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WHY TIDAL ENERGY OR THE FORCE OR POWER OF THE RISING AND FALLING TIDES HAS NOT BEEN, AND CANNOT BE, ECONOMICALLY SUBSERVIENT TO THE REQUIREMENTS OF MAN FOR INDUSTRIAL PURPOSES.

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The mean or average rise and fall of the tides in the vicinity of Quebec and down as far as R. des Monts on the lower St-Lawrence may, from Messrs. Steckel's and Bell Dawson's surveys and statistical data, be taken at, say, 12 feet; the neaps being 7′ to 8′ and the high and spring tides 14′ to 18′.

For instance, from Dawson's report of 1901 we have: neaps at Tadousac ranging from 6 to 7½ feet, with springs at 16½ to 17, as observed by this gentleman on July 6th to 8th; at River du Loup, neaps 5¾ to 9 and highs or springs 17 to 17½; at Pointe aux Orignaux, neaps 7½ to 8¾—springs 19 to 20; at Grosse Isle, neaps 11½ to 13—springs 18½ to 19½; at l'Islet, highs 17 to 18; and at Cap Chatte, 16 to 17; all the highs or springs having been observed on August 12th to 15th.

Steckel's tide tables of 1887-88 at Quebec graving dock, give for

spring tides at low water season..	16½′ to 18½′
and for maximum flood range..	18′ " 19′
minimum flood range	9′ " 3½″
the average of which is	13′ " 6½″
For maximum ebb range..	18′ " 3½″
Minimum ebb range	9′ " 3¼″
Giving an average of..	13′ " 8″
Again the maximum diurnal difference in high water levels during low water season is	4′ " 3½″
and at high water season	3′ " 3½″
while in the low water levels during the low water season, the diurnal difference is	1′ " 4½″
and during the high water season	1′ " 5½″

It is thus seen that one of the difficulties of dealing with the problem, is the constantly varying velocity which any system of gearing to be operated by the tides must be subject to, and which must be sometimes as great as from 1 to 3 ; since a rise at neaps of 6 feet can only create directly a motion having a velocity equal to but one-third of that due to a rise at springs of 18 feet in the same number of hours ; because of the varying attraction or power of attraction of the moon and sun and according as they are in conjunction, as during what are called the sizygies, when the moon and sun both pull the same way, or in opposition, as at full moon, when their pull or influence is exercised in opposite directions ; and a minimum when the moon is in quadrature, when the then influences of the two attracting bodies are counteracting each other.

Again, as there are, during the twenty-four hours, two rises and falls of the tides and as at high tide, there is a momentary lull before the tide begins to ebb and at low tide a similar interval of what is called "slack water"; there must also be in the working of any machinery actuated directly by the tides, the same dead points or nearly complete stoppages, which would render such a power as that of the tides absolutely out of question, even if it could be economically utilized for such services as electric tramways, electric lighting or other services which require to be continuous and which, even if the motion of the tides were continuous, could not either be of uniform intensity ; since, as already said, the varying velocities of motion must at certain moments of the day, more so during certain periods of the month and still more so during the varying seasons of the year, be subjected to constantly varying fluctuation.

We have all noticed during our summer rambles along the beaches of the St. Lawrence, or of any other tidal river, the differences in level of the tide water of those to which the tides attain. This may be seen sometimes in cities where the ebbing tide will leave its mark upon a pier or wharf or jetty, or on the rocks on the foreshore, where there are any. These, however, are but fitting or momentary mementoes which die away or are obliterated by the sun's heat or an evaporating blast of wind; while the marks left along the sea coast or the shore of an estuary, remain there during the whole period or duration of a series of losing tides ; that is when the tides are waning with the waning lunar attraction. These riparian lines of level or horizontal contour lines so well defined by the chips and saw dust from mill streams, twigs, leaves, rushes, and flotsam from passing vessels, or sweepings thrown overboard, and what not else—these lines thus traced out along the river shore persist until again a series of rising or gaining tides with increase of the moon's attraction, cause every successive flow to wipe out and remove or wash higher up on the beach the detritus brought in by the preceding tide.

But this alternating action of the rising and falling tide water can be made continuous in its results as with the wind which is another intermittent or irregular source of power.

In the same way as the wind can be utilized at irregular intervals for work not necessarily consecutive or continuous ; as in pumping water into a railway or other tank, sawing fire wood, threshing grain, pumping out the bilge water of a pontoon or other vessel, grinding corn, etc.,—so could the tides be utilized, as will be explained hereafter ; but for continuous action, the only and best way in which the power afforded by them can be brought to bear, or one of the best ways in which this can be done, is by pumping and storing sufficient water in a reservoir or cistern of adequate dimensions, to hold out from tide to tide, or from day to day, moon to moon, and season to season. The dimensions of the recipient would have to be regulated so as to equalize the outflow from it or nearly so, and the outflowing stream could be used to revolve an overshot or breast wheel ; or better with a turbine, to give the continuous motion sought for. Tide motion, it is evident might thus be utilized successfully, more especially in such inlets or estuaries as the Bay of Fundy, where the rise of the tide attains to forty and even sixty feet, and, in some such estuaries, in other parts of the world, where the tidal amplitudes are very great.

The mechanical action of the tide above alluded to may be secured in two ways, viz.: either by a float or pontoon rising and falling with the tide; and by means of a connecting rod, as between the crank and piston of a steam engine, through or without the intermediary of a working or oscillating beam, procure a rotary motion capable of being multiplied by gearing into a speed practicable for some purposes.

Or by a more direct method of tidal action resorted to in a good many cases already, which consists in enclosing as large an area for the storage of tide water, as can be had by damming a ravine or the mouth of an estuary or river so as to permit the rising tide to overflow the dam in a way to fill the enclosure. Upon the tide receding, the volume of water impounded (especially when supplemented as it may be by the flow of the river itself, or even if there be no other delivery of water into the enclosure) will suffice to keep a turbine or other wheel going during the whole interval between two successive tides, with, of course, increasing energy as the tide falls, and again decreasing power as it rises.

As early as 1847, the writer advocated the damming of the St. Charles estuary, across from the city of Quebec to the Beauport side, a distance of quite a mile at the site proposed. This would have kept up the water within the dike to high tide level all the year round.

His object then was not with the idea of any water power to be derived therefrom or utilized; but to afford water up the St. Charles for ship building purposes and for the dockage of vessels which, on opening the lock gates at high tide, or rather when the outer water reached the level of the inner, would allow of vessels passing in and out, or both ways; or by lockage, when the outer water fell either short of the inner or was at a higher level; a scheme which may still be carried out.

Now it is conceivable how, in this case, the falling tide might be rendered useful and, so to say, operative, though in an indirect or negative manner, by having along the dike, on its outer side and running its full length or less, a line of shafting laid below low water level and causing it to be worked or rotated at intervals along the line, by as many turbines driven by the outpour of water through sluices provided for the purpose. The shaft, as in the hold of an ocean steamer, is carried along on proper pillar-blocks to the screw propeller prolonged into a power house at either or both ends, on the opposite shores of the river, the size of the basin being such, that, continuously replenishing by the flow from above, such a sheet of water would fall but very little until supplemented by the next rising tide through overflow weirs for the purpose with their crests at the proper level and with gates adjustable to suit.

Still, however, would this be an expensive mode of getting power, and especially power of such a constantly varying nature as that due to the greater or less velocity of action of the actuating turbines under the constantly varying head of water, consequent upon the rise and fall of the tide on the outside of the dike, and applicable only to intermittent work ; while shifting again, with the hour of the day and night, and thus most unsatisfactory.

As set forth at page 116, articles 283 and 284 of the writer's "Divers," an oct. vol. of 688 pp. and 1013 paragraphs, published by him in 1898), it will be immediately evident that in order to subserve any practical purpose in the arts and trades, the very slow motion of the rising or falling tide must be converted into one much more rapid.

It has already been said that the average direct motion or velocity obtainable at Quebec and vicinity may be taken at twelve feet rise and twelve feet fall or twenty-four feet per tide, or say, per twelve hours ; though, due to the retardation of the moon's motion, the tides be some fifty minutes later on each successive day. This is equivalent to a motion of two feet per hour ; or taking it another way, the rising and falling tide can only cause one revolution of a wheel in twelve hours, if actuated by crank action.

Such motion or rotation of a wheel can be conceived of as actuated from a floating body rising and falling with the tide, the wheel being equal in circumference to the combined flow and ebb or say, twenty-four feet, and, therefore, of a diameter of eight feet, or a little less, a vertical rack taking hold of and lifting one side of the wheel through half its circumference during rise of tide and the ebb pulling it down by an equal amount by a corresponding vertical rack on the opposite side, while several revolutions per diem might be obtained by applying the rack to a pinion on its shaft, and thus get say one revolution per hour instead of only one in twelve hours.

Bu this system of causing the wheel to rotate, while true in theory, would be difficult to carry out in practice; as the teeth of the rack would, as with the pellets or clappers of a windlass, have to be hung on an axis or swivelled in a way to let them drop or hang during the return motion ; or drop on the rising side of the wheel, while in gear on the falling side, and vice versa on the falling side, while in operation on the opposite one.

If the wheel were operated or made to revolve as already mentioned by a connecting rod, that is, connected at the lower end to a pin in the float or pontoon, the other end of the ,connecting rod, instead of being as in a steam or other engine, of equable piston motion, fixed to the crank pin, must evidently be left to slide up and down or back and forth in a slot in the crank. While the crank must have a minimum length equal to the lowest neaps, or say five feet, it must also have a maximum length of action or radius equal to that of the highest springs, or of ninety to twenty feet, and the upper end of the connecting rod, where meeting the crank, would have to be forcibly held in such toothed or jagged contact with it that it might have no tendency to slide in its slot and thus cause the rotation to stop altogether.

Again, this wheel, to enable it automatically to overcome or pass beyond what are called the dead points, which occur when the connecting rod and crank are in one and the same line, must either have a fly wheel attached or a second connecting rod with a crank at right angles to the first ; or better still three cranks and rods at angles of 120°.

Now supposing all these difficulties of construction and rotation overcome, still have we as yet but a wheel rotating only twice in twenty-four hours, or, of course, too slow for anything but astronomical purposes and too irregular for that.

Then let this wheel of say 7′ 8″ in diameter or twenty-four feet in circumference, considering it as a mere pinion, have next to it or adjoining it on the same shaft or without the first, a wheel, say 120° in circumference, and let this gear into and rotate a pinion on another shaft of say two feet, this pinion would, with a wheel upon the same axis rotate in one-tenth of the time or ten times in twelve hours, twenty times in twenty-four hours, or, say once per hour, which it could be made to do by diminishing the diameter of pinion to twenty inches instead of twenty-four.

Still have we only reached a velocity of one revolution per hour or per sixty minutes, and this again is absolutely inadequate to any practical purpose. Then would a second wheel of like diameter to the large one on the main shaft, have to gear into another pinion and rotate a third pinion and wheel on a third shaft ; and if this third wheel moved at a rate, by virtue of its pinion, of ten or twenty times the velocity of the second wheel, still would we have reached a velocity of but one revolution in six or three minutes.

Now even such a slow process as this could not be practically utilized and the gearing must be carried on. The three systems of shafts and wheels and pinions must be again added to and a fourth system brought into play.

Let then this fourth auxiliary be creative of a velocity of again ten or twenty times that last mentioned, or of a rotation of once in thirty-six or eighteen seconds, say two to four times a minute, and still have we failed to reach a practical solution of the problem. The slowest motions used in the arts and trades may be said to be those of heavy pumps of systems of water supply, whether on the Holly principle or otherwise, where the stroke or double stroke to complete a revolution can hardly fall short of twenty or thirty in a minute, or the motion of a paddle wheel, which in large sized boats is about normal at thirty revolutions in a minute or in a screw propeller at say twice that velocity.

This fourth tier of gearing must then again be supplemented by a fifth to increase the speed to even the slowest for practical requirements.

But we are told in mechanics that the net duty derivable from machinery in general, due to loss by friction of the operating mechanism, is but 85 percent of the initial power or a fifteen percent loss of energy; and, as just shewn, the machinery in this case, to arrive at a reasonable velocity for any purpose must not only be doubled, trebled or quadrupled, but it must be multiplied by five or quintupled ; and if the same allowance for retardation by friction obtained throughout, the loss would be not less than five times fifteen or seventy-five percent, leaving but one-quarter of the initial power to the good.

If, however, the loss by friction, as may sometimes be warranted, be taken at only ten percent instead of fifteen, there would still be but four horse power realized out of every ten of the direct lifting or falling power of the tide, and this alone is enough almost to dissuade any one from falling back upon or appealing to the tides for a lucrative mode of creating or utilizing power; and if we attempted to reach such higher velocities of revolution as required for electric power purposes, it is easy to see how the whole or nearly the whole of the initial power of the tides might be absorbed in so doing and not enough of it remain to make it a paying business.

Therefore, is it probable that if the tides have not as yet been utilized by man, it is because he has by mental process gone through the line of reasoning here laid down, and thus become convinced of the futility of making the trial, especially under the discouraging consideration that not only is there the loss by absorption by rubbing surfaces, but the other allowance of ten percent for wear and tear, and consequent repairs, etc.

But as yet we have said nothing of what this power of the tides really is: this apparently, or at first sight, almost irresistible power, since with the tide rises every thing upon its surface, even to a twenty or thirty thousand ton vessel of war, and which would similarly lift a city if built upon the water on a water tight bottom or platform or pontoon with depth of water sufficient to allow it to sink till the weight of water displaced were equal, as with a vessel, to the weight supported.

This, however, is only apparent as the tide wave has no greater power than that which is required to raise its own weight of water to the average height of one-half a tide or one-half the weight of water to the full height or amplitude; the weight of the vessel or other object on the water being supported by the water, irrespective of the lifting power of the tide, as represented by the hydrostatic pressure exerted as above mentioned, by the weight of the equivalent volume of water displaced; so that where the vessel or object rests or floats, the weight to be raised by the tide is the same as elsewhere or as where there is nothing on its surface.

In other words, the lifting force of the tide per square foot or of the moon and sun which actuate it, is, for an average rise and fall of twelve feet, here assumed approximately, equal to twelve cubic feet of water or 750 pounds raised to an average height of six feet, viz., 4,500 foot-pounds, or, as said before, to one-half the said weight of 750 lbs. or 375 pounds lifted to a height of twelve feet.

But we have the same force or power developed in the falling tide as with an ordinary water power or the power exercised by falling water; since, if we suppose for instance, a cubic foot of water suspended at one end of a rope passing over a drum or pulley, it will, in falling with a certain velocity, be capable of lifting an equal weight suspended from the opposite end of the rope; less, of course, allowance for friction.

The 4,500 pounds has thus to be doubled to be representative of the power developed by a whole tide of rise and fall or flow and ebb; and as there are two such tides roughly in twenty-four hours, which (unlike a horse that must have rest and can only labor for eight to ten hours a day), are constantly and automatically at work, we thus get at the fact that one and every square foot of water surface exercises a power of 18,000 pounds during the twenty-four hours.

Now a horse power (H. P.) is estimated to be equivalent to 33,000 pounds raised to the height of one foot in one minute of time, or, which is the same thing, as explained by the writer at paragraph 275 of his "Divers," already alluded to, 330 pounds raised to a height of one hundred feet in one minute of time, which brings the thing home to us in that we can conceive of an able bodied animal rising such a weight with proper tackle and doing it in that time; as he can walk thirty-three paces or one hundred feet horizontally in thirty-three seconds or less, and have thirty seconds or more to return in and have another load hitched on. As he can continue to do this work for say eight to ten hours a day, the above figures or quantity of energy developed is called horse power; while expressed in a way to subserve a quick process of calculation by rule of three, by one of its factors being reduced to unity.

Thus, then, every square foot of water surface in such a tidal river as the St. Lawrence from above the gulf, to somewhere above Quebec, or in any other river with an equal rise and fall of tide, is a source of power only equivalent to about one-half or two-thirds of a horse power in twenty-four hours.

But a H.-P. as just set forth is equal to 33,000 lbs. raised one foot high in one minute of time or 33,000 foot-pounds; and in twenty-four hours there are 1,440 minutes; therefore must we utilize double the number of feet or 2,880 square feet of float area to secure the power of one horse working during twenty-four hours at the rate of 33,000 foot pounds per minute.

And even if we take but 30,000 foot-pounds per minute for a H. P., as some would have it, and suppose this power to be exerted only during eight to ten hours out of twenty-four hours, still do we arrive at the conclusion that in round numbers it requires an area of eight hundred to one thousand feet or thereabout, of water surface, to represent one H. P. or a float of say forty or fifty feet by twenty feet, or for one hundred H. P. say again one of eight hundred to one thousand feet by one hundred.

And, therefore, if the writer's figures be correct, it is not to be wondered at that the power of the tides has never as yet been, nor is ever likely to be, economically utilized for industrial purposes.