

ous and constant in amplitude. One of these methods for the conversion of direct currents into high frequency oscillations was described in a recent issue of the SCIENTIFIC AMERICAN, and as it was then pointed out, the system utilizing it gives much promise of solving the problem of selective wireless telegraphy.

Elihu Thomson was the first to discover that a direct current could be converted into an alternating current by shunting a suitable capacity and inductive around an arc light. Duddell then showed that by varying the coefficients of the shunt current the arc would emit a continuous musical note. The alternating currents thus produced represented a very small percentage of the direct current impressed upon the arc light and further, the currents thus obtained were of comparatively low frequency, being the equivalent of the musical note emitted, and these were, of course, much too low for the radiation of effective electric waves. Poulsen has recently found that if the arc is produced in an atmosphere of hydrogen or other gases, oscillations will surge through the circuit that are of the order of hundreds of thousands per second.

The object of inclosing the arc light in hydrogen—illuminating gas suffices very well—is due in a measure to its cooling effects, for the oxygen is excluded. It has been further ascertained that by placing the arc in a strong magnetic field the voltage drop in the arc is quite low considering its unit length, that is to say, it requires 440 volts to produce an arc 1/8 inch in length. Where these conditions prevail, it is possible to increase, within certain limitations, the inductance of the circuit without further increasing its capacity, and this permits the potential difference of the terminals of the circuit to be larger than would otherwise be possible.

The principles of resonance that have been so carefully and laboriously worked out in the past will not be lost in the commercial application of the new method, for without the knowledge of timing the circuits continuous oscillations would prove of but little worth. With a transmitter of the hydrogenic arc type and a receptor in which the oscillation circuits are arranged so that the damping factor is reduced to the least possible extent, the degree of accuracy of timing is said to be about one per cent, namely, that two stations equipped with this apparatus may communicate with each other with waves of 600 yards in length and two other stations at the same time in the same field of force with waves 606 yards in length and without any untoward result of interference. Since wave lengths varying from 300 to 3,000 yards may be used, several hundred stations may cover the same territory without suffering from the effects of the others.

There are methods other than the one cited by which continuous oscillations can be produced, but with the results already obtained there is sufficient encouragement to warrant a belief that the limitations which hedged in wireless telegraphy are to be greatly extended within the next few years, and its usefulness, now generally recognized, will prove a more potent factor than ever in the transmission of the world's intelligence.

ADVANTAGES OF TURBINE PROPULSION FOR BATTLESHIPS.

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Repeated comments and the charges of uncalled-for unprogressive conservatism in the Navy Department for not requiring turbines for the propelling machinery of battleships, have caused me to think that the setting forth of some particulars of underlying information regarding the relative merits of turbines and reciprocating engines might be of interest. It must be granted that if turbines (a new and unfamiliar system of machinery) are to be adopted in place of reciprocating engines (an old and familiar system), they should have proven, beyond a reasonable doubt, one or more paramount advantages, which will warrant the making of the change.

What are the advantages of turbines for propelling battleships? The following are sometimes urged: Reduction in weight and space, greater simplicity, less attendance, greater economy, absence of vibration.

Reduction in Weight and Space.—This is a chimera, which may sometimes be found in theory, but has not been proven in practice. The actual marine turbine may weigh slightly less than the best type of reciprocating engine of the same power, but the increase in condensing apparatus and other auxiliaries necessary to the proper operation of the turbine will about balance this saving. Apropos of this, a somewhat misleading comparison has recently appeared in scientific magazines, where the reciprocating engine of a battleship, of a design six or seven years old and built to suit battleship practice, is compared with the turbine of a scout of four years later design and built on the weight schedule of a torpedo boat. A rather fairer comparison might be made by taking the reciprocating engine of the scout's sister ship, which is of same power. Had this been done, the startling advantage in weight for the turbine would have vanished, as would also the

great discrepancy in size. For heavy fighting vessels, turbines have, thus far, not demonstrated that their use will produce a material reduction in weight. Neither is there any very material gain in floor space, if the machinery is installed with an idea of doing any overhauling. Head room is gained, but a great deal of space is necessary for lifting the casings. Large hatches are even more necessary than with reciprocating engines, so that the space that could be gained by the turbines in battleships is extremely slight.

Greater Simplicity.—While the turbine principle is of itself more simple than that of the reciprocating engine, the whole arrangement of the motive power of the type of turbines most in vogue, the Parsons, is not as simple as for an arrangement with reciprocating engines. In the Parsons system the power is developed upon four shafts in place of the two in ordinary use. This naturally leads to some complication and, it may also be remarked, will make it much more difficult to quickly change the direction and speed of these engines for maneuvering purposes. It will naturally be somewhat more of a problem to handle a vessel with four screws than one with only two; and this is something to consider, when quick and reliable maneuvering ability is one of the essential qualities that a battleship should have.

The adjustments of the turbine engine will require considerably greater accuracy than those for a reciprocating engine, and the ill-effect of mal-adjustment is much more serious. Due to slight inaccuracies in alignment, there is danger of many blades being torn out by striking the casing. A hot bearing becomes a very serious matter, since the melting of the white metal is liable to cause the ends of the blades to strike.

The turbine requires the same auxiliaries as the reciprocating engine and a few additional ones, besides larger condensers and air pumps.

There is practically no difference in the number of attendants required for a naval vessel. Though there may be some reduction in the work of oiling, this possible reduction is to a great extent counterbalanced by the fact that turbines are unfamiliar machines, and the engineering personnel will not, for years, understand their operation as well as they do that of the reciprocating engine.

Greater Economy.—At the designed speed, that is full speed, marine turbines are about as economical as the best reciprocating engines now being built. When the speed is decreased, the steam consumption of the turbine, per unit of power delivered, increases very rapidly, so that at one-half power and below, it is considerably more than that of the reciprocating engine, and at low powers, several times as great.

To show how this works out in practice, I will take the results of the "Dreadnought's" trial, as taken from the notes published in the November number of the Journal of the American Society of Naval Engineers, and compare these with some results obtained with the U. S. armored cruiser "Maryland" while in service. The engines of the "Maryland" are not up to what is now the best economical design of reciprocating engines; and they were designed about seven years ago. Reciprocating engines fully 10 per cent better in economy are now being built for large naval vessels. The results are taken from service runs with ordinary American coal and with an ordinary crew, made up largely by recruits.

The coal used on the "Dreadnought" was no doubt about the best in the English market, and probably contained 16,000 B.T.U. per pound. The coal used on the "Maryland" averaged about 14,000 B.T.U. per pound. Considering these differences (13.3 per cent in heating value of coal, and the fact that in one case the coal was in a measure at least picked, that a trial crew was used, and that efforts were made to obtain all possible economy to make a good showing for the turbines), an approximation to a fair comparison of results would be to take off 15 per cent from the "Maryland's" coal per I.H.P. and compare this with that of the "Dreadnought." (See last column under table of "Maryland's" performance.)

The boilers of the "Maryland" and of the "Dreadnought" are of the same type, Babcock & Wilcox, so that differences in boilers may well be left out, and the difference in coal per I. H. P. may be attributed to the engine installation.

By comparing the results, it will appear that the "Maryland's" reciprocating engines are, at designed full power, about as economical as the "Dreadnought's" turbines at full power. Below full power, down to 1/2 power, 22 to 18 knots, the difference is slightly in favor of the reciprocating engine; from 1/2 to 1/4 power there is about 30 per cent in favor of the reciprocating engine; and below 1/4 power the reciprocating engine uses 50 per cent and upward less coal.

The best reciprocating engines used in the merchant service are 10 to 20 per cent more economical than the full-speed performance of the "Dreadnought."

Avoidance of Vibration.—This the turbine accomplishes, and in this it has an important point of superiority. The vibrations of the reciprocating engines installed on battleships are, however, now so slight, due

"DREADNOUGHT'S" PERFORMANCE.

Power.	I.H.P.	Approx. Speed.	I.H.P. per pound of coal.	Pounds of steam per I.H.P.
1/12	1,748	9.0 knots	4.16	41.6
1/9	2,771	10.8 "	4.97	49.7
1/7	3,423	11.4 "	3.23	32.3
1/4	5,000	13.1 "	2.59	25.9
1/2	11,301	17.3 "	1.99	19.9
3/5	13,748	18.1 "	1.89	18.9
4/5	15,875	19 "	1.66	16.6
4/5	16,950	19.3 "	1.7	17
Full	23,000	21 "	1.51	15.1

"MARYLAND'S" PERFORMANCE.

Power.	I.H.P.	Approx. Speed.	I.H.P. per pound of coal.	Pounds of steam per I.H.P.
1/10	2,624	9.5 knots	†2.3	1.95‡
1/8	3,232	11.2 "	2.04	1.734‡
1/8	3,152	12 "	2.3	1.95‡
1/5	5,422	14 "	1.95	1.66‡
1/3	8,444	16 "	1.71	1.45‡
2/5	10,520	17 "	1.74	1.48‡
3/5	15,395	19 "	1.74	1.48‡
Full*	27,101	22.5 "	2.3	1.95‡

to improved balancing, that they offer no serious objection from a military point of view.

The advantage of economy of the turbine in marine work exists at a certain speed, which is the full speed for the turbine; when this speed is lowered, the economy drops rapidly. At 3/4 speed and less the best types of reciprocating engines are more economical, and below 1/2 speed they are twice as economical. If turbines are to be placed in battleships on the ground of economy, they ought to be reasonably economical at the cruising speed. The cruising speed of battleships will be a little above half speed, 11 to 14 knots, 1/5 or 1/4 power. At this speed the turbine will use 50 to 100 per cent more coal per unit of power developed. If it is desired to go full speed, the turbine will show a slight superiority in economy, but hardly over 5 per cent. The question then is: Will this slight increase in economy at top speed be worth the sacrifice in economy of over 50 per cent at the speeds that the vessel will ordinarily run? In those ships where full maximum speed is the essential point of their being, the turbine will have an advantage; but where full speed is not to be used continuously, this advantage disappears. Battleships will not cruise at 20 knots, nor at 18 either. It is too costly, and they do not carry sufficient engineering personnel to maintain such a speed for any length of time.

In view of all this, it seems that the superior advantages of turbines for propelling battleships have not as yet been conclusively proven, nor should the Navy Department be considered extremely conservative in not definitely requiring them without alternative for the battleships whose contracts are about to be let. It may be that in time such increased economy will be developed for the turbine at the lower powers that it will remove this serious objection which is now present.

The turbine, however, has a place in naval vessels where its advantages are fully worth while, and that is in vessels that are built primarily for speed and for continuous steaming at full speed. Such vessels are the scout cruisers, torpedo boats, and destroyers. Here the turbine has more of an advantage, and it is here that its merits should be developed.

There is also another field where the turbine is peculiarly applicable, and that is for operating the dynamo engines on board ship. This is a field where a constant speed of revolution is necessary, and where the turbine system should show with advantage its points of superiority. The proper procedure would seem to be to develop the turbine for those places where its advantages are greatest, and not to place this new and apparently popular motor in a place where it has as yet not proven its superiority in an all-round manner.

The Army and Navy Journal says that though England appears to be taking the lead in turbines, she has copied America far more in her types of screw engines than America has copied England. The prevailing types of screw engines first used in the mercantile marine and the navies of both countries are what are known as the "back-action," "direct-action," and the "vertical overhead cylinder" engines; and these types all originated in America. The first ship in the English navy which had her entire steam machinery below the water line, and the first one whose engines were attached directly to the screw shaft, was the "Amphion," the design of whose machinery was made in New York and sent to England.

\* On this trial steam was put in receivers, and safety valves were blowing part of the time. When all the steam passes through throttle, 25,000 I. H. P., which is 10 per cent above designed power, can be developed with about 1.8 pound per I. H. P., or with 15 per cent reduction, 1.53. The "Pennsylvania," a sister ship, has developed more than this on trial with an expenditure of 1.83 H. P. per pound of coal.

† Results obtained by dividing total coal used for main engines and all auxiliaries by the I. H. P. of main engines.

‡ I. H. P. per pound of coal after taking off 15 per cent to equalize on account of difference in coal and conditions.