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 the wave increases as the opening narrows, and the particles of water composing it acquire a horizontal motion. In fact, the tidal wave, after entering an estuary, may be considered to be a stream, which, while the crest of the wave is passing, becomes quiescent for a time, and then flows in the opposite direction until the trough of the wave, in its turn, causes another period of quiescence. These periods of quiescence are called the tidal intervals.

Now it has been found that the potential energy of a river may be converted to useful energy by damming the stream at a convenient place to obtain a working head for turbines; the difference in level of the stream above and below the dam being but a few feet. The economy of this method of generating electricity has been established by experience, and it is clear that if the utilisation of the tidal stream could be effected on somewhat similar lines, similar results might reasonably be expected. This in effect constitutes the problem which has to be solved.

The chief difficulty which has to be surmounted in utilising the tidal stream for power purposes is the tidal interval, and this difficulty must be considered as a problem to be solved for every location. In one case it might happen that it would be found cheaper to form one tidal reservoir and another reservoir inshore above the level of the highest tide.

The inshore reservoir would be filled twice daily by means of pumps actuated by the tidal reservoir, to serve as the supply to an ordinary hydro-electric installation which could be operated when required. In another case it might be found that the difficulty could be best dealt with by forming an auxiliary reservoir at a convenient spot higher up a neighbouring river, thus providing a separate unit to carry the load over the tidal intervals. In another case, again, it is possible that the intermittent operation of the turbines would not be found inconvenient. But speaking generally, the difficulty can be surmounted by the formation of two or more reservoirs connected to the tide and to a central turbine chamber by means of sluice valves; the feed to the turbines springing alternately from the main tidal stream and from the reservoirs in such a manner that a working head of water might be continuously maintained.

But it cannot be too strongly insisted upon that the first requirement for a tidal installation is a suitable site, the peculiarities of which will determine the character of the system adopted. For, since the success of such an undertaking depends on the cost per unit of power for structural work and equipment, it is evident that advantage must be taken of every favourable peculiarity, and that the system adopted will be dependent on the site.

In a case where the tidal interval is to be bridged by means of three tidal reservoirs the sequence of flow between the reservoirs and the tidal way is somewhat difficult to follow, but may readily be understood from the tabular description below. The three reservoirs are severally denoted by the letters "a," "b," and "c."

The tide rising from low water to one-third of its range:—

"a" Turbines fed from reservoir	"b" Standing empty	"c" Emptying into the tidal way

The tide rising from one-third of its range to high water:—

"a" Filling to high-water level	"b" Empty	"c" Turbines fed from the tidal way into the reservoir

The tide falling from high water to one-third of range:—

"a" Standing full	"b" Turbines fed from the tidal way into the reservoir	"c" Filled up to tide level

The tide falling from one-third of its range to low water:—

"a" Full	"b" Emptying to low-tide level	"c" Turbines fed from reservoir

It has been practically established that the basis of calculation for the power of a tidal installation should be one-third of the range of the minimum tide; hence when high tide is reached, water flowing from the tidal way may be passed through the turbines into the empty reservoir "b," the capacity of which must be such that the water level inside will have risen to the height of one-third of the range of the tide when the tide has fallen that distance. Similarly at low tide, water impounded in reservoir "a" to the level of the last high tide may be discharged through the turbines into the tidal way, the capacity of reservoir "a" being such that the tide will have risen one-third of its range before the water level inside has fallen an equal distance.

A third reservoir "c" must be provided to receive the water flowing through the turbines from the tidal way, during the time that the tide is rising from one-third of its range to high tide. It must then be filled to high-tide level direct from the tide, so that when the latter has fallen one-third of its range, the contents may be discharged through the turbines into the tidal way.

By an arrangement of valves and sluices all the reservoirs can be controlled automatically to perform their several functions as and when required.

The technical description of the several sluice valves or gates, of the structural details of the supply, or turbine chamber, and of the embankment walls was given in detail in the author's paper on tidal waters as a source of power, which was read and discussed before the Society of Engineers on May 5. It is, however, necessary to state that the cost of these details has been exhaustively considered, and it has been found that though the expense entailed is very heavy, it cannot be considered prohibitive unless the capacity of the installation is less than it should be to justify the outlay. For it will readily be seen that the length of the embankment walls will not increase directly as the area of the reservoirs, and hence that within defined limits, the greater the capacity of the installation the smaller will be its cost per unit of horse-power.

It is hoped that in the near future an opportunity will be found to obtain, not only a close estimate of the cost of a tidal installation, but also a proof in practice of its convenience and economy as a means of reducing the national consumption of fuel. C. A. BATTISCOMBE.

NOTES.

THE ninety-sixth annual meeting of the Société Helvétique des Sciences Naturelles is to take place this year at Frauenfeld from September 7 to 10. The programme is an interesting one. Among the lectures announced which are likely to attract considerable attention we notice that by Dr. de Quervain, of Zürich, on the Swiss Expedition to Greenland and its results, and that by Prof. Keller, of Zürich, on the geography of the fauna of the Caucasus, both of which are to be illustrated by lantern slides. Prof. Maillefer, of Lausanne, who will speak of his researches on the laws of geotropism, and Prof. Dutoit, of the same city, who will discourse on recent conquests in the realm of analytical chemistry, are equally certain of an attentive audience. Besides these, Prof. Grubemann's, of Zürich, account of the development of the modern theory of rocks, and Prof. Rikli's geographical studies in the flora of the Caucasus, as well as Prof. Fuhrmann's, of Neuchatel, sketch of his scientific researches during his journey through the Cordilleras of Columbia, will be awaited with interest. Among the men of science who have announced their intention of making communications to the separate sections are Prof. Edouard Fischer, of Bern, and Prof. Ernst, of Zürich, in the botanical section; Dr. Paul Arbenz and Dr. H. Schardt, of Zürich, in the geological section; Prof. C. E. Guye, of Geneva, and Prof. Perrier, of Lausanne, in the physical section, as well as Prof. Einstein and his colleague at Zürich, Prof. M. Grossmann, in a discussion of the physical and mathematical basis of the theory of gravitation, to take place at a common sitting of the physical with the mathematical section. In the latter section, though only added of late years, there is a relatively large number of communications inscribed, of which several are concerned with the more recent theories. In the section for geophysics Prof. P. Mercanton, of Lausanne, and in the section for chemistry, Prof. A. Pictet and Dr. G. Baume, of Geneva, are reading papers.

THE third International Congress for Diseases of Occupation will take place under the presidency of Dr. F. von Haberler and Prof. A. Schattenfroh in Vienna in September, 1914. The subjects for discussion will be:—"The Physiology and Pathology of Fatigue, especially with Regard to Professional Work, Overwork, and Nightwork," "work in Hot and Damp Air," "Anthrax," "Pneumoconiosis," "Electrical Industrial Injuries," "Industrial Poisoning, especially by Anilin, Mercury, and Lead," "Industrial Injuries to Hearing," and "Independent Communications." The general secretary is Dr. Ludwig Teleky, Vienna IX., 23, Türkenstrasse.

THE fourth International Congress of School Hygiene was opened at Buffalo on Tuesday last, and will continue in session until Saturday next. The president is Dr. C. W. Eliot. The work of the congress is divided amongst three sections, devoted respectively to "The Hygiene of School Buildings, Grounds, Material Equipment, and Upkeep," "The Hygiene of School Administration, Curriculum, and Schedule," and "Medical, Hygienic, and Sanitary Supervision in Schools."

THE eleventh International Conference on Tuberculosis will be held in Berlin from October 22 to 25. Among the communications promised are the following:—"Clinical Forms of Koch's Bacillosis at Different Periods of Life," by Prof. Landouzy; "The Surgical Treatment of Pulmonary Tuberculosis," by Dr. Brauer; "Life Insurance," by Dr. K. Frankel; "State Insurance and Schools for Children with a Tendency to Tuberculosis," by Prof. Pannwitz.

THE annual meeting of the International Association of Medical Psychology and Psychotherapy will take place at Vienna on September 19 and 20. The general secretary is Dr. L. Frank, 45, Zürichbergstrasse, Zürich.

THE death is announced, from Bonn, of Robert Rieder Pasha, the well-known surgeon, at the age of fifty-one years. In 1898 he became a professor in the University of Bonn. Afterwards he became Inspector-General of Medical Schools in Turkey, and received the title of Pasha. He remodelled the system of medical training in Turkey, and was responsible for the establishment of several hospitals and similar institutions in and near Constantinople, and returned to Germany in 1906.

THE death is announced, in his fifty-sixth year, of Mr. C. Leslie Reynolds, superintendent of the National Botanic Gardens at Washington. He had been connected with the gardens for nearly forty years.

THE death is announced, in his seventy-third year, of Mr. W. Whitehead, president of the British Medical Association in 1902, and from 1894 to 1900 professor of clinical surgery in the Victoria University of Manchester.

THE death is announced of Mr. J. R. Sheldon, a well-known agriculturist, at the age of seventy-three years. Mr. Sheldon was appointed to the chair of agriculture at the Royal Agricultural College, Cirencester, in 1877, being subsequently lecturer on dairy farming at Downton Agricultural College. He was the author of "Dairy Farming" and "Live Stock in Health and Disease."

THE late Sir Jonathan Hutchinson, F.R.S., left by will the following directions regarding his museums at Selby, Haslemere, and Chenies Street, London:—"I leave the three museums at Haslemere, Selby, and 22 Chenies Street, and their contents to my trustees upon trust to dispose of the same as they in their own absolute discretion shall think best, but my desire is that, without imposing any trust upon my said trustees, they shall dispose of my said museums and their contents in accordance with my wishes expressed to them during my life."