POSSIBILITIES OF THE STEAM YACHT.

BY LEWIS HERRESHOFF.

THE passion for rapid transit, now in full force on land, is becoming general also at sea.

During the last half-decade we have seen the Atlantic covered from land to land in rapidly-lessening time. Hour by hour the passage has been cut down, and to-day trips of less than six days are of such common occurrence that they excite scarcely a passing notice.

In yachting, as well as in the merchant marine, the increasing desire for high speed has been felt, so that a love of rapid motion, once considered devoid of the spirit of sportsmanship, has become so popular that it is quite the ordinary thing to require eighteen or twenty miles an hour for the usual performance of a yacht. There is something exciting in high speed. It stimulates interest that otherwise might be tame. It matters little what force is employed—the bellying sail, the whirling screw, or the dashing paddle—so there is "a bone in her teeth," and particularly if some other yacht is slowly dropping astern, then is the time when your pulses fly and your interest is awakened, as if by some invisible sympathy the straining steel or tugging canvas might receive through your anxiety a fresh measure of power.

Here in America the conditions are conducive to the development of high speed in yachts. We are a restless, quickly-moving people, and many wish to live during the yachting season at a distance from business, where many miles must be traversed daily. Nowhere on the globe do inland water courses afford so ready and agreeable means of rapid transit as with us. The Hudson, the Sound, and the many beautiful bays that diversify our coast line bear the forms of numerous swift steam yachts whose owners must be "on 'change" at 10 A. M., and whose delight it is to cut the waters with the chisel-edge of their bows and leave a glistening wake far in the rear.

In England it is otherwise. They are not so "fast," as a people, as we, and, more than that, their surroundings are not favorable for the comfortable and successful use of high-speed steam yachts; they tend more toward sea-going, moderate-powered vessels, that will make easily and safely a voyage to the Mediterranean, or the coast of Norway, or wherever they choose, for the entire earth is the playground of the English. We owe much, however, to the English in the development of the torpedo-boat, which is of very near kin to a speedy steam yacht. If we omit the warlike implements, and increase a little the size and comfort-giving appointments of the cabin, such a craft is the very best form of high-speed yacht that can be devised.

Since the demand for speed is not limited, and since we see year by year new ocean racers of superior power and swiftness, and yachts or torpedo-boats that excel those of last year's construction, the question naturally comes forward, how far can this passion for speed be carried and still result in the use of reasonably safe and durable vessels? It is a query that never can be fully and definitely answered. So long as improvements in material and mechanism can be made, so long will the last production be the fastest and best.

In using the term "high speed" it is intended to mean at least twenty miles an hour. A speed of less than that is reached with comparative ease with materials and modes of construction already in practice. Let it also be understood that the mile as here considered is the statute mile, containing 5,280 feet; the nautical mile, or knot, has 6,080 feet, and while the latter is in sole use at sea, it is found that the statute mile is more convenient in yachting, particularly where the average cruising-ground is in land-locked water or near coast lines.

The improvement of speed in steam yachts can best be considered in three divisions; namely, the form and construction of the hull, the motive power, and the means of propulsion. These subjects we will discuss in order.

The form or model of a vessel has been the chief subject of study by naval architects for many years, and really astonishing improvements have been made even during the present generation. While the form of a vessel is of prime value when a fixed, moderate speed is required, when high speed is sought the model takes a secondary place, and is supplanted by the proportion of width to length, or, in more exact terms, the relation of the sectional area to the length. It is, however, presumed that some regard is to be paid to the lines; that is, an attempt is made to mould the form so as to present an easy entrance and exit.

There is a certain speed that attaches to every vessel, which may be called its natural rate; it is mainly governed by its length and the length of the carrier wave which always accompanies a vessel parallel to her line of motion. When a vessel reaches a speed great enough to form a wave of the same length as the moving body, then that vessel has reached her natural rate of speed, and all that can be obtained above that is done by sheer brute force. The natural limit of speed of a boat 40 feet long is about 10 miles an hour; a vessel 60 feet will show $12\frac{1}{4}$ miles; one 100 feet, $15\frac{3}{4}$ miles; one 200 feet, 22 miles.

The power employed in propelling a vessel up to her natural limit is in regular proportion to the cube of the speed attained; but when she is forced above that point, the power expended is in greatly increased ratio. For instance, imagine a vessel the natural speed of which is fifteen miles an hour, to obtain which 350 indicated horse-power is required; then the power for twelve miles an hour would be about 180 horse-power; for eighteen miles, over 700 horse-power, and for twenty miles, about 1,000 horse-power. This illustration is approximate, depending on the displacement and weight of the vessel.

The greatly increased power required in making the higher speeds is absorbed by forcing the vessel up an inclined plane, owing to the situation of the carrier wave, the crest of which is so located that the larger portion of the hull is on the falling side, causing the vessel to climb, as it were. Much power is also absorbed by a secondary series of waves.

In this situation lightness of construction will be found to be the greatest factor of speed so far as the hull is concerned, general proportions being first. In the future high-speed yacht we must look more to the subject of lightness of construction, so that greater swiftness can be attained.

In the construction of vessels less than eighty or one hundred feet in length, it is found that wood can be employed with better results of lightness when a reasonable degree of strength and durability is required. In vessels of the size mentioned, if of steel construction, it would be found that durability would be sacrificed if a hull sufficiently light were built to attain the highest speed. Thin steel plates can be made only fairly durable by the utmost care, such as frequent painting, and have to be kept as little as possible afloat, particularly if in salt water.

Some attempts have been successfully made to modify the form of a yacht, with a view to preventing the tendency to lose proper fore-and-aft trim when at top speed. The yacht "Now Then" is a well-known example. Her stern is carried out into "a straight flat," a fan-tail; it slides over the surface of the water, and prevents her stern from settling. As a factor of speed it is successful, not only in its designed intention, but in preventing the access of air to the region of the screw, thus allowing it to be placed near the level of the surface of the surrounding water without danger of racing.

Some improvement in the model of vessels may be made so as to lessen the size and number of secondary waves formed when at high speed; or by a change in the model it may be possible to mount the carrier wave so as to bring the weight of the hull on the forward or advancing side, when an effect similar to sliding down hill can be had, which result has already been reached in extreme examples of high speed, mostly by torpedo-boats.

The most hopeful quarter in which to look for increase of speed from modification of hull is through the employment of new material that combines lightness, strength, and non-liability to corrosion; but at present it is difficult to see where such a material can be found. Aluminum bronze is near it and doubtless will be used in the near future, but it is too costly, and has practical difficulties besides. Much also may be expected from the alloys of steel and aluminum and steel and nickel, which, so far as lightness and strength are concerned, leave little to be reasonably hoped for.

A factor of speed not always the recipient of proper attention is the character of the wetted surface of a vessel. A smooth, glossy surface, and one that repels water, is greatly to be desired, to which qualities that of anti-fouling must be added. Some of these qualities are found in applications in present use; but much can and must be done to lessen the drag of friction on hulls, particularly if they be of metallic construction.

The motive power should perhaps receive the first place in the consideration of high speed, as it stands at the head of prime factors of all progress in manufacturing, railway practice, and navigation. The steam-engine is the only motor that has ever been successfully employed in the attainment of high speed, and from the present outlook it appears as if it would continue to occupy its well-earned position. In the last ten or fifteen years several new motors have been brought to the attention of the public, but for the purposes of this article they are unworthy of consideration.

Electricity has been successfully employed in small vessels as a motive power, but high speed with it has not been reached; yet it would be unwise to say, in face of the astonishing advancement in electrical science, that it may not at some future day answer some special requirement; but as we find it to-day it is absolutely useless where high power and fairly long periods of functioning are necessary.

The steam-engine in its usual form is poorly adapted to use in the development of high power. Steam at pressures far above those employed in the time of the plain or even the compound engine is now commonly and successfully used. Steam above 250 pounds' pressure to the square inch is a far different agent from what it is at pressures generally employed a few years ago. In many of the new torpedo-boats of the smaller class, steam at 300 pounds' pressure is used; and if possibilities are to be considered it is best to take that as a probable pressure.

An engine, to work successfully under a pressure of at least 250 pounds and with 400 revolutions a minute, must be specially designed for such high duty. Not only must the material be the best obtainable, but the bearing surfaces must be greatly increased in area, so that unusual strains can be carried at great velocity, thus allowing adequate chances for lubrication.

In making large cables for bridge-building, wire is used that will stand a pull of 250,000 pounds for each square inch of sectional area, but steel of such abnormal strength cannot be obtained in large masses, even one inch in diameter. So the engine-builder must be content with steel that will sustain a tensional strain of only 65,000 pounds, and if he finds it with all the other desirable properties, he is fortunate.

In considering the possibilities of the engine, the greatest hope is in reducing the ratio of weight to power. It is the same idea as in the improvement of the hull—reduction of weight with increase of strength. The "Stiletto's" engine weighs ten pounds for each indicated horse-power; it is a compound engine of peculiar design, but since the date of its construction new conditions have surrounded the marine engine, and to-day the working pressure has nearly doubled over that used six years ago, when the "Stiletto" raced with the "Mary Powell" on the Hudson. So far as the engine alone is concerned, the compound will give a higher duty for its weight than those of higher expansion; but the latter have so many marked advantages that their employment where high speeds are desired is now considered the best practice in marine engineering.

In the triple and quadruple expansion engine the forces are more widely distributed than in the compound, and they are capable of being more exactly balanced; so vibrations are not communicated to the hull in such violent form as with the compound.

The engines of the torpedo-boat "Cushing" are perhaps the best form for high speed extant; they have each five cylinders, so that the expansion is quadruple (the low-pressure cylinder being divided), the strains are widely distributed, the moving parts as light and as well balanced as possible; with the exertion of 1,600 indicated horse-power they run smoothly and with less risk of injury by momentum of connections, and will function for a longer period under trying conditions than any other form of engine in use.

The engines of the "Cushing" exert a horse-power for each fifteen pounds' weight, but, although heavier than the engines having lower rates of expansion, still by reason of greater economy less coal need be supplied to perform a given amount of work; so the displacement of the vessel is no greater.

It is not expected that the form or general arrangement of the present torpedo-boat engine will undergo much change to fulfil increased demands; but improvements in material, details of moving parts with a view of rendering the machine more easily manipulated, etc., seem easily within reach, and already are receiving the earnest attention of designers.

The generator of steam, or boiler (as in old times it was called), presents a wider field for improvement than any other element of the motive power. As in the case of the hull and engine, the great question to be solved is to lessen weight and at the same time to increase power, both in ability to carry higher pressure and in freedom of steaming. When pressures of 250 or 300 pounds per square inch are considered, the shell boiler is prohibited at the outset, on account of the great weight that would be required to withstand such a pressure.

The tubular boiler is a form that has received a large share of attention from builders, and still its condition is far from satisfactory when economy of fuel, durability, light weight, and accessibility are considered. The more the boiler is subdivided into many integral parts, the lighter each part or tube can be made, the more is danger resulting from a rupture lessened. It is confidently expected that some alloy of aluminum and copper will soon be used in boiler-making, especially as a material for the tubes. Steel is too liable to injury by corrosion from within, as well as from outward exposure. It is true that steel, so long as it lasts, can be made as thin as required for extreme lightness; yet in the consideration of future possibilities it is assumed that practicability is not to be wholly waived, nor the entire construction given over to the one object of high speed.

It is quite reasonable to think that great improvements will be made in fuels and their management. Much has been done with coals, and more can be if always the best means be employed in its combustion. Mechanical stoking and cleaning of fires can be practised with success in high service. The mechanical control of fires is also highly desirable from a humanitarian viewpoint. At high pressures steam is so hot that unless all pipes and exposed surfaces of the boiler be carefully isolated, the temperature of both engine- and boiler-room may become unbearable, even with the best means taken for circulation by fans. Many experiments have been made with liquid fuel, with some measure of success, but while this fuel is very desirable because easily managed and controlled, still its use for even special situations has not prevailed; still with so many determined inventors and experimenters it is to be hoped that some system may be reached by which the hydrocarbons may find the place in marine engineering that they deserve.

The means of propulsion do not present so wide a field for improvement as the foregoing. The paddle and screw are the only agents that are worthy of special notice.

The paddle is best adapted to comparatively sheltered waters, and on account of slow motion the machinery connected with it must be more heavy and ponderous than that for driving a screw. Very high speeds have been reached by the use of the paddle, and still greater results can be obtained by perfecting the means of feathering and by close attention to the elimination of everything that would disturb the surface of the water through which the vessel is passing.

The screw is far more advantageous than the paddle for the development of high speed. It is much lighter, and on account of the rapidity of revolution the engine can also be less weighty than in case of the paddle. With a screw well immersed and favorably situated as to working in fairly undisturbed water, the amount of power that can be transmitted through it is amazing.

Recent transoceanic practice is decidedly tending toward the use of the twin screw, and by its employment the fastest passages across the Atlantic have been made; but it may be doubted if just as swift passages might not be made with a single screw using the same power. The use of the twin screw, however, has many marked advantages which cannot fail to place it in the highest rank of marine adjuncts where speed and safety are prime consideration.

Triple screws have also been successfully used, but the advantage of their employment for other than special reasons can well be doubted. The form of the propeller screw has been a subject of deep study and untiring experiment. The gain in efficiency from the commonest to the best approved form is so slight that we cannot expect with reason much increase of speed from that quarter. All that can be done is to make the screw of the best and strongest material, of the best design, polish it, and balance it; and if it be placed in a situation where it can work in the least disturbed water, then all is done that can be done, and with the exception of the oft-suggested improvement in material little can be expected from the future screw to increase the speed of vessels.

A comparison of the weights of the entire motive plant of different steam vessels shows that much has been done in reducing the weights and consequently the displacement.

The motive plant of the "Cushing" weighs about sixty-five pounds for each horse-power exerted; that of the steamship "City of Paris" about 200 pounds; the former has eight times the power when compared with the displacement of the latter.

Some idea of the power required to attain the highest speed in small vessels may be had by the above comparison. The "City of Paris" at her top speed is not forced beyond her natural rate, while the torpedo-boat is driven far beyond her rate as prescribed by length and displacement.

From a general view of the subject it would appear that no marked gain in speed can be reached by confining the attention to any one element or factor of speed; but by a constant devotion to the details of construction, particularly with a view to lessening weights, much can be done to increase the speed of yachts and other vessels, even with the materials now obtainable.

With means now available a speed for a yacht of twenty-eight miles an hour is quite within our reach; that is, for a run of five hours' duration. Shorter runs at a rate of thirty-one miles an hour have been made by a few torpedo-boats, and whatever this class of vessels can do may be taken as a measure of the possibilities of a yacht, and indeed more; for when the warlike apparatus is omitted the chances for attaining the highest speed are increased.

It would not be wise to place an actual limit on possible speed, but we can only admit that, as progress has been made in the last decade, raising speeds from 40 to 50 per cent., it is not unreasonable to expect a still further gain, although not so marked a one. It is surely within the bounds of reason to say that by the opening of the new century steam yachts having a speed of thirty-five miles an hour will be no uncommon thing; and it is also to be hoped that, with the improvement of materials of construction, there will be a like strengthening of human tissue, both in nerve and muscle, for both will be taxed to their utmost in the management of machinery and the guidance of vessels under such conditions.

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NOTE.—A steam yacht built to the order of William E. Hearst, of San Francisco, Cal., has just been launched in Bristol, R. I. She is 112 feet long, and has an engine of 800 horse-power. This yacht is intended to be the fastest afloat. By the terms of the contract she must attain a speed of twenty-five miles an hour. She is seaworthy enough to make the voyage to the Pacific coast by the way of the Straits of Magellan.—L. H.