tendency due to wind, which in high buildings with narrow base is considerable. In low buildings, where there is no other consideration but direct compression, sound cast-iron columns form a suitable material; but in lofty structures even this direct stress is complicated by the tendency of all loaded columns to buckle sidewise when their length is excessive, and this must be resisted by lateral bracing for which cast iron is not adapted; moreover when there is added the bending due to the overturning efforts of the wind, there arise conditions of design and detail to which cast columns are entirely inadequate.

There are many architects and engineers in New York who can safely be intrusted with the safety of public, laboring, and property interests in the design of such structures; but for the much larger body of the less experienced the building code should be carefully amended and enforced. Demand has been made for superintendents with five years' experience, and for a sufficient staff of competent inspectors empowered to enforce the code; but the Darlington disaster strongly teaches that all obscurity should be eliminated from the code itself, and specifically that the use of cast-iron columns be absolutely limited to wall-bearing buildings, and to those less than seventy-five feet in height.

THE STEAM TURBINE AND ITS FIELD IN MARINE WORK.

BY LIEUT. H. C. DINGER, U. S. N.

The steam turbine continues to develop with improvements in economy, a lessening in weight, and more ease in manipulation. That it has a future useful and brilliant can no longer be doubted. At the same time, there is no immediate likelihood of reciprocating engines being displaced on steamships in general and relegated to the dump as relics and bygone devices.

A brief *résumé* of the peculiar advantages of the turbine, in distinction from the reciprocating engine, viewed from a practical standpoint, may be seen in the following:

For the same power delivered at the shaft, it is considerably lighter than the reciprocating engine. This relative weight is, however, liable to be a very misleading factor, since the weight of quite similar installations of reciprocating engines differs very widely. The weight of the turbine engine alone (Curtis) on the yacht "Revolution" is 8¾ pounds per equivalent I. H. P., while the weight of United States torpedo-boat engines alone is about 11½ pounds per I. H. P. As the torpedo-boat engines are built especially light and the "Revolution's" turbine was not, the probable advantage of the turbine, when developed, will be greater.

In the turbine, there are no other than the shaft bearings, and hence the cost of lubrication almost disappears. Roughly, in marine work one gallon of oil is used per ton of coal; and as a gallon of oil will cost about one-tenth the price of a ton of coal, it can be seen that there are presented very favorable conditions for materially reducing running expenses.

Fewer attendants are required, and thus the wages bill of the engine-room force can be greatly reduced, since the oilers for main engines can be dispensed with.

The space required will not differ very materially from what is necessary for the reciprocating engines, but less height and less length are needed, so the turbine does have some advantage here, and in special cases very material ones. However, for large, moderate-speed merchant vessels, the slight decrease in space will not be of very great importance. Little noise and no vibration are produced by the turbine engine. There is little likelihood of breakdown, and the turbines can run for very long periods without any necessity for adjustment of parts, since the tangled mass of joints and bearings that, in a reciprocating engine, may get loose, are absent. To secure good efficiency, the turbine must have a high peripheral speed. This can be obtained by a high number of revolutions or by an increase in diameter of the turbine disks or drum. To secure economical results, there must be a very good vacuum. When running at reduced speeds, the turbine decreases very materially in economy.

From the above, some idea of the peculiar sphere of the marine turbine may be gleaned. The favorable conditions are: 1. Continuous running at full power. 2. Where a high number of revolutions is not objectionable. 3. Where there is a desire to avoid vibrations. 4. Where saving of weight and space is of great importance. 5. Where economy in running expenses is important. Where a reduction in the number of attendants is greatly desired. It may be observed that not every type of craft presents conditions favorable to the use of the peculiar advantages of the turbine.

It would not seem to be suitable for tugs, ferryboats, or passenger steamers making short trips and frequent stops, because these are constantly stopping and starting, and do not run continually for any length of time. Moreover, for towing, a comparatively low number of revolutions is desirable. It is, likewise, not peculiarly suitable for large, slow freighters, on account of the desirability of having a low number of revolutions for propellers, and the characteristics of less weight and no vibration are here not of very great value. It is not peculiarly suitable for moderate-speed men-of-war, because they do not, as a rule, run full power for any length of time, and it is also here not desirable to have a high number of revolutions for propellers.

The types that the turbine would be suitable for are: Fast passenger steamers, making long trips at full speed. Here economy, less weight, no vibration, and reduction in attendants are greatly desired, and a higher number of revolutions for the propellers is more advisable. In fast scouting cruisers and torpedo boats the desideratum is a maximum speed on the least weight, with no special desire for economy at low speeds. In this case, anything that will reduce weight and the number of attendants will bring very potent advantages.

TYPES OF TURBINES.

The two types of turbines proposed for marine work in this country are the modified Parsons, built by the Westinghouse Company, and the Curtis turbine, being now largely built by the General Electric Company. The chief distinguishing point of difference between these two types is that in the Parsons turbine the expansion of steam takes place while passing through the turbine vanes. The casing in this type is under pressure, while in the Curtis turbine the expansion takes place in nozzles, and the casing in this case is not under pressure above that of the expanded steam. Owing to these differences, the Parsons turbine is long and the casing has to be designed heavy to stand the pressure of the steam. The Curtis turbine is much shorter, and the casing can be made lighter.

Some of the principal points that a successful marine turbine should possess may be stated as follows: It must be easily reversible. This can now be successfully accomplished in both of the above types by providing a set of backing vanes on which steam may be caused to act by opening the reverse valve and by closing the one admitting steam to the go-ahead side.

It should be as light as possible, and for this reason it would seem that the expansion, and hence heavy pressure, should be confined to the nozzles (which are small) so that the casing may be made light. Supposing we have an absolute pressure of 250 pounds and a vacuum of 26 inches. The total expansion possible is 125 times. If this is divided into three stages, there will be an expansion of five times in each stage. Expanding 250 pounds five times gives 50 pounds absolute, and again five times, 2 pounds absolute or 26 inches vacuum. If the expansion takes place in the nozzle, the first part of the casing has to stand 35 pounds per square inch, while the remainder of the casing may be under a vacuum. In this way, the necessity for a great weight in the casing is obviated.

The expansion should be complete in each turbine engine, and not divided into H. P. and L. P. on different shafts. Each engine should be entirely independent.

The number of revolutions should be reduced sufficiently to keep speed of rotation of propellers below a point where any great loss due to cavitation is likely to result.

The number of parts should be reduced, and hence the mounting of turbines on a single drum, as in the Westinghouse Parsons type, would have advantages over the separate disks employed in the Curtis and Rateau.

Extreme fineness of adjustment should not be absolutely necessary, as it cannot be expected that there will be specially fine appliances or expert personnel on every vessel. Where the expansion takes place between the vanes, clearance must be very little, and bad adjustment is likely to result in considerable loss. On the other hand, when the expansion takes place in a nozzle and the steam acts by impact, clearance will not be such a great source of loss.

A high vacuum is important. The economy will depend on the number of times the steam is expanded. Supposing there is a pressure of 200 pounds absolute and a vacuum of 26 inches or 2 pounds pressure absolute. Then there are 100 expansions. Supposing vacuum drops to 24 inches or 3 pounds; the expansion is here only 66 2-3 times. If vacuum is increased to 28 inches or 1 pound, there are 200 expansions. Taking variations in pressure, suppose pressure is lowered 50 pounds, so that we have 150 pounds and 26 inches vacuum; the number of times the steam can expand is 75. It can thus be observed that a drop of 2 inches in the vacuum makes more difference in the relative economy than a drop of 50 pounds in the steam pressure. This is an important point to always have in mind.

It may then be stated as a broad principle that the economical efficiency of the turbine will depend directly on the efficiency of the condenser and air pump, and that for practical results even more attention must be paid to the efficient design of air pump and condenser than to the details of the turbines themselves. It may also be observed that turbines should be more efficient where there is cold injection water, and that if turbines are installed in torpedo boats, a good separate air pump must be supplied.

SUPERHEATED STEAM.—Another great field that the turbine may develop, and to which it peculiarly adapts itself, is the use of superheated steam. In the reciprocating engine, superheated steam is quite objectionable, owing to the difficulty presented by internal friction and the great wear caused to cylinders and valve liners. With turbines these difficulties are entirely absent, and the advantages of superheated steam can be made use of to the limit of its development. The turbine thus presents at the start the possibility of greater economy than the reciprocating engine.

OBJECTION TO OIL.—As the turbine does not use any oil for internal lubrication, the difficulties due to the use of cylinder oil getting into boilers will be greatly lessened, but as various auxiliaries and pumps will be driven in the same way as heretofore, this trouble will not be entirely eradicated.

POSSIBLE GAIN IN WEIGHT.—Although the turbine engine may be considerably lighter than the reciprocating engine, the gain in less weight of machinery will not be very great. The weight of main engines is only a part, and not the major part, of the weight of the machinery installation. The boilers roughly weigh half, and the auxiliaries in engine rooms on men-of-war weigh more than the main engines. The main engines with crank shafts on recently completed battleships weigh from seventeen to twenty per cent of total machinery weights, so that should there be a reduction of fifty per cent in the weight of main engines by the use of turbines, there would only be a reduction of less than ten per cent in the total weight. But as there may be an increase in condenser weights and weight of air pump, the probable figure will not be much more than five per cent. It can thus be seen that for men-of-war no overwhelming reduction of weight is likely to result. In merchant vessels, the main engines are so much larger a percentage of the total weight, that here there will be a greater percentage of weight saved.

The apparent points of advantage that will probably bring the turbine into use are: 1. Reduction in cost of production for same power, when the manufacture has developed sufficiently. 2. Reduction in running expenses produced by less attendants and almost non-use of oil, and reduction in repairs and overhaul. It may be a question whether this decrease in running expenses will counterbalance a probable increase in steam consumption under the conditions imposed on board ship; namely, low revolutions and variable output. This, of course, can only be told by actual trial. The data at present available on this point are not much more than guesswork. It is these practical points in the matter of the expense account that will determine the adoption of the turbine for general work in the merchant marine. In the navy there are a number of other matters that should be considered.

SCIENCE NOTES.

In the Royal Society Proceedings there is described a comparison of plants grown under normal conditions with similar plants grown in an atmosphere containing about 3½ times the normal amount of carbon dioxide. The investigators, Dr. Farmer and S. E. Chandler, state that under abnormal conditions the internodes remained shorter and the surface growth of the leaves is arrested earlier. The number of stomata per unit area of leaf is much greater, but, owing to the reduced size of the epidermal cells, the proportion of stomata to epidermal cells is not altered; the guard cells of the stomata are not, however, reduced in size. The anatomical structure of the stem varies very slightly, in some cases the wood vessels are fewer in number, and this is probably correlated with the diminution in size of the leaves, although disturbance of the general metabolic processes is also quite a possible explanation.

According to Dr. Graham, of Beirut, another disease is to be set down against the mosquito, namely, dengue fever, variously called African fever, break-bone fever, giraffe fever, dandy fever, etc. The disease is an acute eruptive fever, rarely fatal, but leaving various disagreeable sequelæ—paralysis, insomnia, marked mental and physical prostration, etc. It occurs in hot climates and in the Southern States; during the last fifty years several serious epidemics have occurred. Dr. Graham found that he could regularly produce an attack of dengue in a non-immune by submitting the latter to the attack of mosquitoes which had fed on sufferers from the disease. In one experiment he carried dengue-infected mosquitoes to a mountain town 3,000 feet in altitude, where there were no mosquitoes and no dengue. One of the natives was shut up in the room with the mosquitoes, and on the fourth day came down with a sharp attack of dengue, and a second presented the typical symptoms on the fifth day. The mosquitoes were immediately destroyed, and no further cases occurred. Dr. Graham also claims to have discovered the germ which causes dengue in both human blood and the stomach of the mosquito. It resembles some forms of the malarial parasite.