may mention in passing that tubes containing neon are now commercially obtainable, and are claimed, in the larger sizes, to have an efficiency as high as two candle-power per watt. Further researches on the borderland between electricity and radiation will no doubt provide us with still more efficient sources of light.

We are at present very far from any practical means of converting the energy of radiation directly into electrical energy, although on a small scale this conversion really takes place in many photoelectric arrangements. For instance, the action of the light on the liquid potassium sodium alloy has been shown by Prof. Fleming to produce a voltage as high as 0·6 volt when the liquid alloy and a platinum plate are enclosed in a highly exhausted tube, and the liquid alloy is illuminated strongly. There seems little doubt that the current that is generated in this case is produced from the energy of the light that is absorbed.

The effects so far obtained are extremely small. At the most only a few microamperes are obtainable with very strong illumination. Nevertheless, this property of sensitiveness to light, though at the moment it has no practical applications, may at any time be found to fill some useful purpose and make another case illustrating how observations that are one day on the borderland of science may shortly afterwards be of practical use in engineering.

When it is remembered that the water-power in Norway alone is estimated to produce several million kilowatts, it is evidently better, for the present at any rate, for engineers to utilise the solar radiation by harnessing the waterfalls rather than by attempting to build radiation traps in the Sahara.

UNIVERSITY STUDENTS IN STATE-AIDED INSTITUTIONS OF ENGLAND AND WALES.

AN article on the budgets of certain universities and university colleges, based on the reports for the year 1910–11 from universities and university colleges in Great Britain in receipt of grants from the Board of Education, was published in the issue of NATURE for August 15 last. These reports also contain a great deal of information concerning the number of students in the various colleges, their ages, the subjects they are studying, and so on; and we have abstracted the subjoined facts from them and the introductory statement signed by the President of the Board of Education.

Before summarising the statistics under these headings, it is well to point out that the numbers which follow concern the following English universities:—Birmingham, Bristol, Durham (Armstrong College), Leeds, Liverpool, Manchester, Sheffield, London (including University College, King's College, Bedford College, School of Economics, and East London College), and also the University Colleges at Nottingham, Reading, and Southampton. The University of Wales includes the University Colleges of Aberystwyth, Bangor, and Cardiff.

Certain other constituent colleges of universities are in receipt of aid under "The Statement of Grants available from the Board of Education in Aid of Technological and Professional Work in Universities in England and Wales." These institutions are twelve in number, nine being medical schools attached to hospitals in London. They are all schools of the University of London. One, the Newcastle College of Medicine, is a constituent college of the University of Durham, while the two remaining, namely, Manchester Municipal School of Technology and the Bristol Merchant Venturers' College, make provision for the faculties of technology and engineering respectively in the universities to which they are attached.

NUMBER OF FULL-TIME STUDENTS, 1910–11.

	England	Wales
Degree students:—		
Training college	1459	451
Others	3512	702
Total	4971	1153
Non-graduate (diploma) students:—		
Training college	729	—
Others	1100	105
Total	1829	105
Post-graduate students	477	75
Others	628	58
Total	7905	1391

NUMBER OF PART-TIME STUDENTS, 1910–11.

	England	Wales
Day.		
Degree	254	11
Non-graduate (diploma)	112	4
Post-graduate	809	15
Others	2987	286
Evening.		
Degree	494	—
Non-graduate (diploma)	810	—
Post-graduate	173	—
Others	7298	—
Total	12937	316

In addition, there were in England 277 evening students studying for matriculation and nine such students in Wales.

The number of full-time students in England during the year 1910–11 was 7905, as compared with 8174 in the previous year. This apparent drop of 269 is, however, more than accounted for by the stricter classification adopted. A number of students taking post-graduate and special courses have this year been clsssified as part-time students. The number of full-time degree and diploma students, on the other hand, increased by 150, and the real increase was larger since the figures for the earlier year included 78 engineering students at the Bristol Merchant Venturers' College who were included in the returns for Bristol University, but have this year been shown separately. The establishment of a somewhat higher criterion and the consequent exclusion of a certain number of students who simply attend a certain number of lectures render it somewhat difficult to make any detailed comparison of the figures for part-time students with those for the previous year, but it seems safe to say that the apparent reduction in the total number of part-time students is more than accounted for by the reduction in the number of "Other" students, many of whom could scarcely be regarded as serious students, and have consequently been excluded altogether. On the other hand, the number of part-time students taking degree, diploma, or post-graduate courses showed marked increase. It follows that the reduction in the total number of all kinds of students is not to be taken as implying any diminution in the number of genuine students; on the contrary, there is good reason to think that the number of such students is on the increase. In support of this view it may be pointed out that the total number of post-graduate students has increased since the previous year by more than 200.

In Wales there has been a small increase in the total number of full-time students; on the other hand, there has been a drop in the number of part-time day students.

AGE AT ADMISSION OF FULL-TIME STUDENTS.

	England	Wales
Number admitted during 1910–11	3587	465
Percentage under 17	3·8	3·9
Percentage 17–18	12·0	14·4
Percentage 18–19	23·9	31·2
Percentage above 19	60·3	50·5

The number given above under England include 277 students at the nine medical schools of the University of London and 29 students at the Newcastle College of Medicine, which is a constituent college of the University of Durham.

NUMBER OF FULL-TIME STUDENTS IN THE VARIOUS FACULTIES, 1910–11.

	England	Wales
Arts	3410	936
Pure science	1723	254
Medicine	2586	62
Engineering	1015	43
Technology	735	22
Agriculture	162	63
Other departments	203	11

To make the above summary more explicit, it should be pointed out that under "Arts," fine art, music, law, commerce, teachers' diploma, and economics are included; "Engineering" covers naval architecture; "Technology" comprises also mining, metallurgy, and architecture; and "Agriculture' embraces horticulture and dairy-work.