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ROTARY ENGINES.

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In attempting to read a paper with such a portentious title as "Rotary Engines," it would be as well for the members to understand that the author has only endeavoured to put together matter that may be of interest, and that may bring about some discussion which may prove of value to the members of this Association, as apart from the paper itself. As we all very well know, the words "rotary" and "engine" are of Latin origin—Rotary from the word Rota, a wheel; and engine from the words, in-in, and Gigno, Genitum, to beget. The word "rotary" can convey but one idea, but the word "engine" can be used to convey more than one idea—for instance, in medicine, any pill, or concoction that is prescribed by our first and last friend, the doctor, is an engine. In law, our friends, the Crown Prosecutor, or the counsel for the defence (as the case may be) have many engines of offence or defence respectively at their command. But the two words, "rotary" and "engine" combined, have but the one meaning, and that is: "Some method of producing useful rotary motion"; that is, such motion as can be used as a means in conjunction with some other force or power, in such a manner and combination as to produce some beneficial result, as apart from merely whirling around. It is very probable that our long-tailed ancestors indulged in rotary motion for exercise, and possibly some useful end was obtained by them in their indulgence with rotary motion Also, that later on, in the development stage, some one of cunning amongst them observed the rotary motion of the stones rolling down the hillside, and also that, still later, the first roller was used to enable some ancient to enable him to remove masses from one point to another. The next stage is presumably the wheel with an axle. But it is the adaptation of rotary motion with other forces combined, that this paper attempts to deal with. As far as Western history and research can discover to us, it is safe to say that in this respect the ancient of Syracuse—Archimedes—was the first man to bring about a useful combination of forces, and material in regularity of design, as can be described as a rotary engine.

From this great man's idea of subverting the laws of nature, and making water run up a hill, we have to-day the perfection of his idea in our propellers for all purposes. Of course, it is quite possible that in the East the Chinese were using rotary motion, in conjunction with endless bands with buckets attached, for lifting water, ages before Archimedes was born; but it is not so recorded; therefore to Archimedes must be given the kudos of being the first recorded inventor of a rotary engine, some 250 years B.C.

The next most important interesting invention on record is that of "Hero," the Egyptian philosopher, who, about 100 years later, or 150 years B.C., invented a rotating globe (Plate XIV., Fig. 1), actuated by steam. In all truth, according to record, the first steam turbine or steam-driven rotary engine on record. We have very little record of the first rotary engine as adapted for driving by wind, but whatever the date may be of the first windmill, this engine would be an adaptation of the Archimedian principle. For many years there seems to have been no improvement in rotary engines, and the progress to any perfection of the ideas of the two great fathers of the rotary engine, seems to have been very slow. Yet the engineers of the olden days who made improvements, were giants in knowledge and courage. In knowledge—giants—compared to our present-day text-book engineers, who have at their command the condensed results of lifetime researches made by these men of old time, who laboured and studied and experimented for (not only 8 hours per diem) their lifetime, to hand to posterity, perhaps one important and absolute law (such as Gravity, by Newton). Also they were giants in courage, for in the ages that they were discovering they were one and all likely to be attacked by the superstitious as wizards and alchemists, and, or, anything unholy, or as men who were likely to bring calamity to the people. Many times worse than penalties meted out to the inventors of the weaving machine—yet their progress to improvement seems to us slow, and in some respects it was slow. But we have to consider that in their day keen competition did not exist—and that where one set of brains was working out improvements per million people, to-day there is probably one set per ten striving to outwit and outclass his fellow. However, to proceed. Amongst the most notable of our rotary engine inventors and engineers, such men stand out above all others, as Branca, Wolfgang de Kempelen. This eminent engineer has the record of obtaining in 1784 A.D., the first British patent for a steam turbine. After this our well-worshipped friend Watt, with a slight so-called improvement in 1784; then Sadler, in the year 1791; and later, in the year 1809, Noble (not Marian, of cricket fame) with the steam wheel, with a ratchet attachment to prevent the apparatus moving in the opposite direction to which he intended it to move. This engineer's turbine gave to the engineering world the first adapted idea of the radial flow steam turbine. Little progress seems to have been made until the year 1836, when Perkins came along with the impinging points enclosed in a cylinder. This patent evidently did not take hold of the public, for in the year 1843, or seven years later, Pilbrow came along with his "Successive Expansion Turbine" (Plate XIV., Fig. 2), and also claiming to have stationary curves, as well as revolving curves, on his rotary wheel, also claiming that his turbine could reverse according to the direction in which steam was admitted to the blades. Five years later we have our Robert Wilson, of Greenock, granted a patent for improvements to rotary engines, with both radial and parallel flow turbines. (Plate XV., Fig. 1.) After this date a few other engineers (all notable men with notable improvements) came along, until the year 1884 the great Parsons patented his first two inventions or improvements. Plate XV., Fig. 2., shows one of the early Parsons turbines in section, and a 10-h.p. turbine was the first practical result. Eight years later the largest size was 200 h.p.; two years later, in 1894, came the "Turbinia," 2000 h.p. (Plate XVI., Fig. 1.)

Earlier in this paper it was remarked how apparently slow had been the progress made with the perfecting of the rotary engine. Since the first British patent had been applied for by Wolfgang de Kempelin in 1784, 100 years elapsed before Parsons' application. Since 1884, however, the developments of the steam turbine have made enormous leaps and bounds—the "Turbinia," 2000 h.p., 34 knots per hour, after alterations to propeller, etc.

Going back one year to 1883, we find the great De Laval inventing and patenting a reaction turbine, stealing the brains of our old friend "Hero," who had probably been wrapped up in his mummy cloths and correctly entombed some 2000 years earlier; but, finding some better method of usefully producing and applying rotary motion, he in 1889 evolved his steam turbine of the impulse type. (Plate XVI., Fig. 2.)

Of the reaction type of turbine or rotary engine it must be remembered that, as far back as 1730, Barker invented and patented his "mill," which in every-day life is well known to all keen gardeners as a lawn sprinkler; to engineers, the sprinkler in cooling towers, and to the insurance people as the method of minimising their risks in factories and warehouses—all these being the adaptation of Hero's idea of the reaction turbine. The collection and application of the energy given off by flowing or falling water has been known from ages gone by, when man had first to pit himself against the other animals, in order to rise to what he is at the present day. We are not many strides in advance of what he (man) did when (perhaps without any language but that of signs and acoustics) he, with his gibberish, adapted the energy of flowing water to turn a wheel to grind his corn, and we to-day are (excepting in perfecting design with regard to efficiency) using the same ideas as give to us the enormous powers such as gained by the Falls of Niagara and some closer home in Australasia (as instanced in Plate XVII., Fig. 1, Francis turbine installed by Escher, Wyss and Co. at the Waipori Power Station, N.Z., where, by using Pelton water wheels and the available water supply and power, the Dunedin Council can run the whole of their tramway system, the output being equal to work 25 per cent. overload 2500 kw.).

Amongst the well-known and most eminent of the water-driven rotary engine makers and inventors are such names as Francis (Niagara), Pelton, Girard, De Jouval, and many others of the impulse and reaction type. If the shades of Archimedes and Hero could now visit us, what admiration would they have for the men of this age, who had adapted their ideas, and perfected so far their engines, until to-day we can race our steamers through the waters, both on or below, at 40 miles per hour, and over the land at over 100 miles per hour; and if success attends our efforts for the next few years in regard to aviation, we will be able to call our well-known little bird friend the "swift" a "snail" of the atmosphere.

Amongst steam-driven motors, whether of the impulse or reactionary, or combined types, there are standing out to-day some few that have superabundant commercial value in regard to special advantages.

Of the impulse type, the De Laval, the Curtis, and the A.E.G. Co. of Berlin are the most prominent, and worthy of special consideration as compared to others of the reactionary type, and of this class the Parsons and Schultz are the prominent members. There are also some makers of exhaust steam turbines who to-day are giving wonderful results in economics. To give this Association a description of all and every makers' turbines, whether arranged for high or low pressure steam or high or low pressure of water, would be an impossibility. Up to the present the largest units of steam-actuated turbines have been manufactured by the Parsons and the Curtis Company—Parsons first, Curtis second. It must, however, be recognised that, whereas the first patent taken out for the Parsons turbine was in 1884, the first Curtis patent was taken out in the year 1895, about eleven years after the Parsons' first patent. It is therefore reasonable to suppose that, as the years go by, the Curtis turbine people will be manufacturing as large units as the Parsons people are doing to-day—viz., some 17,000 to 20,000 h.p. With water power driven rotary engines, the efficiency depends entirely on the manner in which the water impinges on the buckets, combined with the easiest get-away, or exhaust; also the avoidance of a whirl chamber. Some of the best efficiencies of water wheels or turbines have been as high as 85 per cent. claimed, but it is very probable that the true efficiencies were nearer 70 per cent, or, to be liberal, 75 per cent. In any case, efficiency depends greatly on the manner in which the water gets away.

Now, in the steam turbine or rotary engine the efficiency depends upon:—First, the manner in which the steam is admitted to the surfaces of moving parts. Second, after due consideration has been given to the temperature of steam and degrees of superheat (both valuable factors) of initial steam, arrangement for apparent expansion in the turbine or rotor is absolutely necessary. Third, the easiest get-away for the steam in order to avoid choking—and this can only be produced, after taking 1 and 2 into consideration by having a very high vacuum, and under ordinary conditions 27 in to 29 in. is necessary. If any turbine user comes along and states 25 in. is enough for him, then he has a better bank accommodation than most manufacturers, to say the least of it. In any case, it may be assumed that with a steam-actuated rotary engine, the principal object is to obtain the best advantage of a high or low velocity of flow of steam throughout the system as is possible. With a high pressure steam as initial, the revolutions must be necessarily high and the velocity comparatively high to ensure success. This calls for a fine pitch and a small diameter, but it is essential also that a high vacuum must be obtained, to enable the steam to be pulled away from the chambers, so that no choking occurs.

In a similar manner the low pressure or low speed turbine, actuated by low pressure or even exhaust steam, requires a similar very high vacuum, but the speeds are comfortably slower, the diameter larger, and the pitch of the blade coarser to a degree. By "speed" is meant revolutions, as the peripheral speed is about the same. Any engineer with propeller practice will appreciate this point. One great disadvantage, and therefore deterrent to the success of the turbine, has been the hitherto uneconomical performance it has given. Compared to its competitor, the reciprocating engine, it has in many cases failed, and its success must mainly depend on its get-away first, and secondly on its nicety of adjustment, and thirdly on the possibility of not having erosion of its parts, which considerably reduces its efficiency.

In regard to impulse turbines, Plate XVII., Fig. 2, shows a production of the Curtis Company, 5000 and 9000 kw. sets.

The De Laval turbine, also of the enclosed type, is a rotary engine worthy of immense consideration—more especially taking into consideration that, in consequence of using high-pressure steam and high speeds, they are essentially adapted for many industries where high speeds are absolutely necessary—for instance, milk separation. They have not yet exceeded horse-powers of more than 700 in one unit, and in regard to their efficiency it is rather difficult to estimate what these efficiencies exactly are, and whilst they claim to be very high, very little data is available in regard to same.

Reverting to the reaction turbine, for the best purposes of this Association, we might leave the Schultz alone and consider the turbine of the Parsons type. Of the Parsons type of turbine very large units are being manufactured; many of us are very familiar with this turbine, and have probably some of us been ship-mates with them—that is to say, have travelled in turbine steamers. It might be interesting at this stage to show a plan view of the engine-room arrangement of one of these turbine plants (Plate XVIII., Fig. 1). Here again, in regard to efficiency, it appears that we have slightly better records than we have with regard to the De Laval turbine, and it is quite a moot point whether turbines of the Parsons type, or of the Curtis type, have any preferential efficiencies. They are each suitable for the purposes for which they are installed, and, according to records, either one or the other gives splendid results if we take into consideration the statements made—and which there is no reason to doubt—in regard to the consumption of steam per I.H.P. As before stated, in any of these turbines it is absolutely essential, for the sake of obtaining any high efficiency, to have a vacuum of not less than 27 in.; and from many diagrams placed at the disposal of the author, plotted out from actual tests made, it is safe to say that in the larger units a steam consumption of 17 lbs. per kilowatt hour, equivalent to about 12½ lbs. per I.H.P., is a good result to obtain, and in certain respects, taking into consideration space economised by the use of the turbine, weight considerably reduced, and small cost of upkeep for repairs, compared with the reciprocating engine, the steam-driven turbine is to the fore and will remain there.

Plate XIX. shows a curve of the Parsons turbine (140 lbs. steam pressure, 27 in. vacuum, 100 deg. sup.); Plate XX. shows a curve from the Curtis turbine (150 lbs. steam pressure, 28 in. vacuum, 100 deg. sup.); Plate XXI. shows the relative curves of a Parsons turbine, and a modern high-speed reciprocating engine. In the rotary engine, of the bladed turbine types, different from its competitor the reciprocating engine, after some time the efficiency is reduced, due to wear on the blades, and although all the turbine engineers have endeavoured to use such metals as will resist the erosive action of the steam on the leaving side of the blade, it has been yet an impossible matter to get any metal that will stand the relative strain that is impervious to this erosive action. The result of this action is therefore the necessary increased steam consumption, whereas with our friend the reciprocating engine, with their spring packed steam pistons, the wear and tear on the cylinders, while slightly increasing their diameters in years, only increases the horse-power of the engine. It is safe, therefore, to say that, after twelve months' wear, the turbine has lost considerable efficiency, whereas the reciprocating engine has gained it. Of course, this may be looked upon as a very fine point, but, for all that, very serious consideration has been given to this fact of loss in efficiency by one of the largest steamship companies in Australasia, and their determination has been to use reciprocating engines in their steamers in future, unless for very special conditions of service. Of course, members will immediately turn round and point to the fact that the trans-atlantic steamers are being turbine-engined. The author, in consequence of the limited time at his disposal to prepare a paper of this importance, purposely has abstained from giving any figures for discussion to-night, and trusts that the members will agree that the subject is one of such vast importance, and arrange for a discussion to take place, when he will be prepared to give figures as to performances, as to construction and the reasons therefor, sufficient to satisfy this or any other Association of Engineers. Besides the bladed type of rotary engine, other engines of the hollow piston type, such as the Hult, manufactured by the Hult Brothers, of Stockholm, who were awarded a gold medal in the year 1897 for the rotary engine of this type, and who claim that their engine used as little as 48 lbs. of steam per brake h.p. per hour, and thought it a wonderful result. In this wonderful country of ours —Australia—the outside world would scarcely believe that we have such inventive genius amongst us as could invent and obtain patents for a rotary engine that would beat, in steam consumption, the results of the Hult Brothers' researches. We have, however, such a man in Mr. Herbert Lee, of Kensington. The author, by Mr. Lee's courtesy, was enabled to take a trip in a very bargey sort of a launch, in which was installed a small rotary engine, having a 7-in. diameter piston, with a 5-in. face, the launch fitted with a 20-in. propeller, and with 100 lbs. steam pressure travelled at the rate of five to six miles an hour in this boat. The claim is 35 lbs. steam per I.H.P. Mr. Lee has lately, in conjunction with Mr. John Bryden Brown, a member of this Association, perfected this invention, and conjointly they are manufacturing these engines in Sydney. By the courtesy of the manufacturers, the B.C.L. Company, the author has been allowed to place on the table practically the whole of one of these engines. This engine is claimed to be a 20-h.p. engine. Plate XXII., Figs. 1, 2, and 3, respectively show section and plan of the engine, the latter showing the regulating valve. Messrs. Lee and Brown have informed the author that they would be extremely pleased for any members of this Association, by appointment, to visit the manufacturing works and inspect this engine, and it is quite possible they would also be prepared to have some of the members present when brake tests are being carried out.

The application of the rotary engine to other machines of the rotary class makes the rotary engine stand out so prominently that there is very little choice left, such combinations occupying very little space comparatively, according to design. The propeller, whether for sending our vessels through or over the water, or our ships through the air, or driving our hundreds of thousand generators or motors, our blowers and ventilating fans, our centrifugals for all services—in fact, for all that assists this world in its rotary motion to go round.