from the time they are started until the interior lining is worn out, and the furnace has to be "blown down" to receive a new lining. Since the stopping of a furnace and the building up of the inner lining are extremely costly, it becomes a question whether the best economical results are obtained by driving the furnace at a moderate speed, and thereby prolonging its life, or driving at extremely high pressure, with a view to securing a very large annual output, and making repairs at correspondingly frequent intervals. British practice favors the first method, American the second ; our ironmasters believing that since "a lining is good for so much pig, the sooner it makes it the better." The difference in practice is shown by the fact that whereas the largest Middlesbrough furnaces, with a capacity of 36,000 cubic feet each, produce only 950 tons of pig iron per week per furnace, the Duquesne furnaces, with a capacity of 25,000 cubic feet, have produced 4,200 tons per week. Of course, the life of the American furnaces, working under this terrific pressure, is very much shortened, lasting on an average only four years, as against one case where the lining of a British furnace lasted eighteen years.

Another broad distinction between British and American furnaces is sententiously expressed by The Times correspondent, when he says "nothing seemed to me more notable at the Duquesne Works than their loneliness." He further says : "Had it not been for the subdued hum, characteristic of a furnace in blast, one might have thought that the works were shut down,"—so completely had mechanical appliances taken the place of hand labor. In the production of steel ingots, rails, plates, etc., from the mine to the mill, the American instinct for labor-saving has been followed even to detail. From the iron mine in Minnesota to the shipment of the finished product on the cars at Pittsburg, the American ironmaster does not expect any hand labor to appear in the whole process of manufacture, the single exception being the filling of the buckets which take the ore out of the ship on the lakes, for which spadework is employed.

Of course, as has been suggested above, one great advantage enjoyed by American steel manufacturers is the extraordinary richness and accessibility of the iron ore in the Lake Superior region, immense masses of which lie on the slopes of the hills, covered only by a thin layer of surface soil. A railway track, quickly laid over the surface of the ground, brings into operation a steam shovel which, digging up the ore at the rate of five tons to the shovelful, at five strokes will fill a 25-ton ore car, and will load a train of cars at the rate of 600 tons an hour. The significance of such work as this, in connection with mines so extensive and rich, will be more fully appreciated when we remember that in the Mesaba range alone there are in sight 400,000,000 tons of iron ore.

PETROLEUM FUEL FOR WARSHIPS.

BY ALTON D. ADAMS.

The speed and steaming radius of fighting ships is of the highest importance. Unfortunately, however, the requirements for high speed and for a long steaming radius are conflicting, both as to equipment and operation. The higher the speed to be maintained the greater must be the weight of driving machinery in a given case. The greater the actual rate of speed for a ship, the shorter its steaming radius. Both of these conditions result from the fact that the power required to force any vessel through the water varies approximately as the cube of its speed. A very large part of the tonnage or carrying capacity of a modern warship is taken up by its driving machinery and fuel, so that the constant effort of designers is to lighten the engines and boilers and extend the coal spaces. In so far as the fuel capacity of fighting vessels can be increased, the steaming radius can be lengthened, or the speed over a given distance raised. As far as can now be seen, the capacity for coal in war vessels has been pushed to nearly its utmost limit, unless some important modifications are made in the structure of their hulls or in the weights of the contained machinery. The tendency seems to be toward heavier instead of lighter armor in the most important classes of battleships, and while some gains are being made in the weights of engines and boilers, the net result in this latter direction can hardly be very important. At present the great naval powers of the world are nearly abreast of each other in the adoption of improvements as to the construction and equipment of ships of war. The foregoing makes it quite evident, however, that any great power, applying means to largely increase the fuel capacity of its ships, without impairing their efficiency in other respects, would gain a decided advantage.

Especially would this be true if the means by which the large increase of fuel capacity is attained, is not generally available for the other powers. The ships having longer radii of operation, because of fuel capacities, beyond others of their class, would have still another advantage if the increase extended to the possible speed with given equipment Important as are the advantages just pointed out, they are to-day within the grasp of two of the greatest powers, Russia and the United States. Petroleum is the fuel whose substitution for coal on warships will largely increase their steaming radii and to a smaller extent their speeds. As by far the most important deposits of this substance, thus far developed, are in the United States and Russia, the advantage of these countries in its use is plain. The ability of petroleum to largely increase the fuel capacity of fighting ships, without changing their present dimensions or machinery equipments, lies in its greater heating power over coal per unit of weight and volume. Steam coal of the best grades develops approximately 14,000 heat-units per pound, on perfect combustion. The high grades of petroleum yield 21,000 units of heat per pound, when fully burned. With these two fuels in actual use under steam boilers, the results in the evaporation of water are more favorable to the petroleum than the figures just named indicate, because it is practicable to get more nearly perfect combustion of the oil than of the coal. In present ships, therefore, devoting the same tonnage to petroleum that is now devoted to coal, the fuel capacity with the former is more than 50 per cent greater than with the latter. This increase of fuel capacity gives the ships with oil fuel one and one-half times the steaming radius at any speed, the ability to attain a greater maximum speed and to continue it for a longer period.

Not only is the heating power of petroleum 50 per cent greater than that of coal for the same weight, but the same relation holds good for equal bulk. The weight of petroleum is very nearly 54 pounds per cubic foot, and this figure is also a fair average for a cubic foot of steam coal. Fighting ships may, therefore, increase their fuel capacities by one-half the present values with coal, without adding to either the present tonnage or bulk, by using oil. In the matters of rapid steam raising, long continued operation at maximum capacity, the removal of refuse from the furnace, and the labor of firing, the oil fuel is at a great advantage. Petroleum is fed to the furnace through pipes under pressure, and the heat of the fire is changed at once by regulating the flow of oil and supply of air. Much less than one per cent of the weight of petroleum remains as ash after combustion, while the ratio of ash in coal is 5 to 10 per cent. With oil the labor of firing is to a very large extent avoided, not more than one-fourth of the number of men required for coal are necessary, and their duties are much less exacting. This last point is seen to be of no small importance, when the great strain on the stoking force of war vessels on long and fast runs are considered. Petroleum fuel implies no material change in the steam power equipments now in general use on ships. The oil can be burned under any kind of boiler and its use may even alternate with that of coal. To apply the petroleum it is only necessary to introduce a pipe carrying it, and another pipe with compressed air or steam, into the furnace, and arrange suitable nozzles to insure a mixture of the oil in a finely divided state with the air or steam. Thus far the fuel properties of crude petroleum, as it comes from the earth, have been pointed out, but the heavy oil called refuse, that remains after the more volatile parts are extracted by distillation, has practically the same heating power per unit of bulk. This petroleum refuse constitutes 10 to 15 per cent by weight of the crude oil and is extensively used as fuel by ships on the Black and Caspian Seas and on locomotives in Southern Russia. The great Caspian oil fields and their refineries account for cheap petroleum refuse at the ports of the seas named.

Great as are the advantages to be derived from petroleum fuel on warships with steam power plants, still more favorable results seem possible if internal combustion motors are adopted. Steam boilers and their contained water form a large item in the weight of warship equipments, and the space and tonnage they require would be of the highest value for the storage of fuel. Oil engines require no boilers and consume less fuel than the best steam power equipments per unit of effective work. A fair approximate figure for the weight of ship boiler plants and their contained water is 150 pounds per horse power capacity, where the best class of steam engines is used. In the petroleum engine ·75 pound of oil will develop a brake horse power hour, so that if the boilers are replaced by an equal weight of fuel oil the radius of action for the ship is increased to correspond with 200 hours of operation for its engines at full capacity. It must be said, however, that the development of very large oil engines, such as would be required to drive warships, is in the experimental stage, and the hopes now held for them may not be realized. Concerning the advantages of petroleum fuel for steam boilers there remains, however, no doubt whatever. It may be mentioned here that the so-called petroleum engines do not use the crude oil, but usually those products of distillation that are obtained at temperatures of 340° to 476°F. This part of petroleum, known as the illuminating oils, constitute about one-half of its total weight. The amount of coal consumed by navies is known to be very large, and it may be questioned whether the supply of petroleum is sufficient to permit its use for fuel under their boilers.

During the year 1898 there was produced in the United States petroleum to the amount of 8,500,000 tons. Allowing a large warship to consume 7,000 tons of coal per year on an average, the 8,500,000 tons of petroleum, with a heating power equal to 12,800,000 tons of coal, would supply 1,800 such ships. As it would be impracticable to devote the entire output of petroleum to naval purposes, the number of war vessels that could be supplied from present production in the United States would be a mere fraction of that just named. Unless the rate of petroleum production is very largely increased, it is quite evident that this desirable fuel cannot be generally and constantly used by the navies of the world. The great advantages to fighting ships of petroleum, in times of war, seems to indicate that naval powers will come to regard large natural deposits of this fuel with jealousy, and accumulate great stores of it at their coaling stations. Since petroleum may be used alternately with coal under the same boilers, it may well be that coal will continue to be the principal fuel for navies during times of peace, while petroleum is held in reserve for actual war. The commercial demands for petroleum are already tending to develop new fields of production, and its recognition as the most effective fuel for warships is sure to hasten this process. Petroleum is now produced on a very large scale in only the United States and Russia, and the export trade is carried on almost exclusively from these countries.

Deposits of petroleum in greater or less amounts seem to be almost as generally distributed as are those of coal. Most of the countries of Continental Europe produce small quantities of petroleum for home consumption, and in Germany and Austria the supply is quite large. The oil from Scotch shales is sufficient for only a small part of the demand in Great Britain, where the annual import of the distilled products of petroleum is nearly 200,000,000 gallons. China and India have long produced some petroleum and are believed to have large deposits. Several islands of the Far East, as Japan, Borneo, and Java, are said to promise future supplies of petroleum. In the Western Hemisphere vast quantities of petroleum are believed to exist in Canada, Mexico and several of the countries of South America. When these undeveloped fields are in operation, the supply of oil may be as plentiful as that of coal, but this seems improbable. Meantime petroleum fuel is being applied in some recent war vessels of Russia and the United States, with a decided increase of speed over that attained with coal. So long ago as the time of Admiral Selwin, petroleum was shown by the British Navy to be a superior fuel. But it yet remains for Great Britain to take any definite steps for its general use. Merchant ships do not find the advantages of petroleum so important as do vessels of war, because steaming radius or rate of speed in the latter may determine the result of a battle or the fate of a nation For the same cost of equivalent heating power, crude petroleum at 4 cents per gallon equals steam coal at $7.32 per ton. Petroleum must, therefore, be materially reduced in price before it becomes the general fuel for merchant ships.

OPERATION ON THE XIPHOPAGES.

We have already mentioned the fact that the xiphopage twins whose portraits were published in the SCIENTIFIC AMERICAN for February 24, 1900, have been separated by a surgical operation. We give a full account of this operation in the SUPPLEMENT for the current week. One of the most distinguished physicians in Brazil, Dr. Prevost, separated the eight-year-old twins, Rosalina and Maria, but we regret to say that one of the twins, Maria, died from the effects of the operation. The operation was performed on May 30 in the operating room of the St. Sebastian Hospital.

Before the operation, while under the inspection of the surgeon, Rosalina had an attack of grippe which lasted eight days, while Maria remained well. This confirmed the surgeon's opinion that there was no psychological condition which forbade their separation. The children were chloroformed separately and the operation, which is fully described in the SUPPLEMENT, was performed. It required two hours, and when they came out from under the influence of the anæsthetic, each asked where the other was and when they realized that they were separated and still alive they exclaimed, "Oh, Doctor, how good you are." On the seventh day Maria died and the post-mortem examination showed that death was caused by inflammation of the pleura. Rosalina continues to improve.

THE Roentgen Society of the United States will meet in New York City, December 13 and 14, 1900, at the Academy of Medicine. Addresses have been promised by eminent men at home and abroad, and a successful meeting is assured. Visiting members may obtain information in X-ray work. It is especially desired that all those who are using the X-ray in any way, either professionally or experimentally, send their names and addresses to the chairman of the Committee of Arrangements, Dr. S. H. Monell, 45 East Forty-second Street, New York city. The Society is the only one of its kind in America and is for scientific purposes only.