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The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

THE LOCOMOTIVE OF THE FUTURE—A SUGGESTION.

The really remarkable rate of increase in the size and power of the modern locomotive, especially in the past four years, brings the locomotive-builder face to face with the question of making some very radical changes, if he is to satisfy the inevitable demand of the twentieth century for locomotives of greatly increased power and endurance. We recently illustrated a locomotive built for the New York Central Railroad, which showed a boiler capacity not far from double that of the celebrated No. 999 of the same road. The great dimensions of the boiler were rendered possible by the adoption of the Atlantic-type method of disposing the driving wheels, whereby the firebox may be extended to the full width of the loading gage. The diameter of the barrel, however, in locomotives of this type cannot be increased in proportion, the necessarily large driving wheels in express locomotives placing the barrel of the boiler so high that a restriction is put on its size beyond which it cannot go.

At the present juncture, then, we may reasonably ask whether, in view of the restrictions upon boiler space offered by the present method of carrying the engines and the boiler upon one frame, it would not be advisable to remove the engines and driving-wheels to the tender, replacing the present locomotive frame by a low frame or platform, designed simply for carrying a boiler of the full diameter allowable by the present loading gage. We have given the subject considerable study, and are satisfied that, as far as the tender is concerned, there are no structural difficulties to prevent the engines from being carried upon the same frame as the coal and water.

It is a common occurrence in the history of engineering for a device to anticipate the true era of its usefulness; witness Brunel's "Great Eastern," which was forty years ahead of its time, and is only now being equaled in size. The suggestion of engining the tender is not new; for between 1855 and 1860 Sturrock introduced, upon the Great Northern Railway, England, some locomotives which, in addition to the engines on the locomotive proper, had a set of engines carried beneath the tender. So great was the increase in hauling power that the device defeated its own ends, the sidings of the railroads at that day being all too short to accommodate the long trains of cars that these steam-tender locomotives could haul. Two other difficulties encountered by Sturrock were the fact that the dust and grit raised by the locomotive caused a rapid deterioration of the wearing parts of the tender engines, and that it was impossible in those days to provide a satisfactory flexible joint in the steam pipe between boiler and tender. The difficulties above mentioned would not be encountered in a present-day application of the system, the platform and siding space being ample, while the dust and grit difficulty could be overcome by running the locomotive tender first. Moreover, a three-joint ball-and-socket connection in the steam pipe might be used between engines and boiler; or, if this were found to be impracticable, it might be replaced by a large-diameter coil of pipe, made of steel of a high degree of elasticity. We are free to admit that this connection would probably be the most difficult problem in the design; but there is no reason to suppose that it would be beyond the possibilities of modern workmanship and materials.

By this separation of engines and boiler, it would be quite practicable to produce an express locomotive of from two and one-half to three times the power of the most powerful express locomotive existing today. In the first place, the boiler platform could be carried on two low, six-wheeled trucks, and by utilizing its full ten feet of width to carry a water-tube boiler of the Yarrow or some other first-class torpedo-boat type, and installing the necessary fans for forced draft, (the latter, by the way, a device tried as long ago as 1830 by Seguin on one of Stephenson's engines), it would be possible to provide three times as much heating surface as is found in the boilers of our largest express locomotives.

As to the utilization of this great steam capacity, the tender might contain two independent sets of engines, arranged on the Atlantic type system, with the cylinders carried over four-wheeled trucks at either end, and two independent sets of four-coupled driving-wheels between them. Such an arrangement, using blind drivers of 6 feet 6 inches diameter, with only an inch of clearance between them, could be accommodated on a rigid wheel-base not to exceed 31 feet. The decreasing weight on the drivers when the engine is running, due to the consumption of fuel and water, could be compensated by utilizing an adjustable fulcrum to transfer an increasing amount of weight from trucks to drivers. The coal space on the tender could be built with its sides and ends sloping to the center, after the fashion of a hopper-car, and a small bucket or screw conveyor could be arranged to bring a constant feed of coal from the bottom of the coal space up to the footplate of the boiler.

A water-tube boiler, built up to the full limits of the platform on which it was carried, would provide an ample supply of steam at 225 pounds pressure for two sets of the largest-sized engines that the adhesive weight of the tender would allow.

If the steam tender were provided with four 22 x 28 inch cylinders, and the maximum load on each set of coupled drivers were 110,000 pounds, the total draw-bar pull would be about 60,000 pounds, or sufficient to haul a train of fifteen Pullman cars over a road of normal gradients and curvature at an average speed of 60 to 65 miles an hour. A common cab would do duty for the engineer and the two firemen, the arrangement being similar to that adopted on the well-known Fairlie type of locomotive.

As to the method of using the steam, it might be found preferable to expand it in three or four stages; but if the simple, high-pressure system were used, there would be the advantage that, the boiler being supplied with independent forced draft, the exhaust nozzles could be greatly enlarged and the back pressure reduced.

It will be seen, at once, that should the development of the locomotive follow along the lines indicated above, there would be a considerable increase in the total load on a given wheel-base, with the result that even our first-class roads would have to consider once more the question of replacing, or considerably strengthening, their bridges and track structures. This, however, will have to be done, in any case, before the locomotive of the present type has reached its limit of power and weight.

BEHR ON HIS HIGH-SPEED MONORAIL SYSTEM.

At a meeting of the Society of Arts, held last month, F. H. Behr read a paper upon his proposed high-speed electrical monorail between Manchester and Liverpool, which gives a better insight into the theories and aims of this indefatigable engineer than was obtained from any previous published account of the system. Mr. Behr states that he himself lays no claim to the propounding of the original idea, the credit due him being based upon his having developed the general ideas and principles of others in the designing of the practical details, and in having constructed monorails which have been worked successfully in carrying passengers and goods on a commercial scale for a number of years. He admits that the form of monorail which he has adopted was invented by Charles Lartigue, a French engineer, who constructed some primitive and simple lines in Algeria and Tiflis.

The first practical line built on the Behr system was a short length of passenger and freight railway in the north of Ireland. It was opened in 1888, and has been operated ever since without any difficulty or accidents. Another line was built on this system in 1893 in France as a branch line of the Paris, Lyons and Mediterranean Railway. Originally the inventor was impressed only with the advantages to be derived from applying the principle of the monorail to light railways in countries where the population was sparse, such railways to act as feeders to the main lines; but as electric traction became more perfected, Mr. Behr was impressed with the fact that an even more important application of the principle was to be found in the construction of high-speed railways.

The first experimental line designed to show the practicability of high-speed monorail travel by cars of standard size was built in the neighborhood of Brussels, as an annex to the exhibition of 1897. It was constructed under the auspices, and with the financial assistance, of the Belgian government; and although the electrical horse power furnished from the exhibition was only a quarter of the amount promised, and although over 75 per cent of the line consisted of curvature, a maximum speed of 70 miles an hour was obtained on the curves, on an elliptical track whose total length was about 3 miles. This structure consisted of a single rail, elevated 3 feet from the ground, and supported on A-shaped steel trestles. On each side of the structure were fixed two guide rails, 18 inches apart, whose duty it was to engage the thirty-two horizontal guide wheels which were provided on the car, and thereby prevent oscillation, and counteract the effect of the centrifugal force when rounding curves. The car was 60 feet long, 10 feet 10 inches wide, and weighed 70 tons. It was driven by 200 horse power electrical motors. During three months of the exhibition passengers were carried with safety at a speed of 70 miles an hour around curves of 540 yards radius. In the opinion of the Belgian government, the results obtained, considering the unsatisfactory conditions, were promising, and Mr. Behr was authorized to reconstruct the generating plant and make certain changes in the way of lightening the extremely heavy car. With a car weighing 59 instead of 70 tons, a speed was recorded of 83 miles an hour on curves of 540 yards radius, and it is considered probable that higher speeds than this were obtained for short distances. The report of these experiments stated that there was a marked absence of vibration, and it was thought that the results of the trial were such that, with a properly constructed generating plant, speeds of as high as 120 and 130 miles an hour could be obtained with absolute safety and at moderate expense.

The proposed line, for which Parliamentary sanction is being sought, will run from the city of Manchester to the heart of Liverpool. The trains will consist of single cars, with accommodation for from 60 to 90 passengers. The power station is to be located at Warrington, which is exactly half way, or 17½ miles from each terminus. According to Mr. Behr's calculations, he will require about 7,500 horse power to maintain this service at a maximum speed of 110 miles an hour, which speed is to be attained within 1¾ miles from the start. With a car accommodating 90 passengers the capacity of the line is estimated at 18,000 per day, although this could be doubled by providing a five-minute train service.

It is self-evident that the most crucial problem to be solved in a line of this kind is that of proper braking power. Mr. Behr relies upon experiments made with the Westinghouse brake, which prove that it is possible to apply a retarding force of 3 miles per second. That is to say, a train running at 60 miles an hour can be brought to a stop in 20 seconds, or in a distance of 360 yards. Behr believes that with the Westinghouse brake alone it will be possible to bring a train that is traveling at 110 miles an hour to a stop in 37 seconds, or in a distance of 995 yards. He proposes also to equip this railway with an electric brake as an auxiliary to the Westinghouse brake. After the current from the generating station is cut off, the current generated by the rotation of the motors is to be passed through a set of electro-magnets, thereby creating a strong magnetic field. There will be four magnets, each about 18 inches long, which will act on corresponding lengths of guide rail, the pull being equal to 200 pounds per square inch. The inventor considers that he can obtain this result with magnets each weighing less than 1,000 pounds. The combined effect of the Westinghouse and electric brakes is supposed to be sufficient to stop a train running at 110 miles an hour in 500 yards. The combination is only to be utilized in cases of emergency. The stopping of the trains is to be further assisted by a grade of 24 feet in 1,500 yards entering Liverpool, and a rise of 46 feet in 1,200 yards entering Manchester.

SUBMARINES FOR THE BRITISH NAVY.

After prolonged experiments and consideration, the British Naval Department have decided to construct five submarine vessels for the English navy. They are of the Holland type with some improvements carried out by their own experts, the exact nature of which, however, is not divulged. When presenting the Naval Estimates before Parliament the First Lord of the Admiralty remarked in connection with this latest acquisition to the fleet: "What the future value of these boats may be in naval warfare can only be a matter of pure conjecture, but the experiments with these boats will assist the Admiralty in assessing their true value. The question of their employment must be studied and all developments in their mechanism carefully watched by this country." From these remarks it is apparent that the English Admiralty, in view of the success that has attended the trials of this type, both in this country and in France, have at last realized that they are destined to play an important part in naval warfare of the future. The French are zealously following up the invention, and their latest experiments have resulted in a new use being discovered for the submarine. The storing of torpedoes upon a battleship is always attended with considerable danger, and the French naval authorities have been endeavoring to solve the problem by carrying the torpedoes in the submarines, and then taking the latter in tow by a battleship. The trials were undertaken with the "Gustave Zede," and it was proved that the submarine could be towed in this manner under water and submerged for several hours at a stretch.

Messrs. Vickers, Sons & Maxim have the British vessels under construction at their shipyards at

Barrow-in-Furness. They will each measure 63 feet 4 inches in length, with a beam of 11 feet 9 inches and a displacement, when submerged, of 120 tons. The main engine will be of the gasoline type for surface propulsion and will be of 160 horse power. The fuel capacity will admit of a run of 400 knots without replenishing. The maximum surface speed will be 9 knots per hour. The main motor is of the electric waterproof type, capable of propelling the craft when submerged at 7 knots per hour with a storage battery capacity for four hours at this speed.

The vessels will be very substantially constructed. The plating and frames are of steel of sufficient strength to withstand water pressure at a maximum depth of 100 feet. For the purpose of stiffening the hull, and to insure safety in the event of collision, bulkheads are provided. The superstructure is built to admit of an above-water deck 31 feet in length when the vessel is light for surface running. The conning tower will be of armored steel with an outside diameter of 32 inches, and a minimum thickness of 4 inches, adequately provided with observation ports. The interior of the vessels will be lighted with electricity. Compressed air will be stored aboard, and ventilators provided for the circulation of the outside air throughout the vessel.

The armament will comprise one torpedo tube in the extreme forward end of the vessel, opening outboard 2 feet below the light water-line. The vessels will be equipped with five torpedoes each, measuring 11 feet 8 inches in length. The torpedoes are to be discharged while the vessel is in the following positions: At rest or during a run on surface; before or after submergence; while awash, either at rest or when running full speed; and while running full speed when submerged.

When it is desired to descend, the boat will be brought to an awash condition, with only the conning tower ports visible above the water, and will then dive at a gentle angle until the desired depth is attained, at which point the vessel will be brought to a horizontal position, either automatically or by manual power. It is anticipated that the first of these craft will be launched early in May.

THE NATIONAL ACADEMY OF SCIENCES.

BY MARCUS BENJAMIN, PH.D.

The regular annual meeting of the National Academy was held, as usual, in Washington city, on April 16, 17 and 18. After an absence of three years this distinguished body again convened in the National Museum, to the new lecture hall of which it was welcomed by Secretary Langley, thus happily dedicating to the cause of science the recently reconstructed hall.

The sudden death of Henry A. Rowland occurred early in the morning of the first meeting of the Academy, and it was with much feeling that Secretary Remsen announced the passing away of him who for a quarter of a century had been his colleague in the faculty of the Johns Hopkins University. For twenty years Rowland had been a member of the Academy, and his death was a cruel shock to many of his friends, who so well know the great value of his eminent contributions in physics.

During this session, which is the one at which the Academy transacts its business, the chair was held by Asaph Hall, the acting president. At the first meeting the committee on the Draper medal recommended that this distinction be conferred upon Sir William Huggins, of London, England, for his researches in astro-physics. This report received the approval of the Academy. Those who have previously received this honor are Samuel P. Langley, in 1885; Edward C. Pickering, in 1887; Henry A. Rowland, in 1889; H. C. Vogel, in 1892, and James E. Keeler, in 1899. It was also at this meeting that the following foreign associates were elected: A. Bornet, M. Cornu, J. Jannssen, and M. Loewy, of Paris, France; Sir Archibald Geikie, of London, England; and H. Kroniker, of Bonn, and Frederich Kohlrausch, of Berlin, Germany, all of whom have naturally attained unusual prominence in their several branches of science.

The meeting on Tuesday was largely devoted to the election of officers; and to the presidency of the Academy, made vacant by the resignation of Wolcott Gibbs, a year ago, Alexander Agassiz, of the Museum of Comparative Zoology, in Cambridge, Mass., was chosen. He had for many years been foreign secretary. Ira Remsen was elected to the resulting vacancy. Also the following additional members of the Council were chosen: John S. Billings, director of the New York Public Library; Henry P. Bowditch, of the Harvard Medical School; George J. Brush, former director of the Sheffield Scientific School; Arnold Hague, of the United States Geological Survey; Samuel P. Langley, secretary of the Smithsonian Institution; and Simon Newcomb, formerly of the United States Naval Observatory. Samuel P. Langley and Thomas C. Mendenhall were delegated to represent the Academy at the funeral of Henry A. Rowland.

The final business session of the Academy was devoted to the election of new members, and those who were so fortunate on this occasion as to receive the approval of the members were George Ferdinand Becker, who, since 1879, has been connected with the United States Geological Survey; James McKeen Cattell, who fills the chair of Psychology in Columbia University, and is the editor of Science; Eliakim Hastings Moore, Head Professor of Mathematics in the University of Chicago since 1896; Edward Leamington Nichols, who, since 1887, has held the chair of Physics in Cornell University; and Theophile Mitchell Pruden, Professor of Pathology in Columbia University and director of its histological laboratory.

During the afternoons sessions were held at which papers were read. They were, for the most part, highly technical, and only very brief descriptions of them can be given. The first was on "The Climatology of the Isthmus of Panama," by Henry L. Abbot. He compared the temperature and rainfall in a number of places in the tropics, and showed that the annual temperature in Panama was 79.1 deg. F. The average of the hottest month was 80.4 deg., and that of the coldest month 78 deg. F., thus showing that the temperature is equable, the difference being only 2.4 deg. He contended that under proper conditions it was quite possible to endure the climate on the isthmus, but after two or three years it was desirable to remove to a colder climate. Robert S. Woodward, of Columbia College, presented a technical paper on the "Effects of Secular Cooling and Meteoric Dust on the Length of the Terrestrial Day," showing by means of mathematical formulas, derived from recorded results, that in the course of several million years the length of the terrestrial day would be slightly reduced. "The Use of Formulæ in Demonstrating the Relations of the Life History of an Individual to the Evolution of Its Group," by Alpheus Hyatt, consisted of an exhibition of a series of charts showing how, by the use of formulas, the life history of very many of the mollusks could be determined at a glance. Incidentally, by the application of these formulas, he showed that individuals in different geological formations exhibited a development which naturally was an evidence in favor of evolution.

Edmund B. Wilson briefly offered an explanation of Artificial Parthenogenesis and its Relation to Normal Fertilization. His experiments had revealed some exceedingly interesting facts with relation to normal fertilization, and he presented tentatively a theory which explained how fertilization could be accomplished in certain magnesium solutions. Under the title of Simultaneous Volumetric and Electric Graduation of the Condensation Tube, Carl Barus showed how the computation necessary to express the co-ordinates of cloudy condensation in terms of the number of nuclei in action were explained. Two methods were investigated by Prof. Barus. The work was mathematical in character, and does not admit of full presentation without diagrams and formulas. John S. Billings presented a Table of Results of an Experimental Enquiry regarding the Nutritive Action of Alcohol, prepared by Prof. Wilbur O. Atwater, of Middletown, Conn. The title clearly indicates the nature of the paper, and it is not possible at this place to give the various results. Theodore Gill discussed the significance of the Dissimilar Limbs of the Ornithopodous Dinosaurs, which was of a highly technical character, and described his studies made on the skeletons of these early reptiles, which once populated the world. The Place of Mind in Nature and the Foundation of Mind, by John W. Powell, were philosophical presentations of the subject which they described, and form chapters in the scheme of philosophy to which this eminent anthropologist has devoted to recent years. Under the title of Conditions Affecting the Fertility of Sheep and the Sex of Their Offspring, Alexander Graham Bell described the peculiar experiences that he had observed in his flock of sheep in Nova Scotia. He found that the food given to the animals seemed to have a direct relation to the sex of their young. His paper was illustrated by curves on which he showed the proportion of males and females that had been born, and the different periods of their growth. The closing paper presented to the Academy was one by Samuel P. Langley, in which he showed by means of a long chart the infra-red portion of the spectrum which he had mapped out by means of the bolometer. It was simply a statement of results without any descriptions or explanations of what would ultimately be the result of his research. In connection with this he also presented to the Academy the first volume of the Annals of the Smithsonian Astro-Physical Observatory.

In closing, Acting President Hall formally announced the death of Henry A. Rowland and named Ira Remsen to prepare the biographical memoir. The preparation of a memoir on John G. Barnard was assigned to Henry L. Abbott. Arnold Hague, of Washington city, was chosen home secretary to fill the vacancy caused by the election of Ira Remsen to the place of foreign secretary. The Academy then adjourned to meet in Philadelphia on November 12, 1901.

THE ORDNANCE BOARD'S TEST OF THORITE.

As a result of the tests made by the Ordnance Board with thorite the class of ammonium-nitrate shell-fillers have been rejected for the use of the army artillery. In all, eighteen reports on thorite have now been made. The board finds that in eight tests made with 12, 7, and 5-inch shells thorite failed to explode uniformly; for after fragmentation much of the explosive was recovered.

A good filler should be completely burnt and break the shell into pieces neither too large nor too small. The fragmentation secured in the tests was in the main poor. A 12-inch armor-piercing shell charged with 36 pounds of compressed thorite, the pressure varying from 7,000 pounds at the point to 4,900 at the middle and 5,400 at the base, was buried in nine feet of sand. So bad was the fragmentation that only thirty-seven pieces were recovered, the smallest of which weighed one-half a pound and the largest 271 pounds. Over 30 pounds of explosive were undischarged. The most satisfactory of these fragmentation tests was made under the following conditions which could not be actually realized. The fuse was embedded 1½ inches in 36 pounds of thorite rammed in a 954-pound cast-steel armor-piercing shell. About 2,600 pieces were recovered, the largest of which weighed 31 pounds.

The explosive is not only unsatisfactory in its fragmentation, but also tends to pack in the point of the shell, without being ignited by the fuse. An unfused 12-inch armor-piercing shell, charged with thorite, was fired through 5¾ inches of tempered steel, with results not very encouraging. The explosive was driven forward, and so solidly compressed as to leave in the rear a clear space of over a foot, with some four inches of loose thorite. As a whole, the best results were secured with those shells which before fragmentation had passed through steel plates.

The experience of the board with mixtures of thorite and black powder is no more flattering than are the tests made with thorite alone. The entire ammonium-nitrate class of shell-fillers, it is considered, is not to be compared in efficiency with the explosives at present in use.

DEATH OF PROF. HENRY A. ROWLAND.

Prof. Henry A. Rowland died at Baltimore April 16, and by his death America has lost one of her most illustrious physicists. He was born at Honesdale, Pa., 1848, and graduated as a civil engineer at the Rensselaer Polytechnic Institute, at Troy, in 1870. His earliest work was on a railroad survey. He then taught for a time in Worcester University, where he became instructor in physics, and finally assistant professor. He spent a year in Europe about this time, studying under Helmholtz and examining physical laboratories. His reputation grew rapidly, and in 1876 he was tendered the chair of physics in the newly founded Johns Hopkins University at Baltimore, which he held at the time of his death. He was well known as an inventor, and his numerous devices include the multiplex telegraph instrument and a machine for making diffraction gratings. His investigations resulted in a large number of electric and optical discoveries and improvements, and some of the photographs which he succeeded in making of the solar spectrum were the finest ever secured. As a consulting engineer he was retained to direct many great works, such as the electrical plants at Niagara Falls. His work as a member of the Electrical Congress of Paris in 1881 brought him a decoration. He received the Rumford medal in 1884 for his researches on light and heat. He was the author of many papers, and was a member of many learned societies.

DEATH OF RICHARD P. ROTHWELL.

Richard P. Rothwell, a mining engineer, and the editor of our esteemed contemporary, The Engineering and Mining Journal, died in New York April 17. He was born in Canada in 1837. He was graduated from the Rensselaer Polytechnic Institute, at Troy, N. Y., in 1858, where he took a course in civil engineering. He afterward took a three years' course in the School of Mines, at Paris, and then entered a mining academy at Freiberg, Saxony. His active career commenced in a cable and wire rope manufactory in London. In 1864 he returned to America, where he followed the profession of mining in the Pennsylvania coal fields. At about this time he also invented some wire-rope-making machinery which is in use at the present time. He came to New York in 1873, and soon after became editor of The Engineering and Mining Journal, which position he held until his death. He was also editor of The Mineral Industry, a most important technical and statistical volume published annually. He had charge of the statistics of the gold and silver of the United States Census of 1890. He founded the American Institute of Mining Engineers, at Wilkesbarre, in 1871, and in 1882 became its president. He was a member of scientific societies, both at home and abroad.