gatherings and the renewal of old associations. I doubt not you will always turn with affectionate remembrance to your years in your alma mater and think kindly of the nights when you fell asleep while the Ball and Nordberg stamps beat time for the deep bass lullaby of the Copper Country's mills.

FUEL OIL IN UNITED STATES NAVY

By Admiral H. I. Cone.

The fuels used in the U. S. navy are coal, fuel oil and gasoline. Coal must have certain characteristics to make it suitable for naval use. One of the most important strategical requirements of a warship is her ability to steam great distances without recoaling. Another is her ability, in time of need, to make high speeds. As both bunker capacity and boiler power are limited by other features of design, it follows that the coal must have the greatest thermal efficiency obtainable in connection with the other necessary characteristics. High volatile coals are usually very smoky in naval boilers. Smoke not only reveals the location of the fleet, but might fatally interfere with accuracy of gun fire.

The advantages of oil as compared with coal are: An evaporation per pound of fuel in the ratio of about 14 to 9, and per square foot of heating surface in about the ratio of 10 to 8. Fuel can be taken aboard more rapidly without manual labor, and without interruption to the routine of the ship. The problem of fueling at sea is solved. Steam for full power can be maintained as readily as for low power. A vessel burning oil is capable of runs at full speed limited in duration only by the supply of fuel. There is no reduction in speed due to dirty fires or to difficulty in trimming coal from remote bunkers, or to exhaustion of the fire room force. There are no cinders and the amount of smoke can be controlled. A considerable reduction in personnel is possible. The weight and space required for boilers is reduced. First, by the reduction in heating surface required, and second by the shortening of fire rooms. Consequent on the reduction in heating surface is a decrease in weight and cost of boilers. Coal and ash handling gear is eliminated. This renders unnecessary the piercing of the hull for coal trunks and discharges from the ash expellers or ash ejectors. The stowage and handling of oil is much easier than of coal and will result in a much cleaner ship with consequent increase in time available for drills. The mechanical supply of fuel to the boilers gives a prompt and delicate control of the steam supply, permitting more sudden changes in speed than with coal, which is a tactical advantage. The nature of fuel oil permits utilization of remote portions of the ship and of constricted spaces for its stowage.

These advantages have long been recognized by the U. S. navy, and there have been experiments with liquid fuel dating as far as 1867. All these experiments have confirmed our belief in the considerable military advantages which will accrue from its use, but until recently it has been impracticable to use it extensively on account of the uncertainty as to the adequacy of its supply and the sufficiency of its distribution among the seaports of the world. We are now assured, however, as regards the supply, that there is sufficient oil on the public lands of the state of California alone to supply all probable naval demands for one hundred years should oil be burned to the exclusion of coal, and of course there is considerable oil in other portions of United States territory. The question as to the distribution of oil among the ports from which fuel might be required by our vessels in time of war is one that is well within our power to solve, as from its nature the oil can be transported and stored more easily than coal. Indeed for transport of oil in time of war we are already better provided than for coal, there being a large number of tank steamers flying the American flag. Oil is therefore certain rapidly to replace coal as a fuel for navy purposes.

Since 1907 all torpedo boat destroyers contracted for, of which there are twenty-nine, burn oil exclusively, and the battleships "Delaware," "North Dakota," "Florida," "Utah," "Wyoming," "Arkansas," "Texas" and "New York," contracted for during this period, are fitted to burn oil as auxiliary to coal, each of these vessels carrying about 400 tons of the liquid fuel to be burned at full power after the coal fires become dirty, or when it becomes difficult to trim coal from the bunkers in the fire rooms. In the case of these battleships the advantages of the oil have so appealed to the personnel that oil alone is burned to a great extent in port, and to some extent while cruising, although the installation of the oil burning equipment did not contemplate these uses.

The "Nevada" and "Oklahoma," the two battleships which have recently been contracted for, will burn oil exclusively. This is perhaps the most radical development in naval engineering since the advent of the turbine. It has permitted in the case of these vessels a reduction in boiler weights, which has made possible the use of heavier armor than has hitherto been employed. The reduction in length of boiler compartments has permited the grouping of all boilers under one smoke pipe, which course clears the upper deck considerably and permits more extensive arcs of fire for the turrets.

Aside from the use of oil as fuel under steam boilers, it now seems probable that within comparatively few years oil used in internal combustion engines will furnish the principal fuel for all naval vessels. This is in consequence of the recent remarkable development of heavy oil engines of the Diesel type in Europe. Hitherto, oil engines have not merited much consideration for large naval vessels on account of the limited power that could be developed in a single cylinder. An installation of any considerable power required a multiplicity of cylinders. Now, however, we are credibly informed that 1,000 horse-power has been developed in a cylinder about 33 in. in diameter with a 40 in. stroke, at 150 revolutions per minute in a two-cycle marine type readily reversible engine. This engine has a speed control that is satisfactory, and an economy of fuel consumption probably twice that of a steam engine.

In the United States navy heavy oil engines built or so far projected are limited to a number of submarine vessels and to mother ships for submarines. The former develop 1,200 horse-power, distributed between two shafts, the latter 900 horse-power on one shaft.

Gasoline is used as fuel for all of our earlier submarines and for a large number of small power boats

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