It is hoped that both of these parties may be arranged by about the middle of November, while the organising secretary for the Australian meeting (Dr. A. C. D. Rivett) is in England. Inquiries should be addressed to the Secretary, British Association, Burlington House, Piccadilly, W.

TWENTY-FIVE YEARS' WORK AT THE PHYSIKALISCH-TECHNISCHE REICHSANSTALT, CHARLOTTENBURG.

THE Physikalisch-Technische Reichsanstalt, which may be aptly termed the German "National Physical Laboratory," plays such an important part in physical science that it may not be without interest to readers of NATURE to indicate briefly a few of the more prominent questions which have been dealt with at the institution since its foundation in 1885, which, by the way, was due in great measure to Werner von Siemens. Considerable information is afforded in two articles[1] recently published by members of the staff, and these papers should make interesting reading to those desiring further particulars of the work.

In addition to carrying out research work of direct interest to science and industry, the Reichsanstalt carries out the verification against standards of all kinds of instruments in the same manner as does the National Physical Laboratory in this country. It is, however, the research work to which we will confine ourselves here. The remarkable growth in the activities of the institution has kept pace with the advancement in scientific research during the last quarter of a century.

Dealing first with heat, the Reichsanstalt has occupied itself with practically every question in this branch of physics. One of its first tasks after getting into working order was the continuation of Regnault's famous work: he had shown that the scale of the mercurial thermometer could not be used as a standard owing to the influence exerted on the readings of the instrument by the expansion of the glass tube, the indications differing considerably in the range above 100° C. with thermometers made of different sorts of glass. Great difficulty had been experienced in finding a glass suitable for high temperatures when the Reichsanstalt commenced operations. Schott and Genossen, of Jena, experimented with different types of glasses and produced thermometer tubes constructed of new types of glass, and the Reichsanstalt tested these tubes as regards their accuracy over the fundamental interval 0–100° C., and their suitability for higher temperatures. The result is that the well-known Jena 59 quality has up to the present proved the most suitable in respect of small thermal expansion and of robustness. Extensive comparisons were afterwards carried out between the mercury thermometer and the air thermometer, owing to the difficulty experienced in realising the hydrogen thermometer scale at temperatures above 100° C. These measurements were carried to 500° C. At the present day nitrogen-filled thermometers are recognised as the most practical for high temperatures, and their success is to no small degree due to the labours of the Reichsanstalt. The institution has also played a not inappreciable rôle in the development of pyrometry, from the introduction of the thermo-couple by Le Chatelier to the more recent progress which resulted in the introduction of radiation pyrometry, based on the early observations of Becquerel, and on the later investigations of Kirchhoff and Wien on the subject of "black body" radiation. Following on Regnault's experiments, the Reichsanstalt has carried out research on the thermal properties of substances: this included experiments on the expansion of water between 0° and 100° by the communicating tube principle, and the determination of the saturation pressure between −60° and +370° C. The determination of the specific heat of gases—a question of high importance in internal combustion engine work—has been carried out with nitrogen, carbonic acid gas, and water vapour up to 1400° C., thus completing the work of Le Chatelier and Mallard in this connection, and the determination of the specific heat of gases at low temperatures has been made by Callendar's continuous flow method, improved by the counter-flow principle.

The electrical side of the work is no less interesting, and the activities of the institution have kept pace with the unceasing progress of this all-embracing science. It is, of course, of prime importance that the electrical units of measurement should be defined and realised as accurately as possible, and in this connection the Reichsanstalt has taken part in international conferences dealing with the subject, as well as cooperating with the State laboratories of other countries in carrying out measurements. Mercury copies of standard resistances had been found to be inconvenient in practice, and resistance boxes of German silver had proved inconstant and shown the resistance to be an intimate function of the temperature. It was Weston, in America, who first paved the way to improvement in this respect by inventing an alloy which showed but slight change of resistance with temperature; but it was left to the Germans to improve on Weston's discovery, the result being the introduction of the alloy (copper eight parts, nickel four, and manganese twelve) known universally as "manganin." Twenty years' experience at the Reichsanstalt with manganin resistances has shown the material to be unsurpassed by any other.

At the time the Reichsanstalt was founded standard cells were scarcely in use: it was only in the 'nineties that the Reichsanstalt, as the result of investigations, produced a practical standard cell, and one capable, moreover, of undergoing transit. This cell has, however, been superseded by the well-known Weston normal cell, which was accepted as the standard of e.m.f. by the London

[1] "Die Physikalisch-Technische Reichsanstalt; Fünfundzwanzig Jahre ihrer Tätigkeit." By Profs. Scheel, Holborn, Jaeger, and Brodhun. *Die Naturwissenschaften*, 1913, Nos. 8, 10, 12, 14.
"Die Physikalisch-Technische Reichsanstalt in Charlottenburg." By Prof. Karl Scheel. *Akademische Rundschau*, January, 1913.

conference on electrical units and standards (1908).

For direct-current measurements in electricity the three fundamental units—the ohm, the ampere, and the volt—are sufficient; but the Reichsanstalt experiments have contributed to a great extent to the improvement and simplification of methods of measurement. It was this institution that helped largely in the development of the potentiometer, which, in conjunction with the standard cell, forms the real basis of very many electrical measurements.

Mention should also be made of the "artificial loading" method introduced by the Reichsanstalt (separate circuit for current and pressure), which enables tests to be carried out, with but a small expenditure of electrical energy, on apparatus intended for the measurement of outputs up to many thousand kilowatts. It was also the Reichsanstalt which introduced the optical method of measuring current densities by means of the optical pyrometer.

Considerable interest attaches to the testing of sheet-iron employed in dynamo and transformer construction, and endeavours have repeatedly been made to keep down the energy losses in the material while augmenting the permeability (magnetisability) of the iron as much as possible. The Reichsanstalt was the first to suggest the use of iron alloyed with silicon for this purpose; and the researches of Barrett, Brown, and Hadfield appear to show the great advantage of this alloyed iron, which results in the reduction of eddy currents.

The optical work of the Reichsanstalt is not discussed quite so fully as that of the other branches. After a mention of pre-existing units of light, a space is devoted to the amyl acetate lamp of Hefner (briefly, the Hefner lamp) as a photometric standard. Whilst recognising its many advantages the Reichsanstalt has not lost sight of its deficiencies, and for this reason has always endeavoured to establish a measure of light to satisfy the broadest requirements of scientific and technical practice. Successful experiments have been conducted to secure a constant radiation of light from incandescent platinum with the aid of the bolometer, and tests now in hand justify the hope of arriving shortly at a mode of realisation of the "black body" which will fulfil all requirements in regard to accuracy and trustworthiness. Through the labours of the Reichsanstalt Germany was the first country to possess a generally recognised, accurately investigated unit of light.

The Charlottenburg establishment has also kept in close touch with practical requirements connected with saccharimetrical work. For ascertaining the value of sugar use is made of its rotation relative to the plane of polarisation, the Germans (and many other countries) using the Ventzke scale of divisions for the saccharimeters. The hundred point of this scale is defined by the rotation of a standard sugar solution (26 grammes in 100 c.c. of water at 20° C.) in a 20 cm. tube. For checking the readings of this apparatus, a quartz plate ground perpendicular to the axis is employed. Extensive experiments had to be made on the rotation of the pure sugar at the concentration of the standard solution, in order to arrive at a basis for test purposes. Great accuracy is necessary, as it is estimated that an error of 0·1 per cent. would make a difference in the sale value of the annual production of sugar in Germany of about 25,000*l*. The Reichsanstalt has, in addition, introduced the Abbe refractometer for determining the percentage of solids or of dry substance in connection with the impure sugar solutions to be investigated in the course of manufacture. Particulars are given of the method employed. Experiments have also been undertaken on the refractivity of other substances with the Abbe-Fizeau dilatometer, such as the refraction of different gases (air, H, N, and He) at room temperature and at very low temperatures; in addition, accurate measurements have been made on the refractive power of quartz and fluorspar—substances of such great importance in radiation measurements.

A series of optical experiments on metals have been made, yielding important results. The reflecting power was first determined by measuring the quantity of light reflected nearly perpendicular (to within $\frac{1}{4}°$) to the surface, for light of different wave-lengths, not only for the visible part of the spectrum, but also for ultra-violet (to wave-lengths of 0·25μ) and for ultra-red rays (to wave-lengths of 1·5μ). In the visible range the work was carried out with the spectrophotometer, and in the invisible range with a Rubens thermopile. In addition to pure metals the technically important mirror-alloys were investigated, and, for the visible range, glass mirrors coated with silver and mercury amalgam. It is interesting to note that silver, which in the visible spectrum reflects better (viz. 90–95 per cent.) than all other metals, reflects much less than all other metals in an ultra-violet region (between 0·25 and 0·3μ), namely, only about 4 per cent.—or less even than a quartz surface.

An apparatus has been constructed by the Reichsanstalt for producing sharp interference bands, and having a high capacity. Its main constituent is a plane-parallel glass strip into which the light to be tested is transmitted in such manner as to fall on the bounding planes near to the angle of total reflection, thus emerging striated. With this apparatus a number of spectrum lines, particularly the mercury lines, have been tested as regards their structure and the presence of accompanying lines ("satellites").

In conclusion mention should be made of a series of experiments relative to the luminous phenomena in highly evacuated Geissler tubes. A new kind of ray, similar to the kathode rays, was discovered which was emitted from the anode under certain conditions. These anode rays, which are emitted in particular from hot salt anodes, show magnetic and electric deflection like the kathode rays and the Doppler effect (displacement of the lines in the spectrum). They were conceived as being positively charged metallic atoms of the

salts contained in the anode, and are cast off from the anode at great velocity (100 to 1000 kilometres per second). Difficult measurements carried out have had reference to the velocity and to the ratio of the electric charge to the mass of a luminescent particle for different metals. Views, corroborated chiefly by spectroscopic tests, make it probable that the anode rays are identical with the sun's protuberances—that the latter are nothing but anode rays of gigantic dimensions.

The annual report of the Reichsanstalt for the past year, just to hand, gives evidence of continued progress in the various branches of scientific investigation, but space will not permit of touching on the subjects dealt with: readers are referred to the *Zeitschrift für Instrumentenkunde*, March, April, and May, 1913, in this connection.

E. S. HODGSON.

DERIVATION OF POWER FROM TIDAL WATERS.

THOUSANDS of years have been required to evolve the processes by which the energy stored by natural agencies has been made to fulfil our requirements; thousands of years may still be required to evolve processes by which the internal heat of the earth, the phenomena attendant on barometric pressure, and the potential energy of the tidal wave may be similarly utilised.

But with regard to the latter much has in reality been already achieved. Vast fleets of barges and shipping are daily carried to and fro by means of the tidal stream in estuaries and the mouths of rivers. Ships of all sizes are lifted and kept afloat in inland tidal basins. London, Cardiff, Bristol, and numerous seaport towns illustrate the fact that ends impracticable by other means may be attained by the utilisation of the tidal wave; and there is little doubt that as time goes on, the advantages to be derived from the utilisation of the tides in dock work will be manifested by even greater and more important works than have yet been undertaken.

Why, then, should it generally be considered impracticable to utilise some small portion of the potential energy of the tidal wave in the production of energy for other useful purposes? The answer to this question is difficult to find, but it appears that about forty years ago an attempt was made to investigate the matter. An analysis of the initial cost and probable revenue from a tidal installation was made the subject of articles in *The Engineer*. The result of the analysis showed that electricity could be produced at a cheaper rate with gas engines than by a tidal installation. The cumulative result of this weighty opinion was evidently far-reaching, and for many years only half-hearted attempts have been made to prove that the tidal installation is no longer to be considered outside the range of practical engineering problems.

The conditions which obtained forty years ago are no longer in existence. The improvements in plant for carrying out large works are so great that they are difficult to realise. The hydro-electric installations in those days were so few in number and so unimportant in effect, that the vast works which have been executed in the past few years would likewise have been considered impracticable from a commercial point of view, or, at the best, in the light of doubtful experiments. Even so late as 1904, in a paper read before the Institution of Civil Engineers (vol. clvii., session 1903–04, part iii.), Mr. Steiger gives it as his opinion that water power has been chiefly used for driving flour mills, and as the authority of the author is above dispute, it may be safely concluded that an analysis made forty years ago should no longer be allowed to stand without revision.

Perhaps the most important modification of the conditions which obtained until quite recently is the use of ferro-concrete as an auxiliary to the formation of embankments. The strength and durability of structures, such as bridges and landing stages, with struts and braces of ferro-concrete has proved the possibilities of that material in braced structural work, while the small section and great length of ferro-concrete piles has shown the possibility of handling suitably designed beams and girders of this material without risk of injury to them.

Now by constructing braced trestles which can be handled by a crane, and placed so accurately in position that slabs of ferro-concrete, designed for the purpose, may be set between them and fixed, an extremely economical shell may be formed to serve as the matrix of an earthwork embankment.

The present writer has had the privilege of making an exhaustive investigation into modern methods of forming sea walls, wharfs, breakwaters, and other sea works of that kind, and he is in a position to state that where there is no danger from the action of heavy seas, great economy can be effected by forming the face of a sea wall with a skin of concrete slabs, held in position by trestles of the same material.

But even with the saving which can be effected by this method of construction, the tidal installation is only practicable from a commercial viewpoint when the initial cost can be reduced to between 40*l*. and 50*l*. per horse-power; or, stating the matter in another way, unless the sum of the maintenance charges, plus about 10 per cent. on the capital outlay, divided by the capacity of the installation in horse-power, does not exceed 4*l*. per horse-power year.

The financial side of the question is of the first importance, but the difficulties to be overcome on the technical side are also, it is to be presumed, regarded as nearly insuperable as well. To deal with the latter it is necessary briefly to consider the general characteristics of tidal waters in estuaries or similar locations, and to indicate the methods proposed for overcoming them.

When the tidal wave passes from the open sea into the funnel-shaped entrance of a channel or estuary, its volume being constant, the height of