the vertical plane by rudder action only, is also fully justified by tactical and construction reasons. It is obvious that a change in depth can be effected in the least time and by the least expenditure of energy, if the vessel be moved in the direction of least resistance; in other words, if she is steered up and down inclines by altering the angle of her longitudinal axis to the horizon. In order to be effective the turning moment used must be of considerable magnitude and under the most sensitive control, conditions best met by horizontal rudders, which have also the advantages of simplicity and economy of space, weight and power. Other things being equal the rapidity with which a submarine can rise for observation and dive again is a direct measure of its efficiency, since its chance of escape from observation or projectiles is in inverse proportion to the period of exposure. As pointed out below, a loss in this quality may be justified when balanced by a corresponding gain in the equally important tactical feature of speed, but in no other way; hence it may fairly be concluded that this feature also has come to stay.

The correspondence between the French and American designs extends also in a general way to the most important construction feature—viz., the power plant. For submerged work both have adopted the electric drive, and for surface work and recharging batteries, etc., both go back to the hydrocarbons, the American using the light oil gasoline, with an explosive engine while the French employ a heavier oil, petroleum, and transform its energy into steam instead of using it direct in an explosive engine.

American System Best.—From a purely theoretical point of view, the American system is better adapted to the purpose, involving as it does only one variable weight—viz., fuel, against two for the other—viz., fuel and feed water. This leads directly to simple and rapid compensating arrangements tending toward a reduction in the time necessary to pass from a cruising to the fighting condition, a tendency still further helped by the absence of the high temperature accompanying steam propulsion, as well as the slow working apparatus for the escape of the products of combustion. In general simplicity and economy of space the American system offers additional advantages. On the score of safety the advantage, if any, lies at present with the French. A less volatile oil is used in the first instance, and it is probably less difficult to secure the complete expulsion of the products of combustion. The advantage, however, is not important as the danger element in either case is well within permissible limits and will undoubtedly be still further reduced in future boats employing the American system by the use of heavier oils and the perfection of the apparatus for disposing of the products of combustion. The principal advantage of steam propulsion lies in the fact that the designer can avail himself of very complete data based on experience, whereas since the marine oil engine of the power now required is practically new in the field, the designer is hampered by lack of reliable data. Ultimately, however, the oil engine will probably displace the steam engine, since the development of the former offers the possibility of a single motive power for all conditions, which will be reasonably efficient in the submerged condition. Modern chemistry is already in a fair way to provide the materials for supplying the necessary oxygen in such form as to meet the conditions imposed in a submarine. In the meantime the growing field of the oil engine, both afloat and ashore, will supply the experience necessary for the development of the largest powers apt to be used in the submarine.

Electric Drive.—The remaining important feature common to both designs is the employment of the electric drive for submerged work. The storage battery and motor are admirable in some respects, but exceedingly inadequate in others, the principal objection being the well-known one of excessive weight and space in proportion to the power developed. When it is stated that a weight of 370 pounds per horse power hour is a fair average for a suitable installation, it is readily seen that there is much room for improvement. Another disadvantage of the battery lies in the care and attention necessary for its safe operation after sensible deterioration has set in. The difficulty which takes the shape of abnormal behavior with respect to "gassing" may, under certain conditions, result in an explosion, such as took place on the "Fulton" last spring, and more recently on the "Holland." Fortunately, however, this condition is not inevitable, and is susceptible of control when it does occur.

There is no particular quarrel with the motor, except as to the difficulty in fitting it with a suitable propeller, and the battery bids fair to develop faster in the future than in the past, on account of the increasing demand for a light, compact battery for automobile use. Its continued use may thus be expected until the appearance in practical form of a development of a heat engine similar to that hinted at above.

The principal difference between the French and American designs lies in the choice made of dimensions and proportions, which appears to be the direct result of different ideas as to the relative values of speed and maneuvering qualities. To attain the high surface speed desired the French designers have been forced to adopt a considerable displacement, great length in proportion to beam, the double hull with large tank capacity, and incidentally the steam engine and multiple rudders. As compared with the Holland boats, the increase in surface speed is gained by a sacrifice of efficiency in three directions: 1, As to simplicity; 2, as to the length of time necessary to pass from a cruising to the diving condition, and, 3, as to the necessary period of exposure for conning tower observations. No exact data are available as to the minimum observation period required by the French boats, but their extensive use of the periscope indicates a relative inferiority in this respect. In shallow water at least this result would naturally follow from the dimensions and form adopted, as it is probable that the rudders are then used to produce not only a turning moment, but also a vertical thrust.

While the limit of surface speed for a given displacement has not yet been reached for either type, further material advances are most apt to be made by further increases in displacement. The limit to this process is not set by construction reasons, but by the probable use of the type, which for any one country is fixed by its geographical location and the nature of its coast and harbors. For instance, a submersible of the "Narval" type and dimensions is for France not only a defensive, but an offensive weapon, and the partial sacrifice of submarine qualities in the design is warranted by the possibilities for offensive use. The same boat transferred to America would become purely defensive and would not be so well adapted to the conditions here as is the American type. It is probable then that in countries situated like France, where the possible enemy possesses large ports and arsenals within easy striking distance, the submersible will eventually be increased in displacement to perhaps 300 tons, in order to obtain a vessel which shall be seaworthy in a large sense, habitable for considerable periods, self-supporting and capable of a fairly high sustained sea speed. Such a boat would be first and foremost a weapon of offense and only incidentally a weapon of defense, in which field its place would be taken by several smaller units. Whether these units should be of the submersible or pure submarine type depends upon the extent of the coast, the number of harbors, the internal water ways and the condition of the fixed defenses. As noted above, France has adopted for this purpose the submarine of the Perle type, a course which is probably justified by the small number of her harbors and her highly organized fixed defenses.

Turning now to the United States, her location with respect to possible enemies is such that there is no immediate prospect of the development of the large submersible into an offensive weapon; still the extent of her coasts, the number of her harbors and rudimentary character of her fixed defenses render this type preferable to the pure submarine for defensive purposes. The development of the best all round boat to meet the conditions is likely here also to lead to some increase in total displacement, which eventually, however, will probably not exceed 200 tons. As compared with the larger offensive submersible, such a vessel would be less seaworthy and would have less surface speed, better maneuvering qualities, and greater submerged endurance. The pure submarine would thus at first glance appear to be an undesirable type for the conditions prevailing in the United States, but this is only true so long as the sole aim is torpedo work. As a matter of fact, however, the usefulness of the submarine is not confined to this one function, as it affords to-day the best known means for the destruction of mine fields and cables and the reconnoitering of fortified harbors. The objective being far removed, it is essential that the dimensions and weight of this type of vessel be kept at the lowest limit in order to admit of transportation by battleships, armored cruisers and the larger class of scouts. In such a vessel some armament would be desirable for attack upon stationary shipping, dry docks, etc., but this feature should be subordinated to the features necessary for efficient bottom work. By taking full advantage of the latest developments in diving apparatus all the essential features, including efficient signaling apparatus, could to-day be combined in a maximum length of 35 feet and a maximum displacement of 25 tons. This appears to be the only possible guise in which the pure submarine may play an offensive rôle, and even here, in the author's opinion, means for recharging batteries are desirable and justifiable, as scout work might require a considerable radius of action.

CONCLUSION.

To sum up, it appears that the submarine boats of the near future will naturally divide themselves into four types and two main groups, to conform to the different conditions in the different maritime countries. Group 1 would be suitable for many of the European countries, and would include the large offensive submersible, self-supporting, with auxiliary bottom working features, and the small defensive submarine for torpedo work only. Group 2, suitable for the United States and similarly situated countries, would include the small offensive ground working submarine or submersible (with auxiliary armament) and the medium sized defensive submersible for torpedo work only. It appears, further, that the submarine qualities of the modern boats are based on sound principles, and that the future development of the four different types within the limiting displacements of each must be along the present lines, and in the direction of improvement in the tactical qualities of speed and practical radius of action. As pointed out above, improvements in these respects are largely dependent upon the general improvement of the power installations, and as compared with the corresponding feature in the main objective, the battleship, the improvement in the submarine bids fair to be the more rapid.

THE NAVAL WAR GAME "WAR."—VII.*

By Fred T. Jane.

AFTER THE BATTLE OF MANILA.

After the victory of Manila the German fleet proceeded to blockade the bay, and a claim was put in for the capture of the American base. This the umpires disallowed.

The entire German military force was then landed, and a number of shore operations followed. To follow these in detail would be tedious, and it suffices to say that the net result was a falling back of the American army upon Cavite, which the Germans invested.

The working of the game about here was not eminently satisfactory to all those engaged in it, for reasons to be found below. The umpires deducted ten per cent of the German force for "sickness due to the effect of climate on troops worn out by a long sea voyage." This decision was hotly contested by the German players, as also was a second decision in which the umpires refused to allow the Germans any information as to the whereabouts of the American North Atlantic squadron, last heard of as steaming south off Rio de Janeiro. The reasons for this refusal were as follows:

The American players put in that the North Atlantic squadron after passing Rio Janeiro, spread out, so that if sighted by any merchant vessels, one American warship and not an American fleet would be reported. In addition to this the "Maine" and "Missouri" were ordered to steam back toward Key West until they had been sighted thus by merchant vessels. This accomplished, they were to return again and pick up the rest of the squadron off the Horn.

The whole American situation was at this time precarious, for the second Kiel fleet was displaying considerable activity. Leaving Kiel, it steamed north, a formidable enough squadron consisting of the "Wettin," "Mecklenburg" (lacking her heavy guns), "Brandenburg," "Woerth," "Weissemburg," "Kurfurst Friedrich Wilhelm," "Baden," "Sachsen," "Würtemburg," "Bayern," "Aegir," "Odin," "Heimdall," "Hildebrand," "Hagen," the new armored cruiser "Prinz Adalbert," the old cruisers, "Irene" and "Prinzess Wilhelm," with sixteen destroyers and six 25-knot torpedo boats. With it were several colliers. Ostensibly this fleet, of practically every available German ship remaining, was bound for the North American coast. The whole move constituted a very clever ruse, in the following fashion:

A trifling calculation showed that by far the greater number of these ships carried too little coal to cross the Atlantic, so the United States North Atlantic squadron proceeded toward the Philippines without regard to the new menace. Presently the (from the U. S. standpoint) expected happened, and the second Kiel fleet was heard of as having gone into various bays on the Norwegian coast. It was then ascertained that many ships were going back singly and more or less secretly to Kiel. The American side chuckled and went on chuckling till they heard that the "Wettin," "Mecklenburg," "Brandenburg," "Woerth," "Weissemburg," "Kurfurst Friedrich Wilhelm," "Prinz Adalbert," "Irene," and "Prinzess Wilhelm," accompanied by many colliers and with from twelve to fourteen destroyers in tow, were in mid-Atlantic. The ruse, in fine, was eminently successful.

We may here leave the second Kiel fleet for a time and return to events in the Pacific.

Off Manila, presently isolated and unable to cable, the Germans maintained a desultory blockade. Three of the "Kaiser" class ("Kaiser Friedrich III.," "Wilhelm II.," and "Wilhelm der Grosse") had gone to Kiao Chau to refit; the "Bismarck" also had gone thither for the same purpose.

All this while the U. S. S. "Ohio" had been completing for sea at San Francisco. When ready she ran south, intending to meet the North Atlantic squadron at Cape Horn. The Germans, having received information of her departure, dispatched the "Wittelsbach" and "Zaehringen" to intercept her.

This reduced the blockaders to two ships of the "Kaiser" class and the "Hertha" and "Hansa." Learning this, the "Albany" ran the blockade and got away south without injury. The "Hertha" and "Hansa" chased her a little way, but were soon left behind.

The next night the "Brooklyn" essayed the same thing, but blundering into one of the battleships, was sunk by a short range fire.

The methods by which this blockade running was worked may be of interest. The blockaders were made to furnish a chart and full notes of their positions for the whole period. All movements and positions that could be observed from the shore were communicated to the Americans, and the course of any blockade runner compared with the positions of the blockaders at any given time. If this brought hostile ships within sighting distance, subsequent incidents were worked out by whatever orders had been issued by either side against such a contingency.

On the night that the Albany ran out, the battleships were some ten miles out, due west, the "Hertha" and "Hansa" being well south, the latter close inshore. Passing between these two ships, the "Albany" was sighted by the "Hertha," which fired rockets. Bearing inshore to avoid the "Hertha," the "Albany" came within 2,500 yards of the "Hansa," and shots were exchanged. These were ineffectual, and her high speed enabled the "Albany" to escape.

The "Brooklyn" the next night took an identical course, but when bending inshore from the "Hertha," sighted the "Hansa" without being seen. (These questions of sighting, being pure chance, were settled by dice throws.)

Seeing the "Hansa," she bore round due west. The player who acted as captain of the "Hertha" also sighted the "Hansa," and opened fire on her in mistake for the "Brooklyn." She then got out searchlights, and discovering her mistake, fired signal rockets. The battleships, acting on the prearranged orders, steamed in toward the lights, and it was umpired that, silhouetted against these lights, the "Brooklyn" would be seen before seeing the Germans.

One battleship opened on the American cruiser at once, the other bore round southwest, and this ship—the "Kaiser Barbarossa"—it was that sank the "Brooklyn."

The "Albany," once clear, went on south and fell in with the U. S. North Atlantic squadron without incident. This fleet, lacking scouts, found her extremely useful.

(To be continued.)

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ATMOSPHERIC ELECTRICITY AND EARTH CURRENTS.

By E. O. Walker, C. I. E.

On the Nilgiri Hills, in India, Michie Smith found, on the edge of a dissolving mist, the potential to be lower than the normal, and, on the edge of a condensing mist, higher. On Ben Nevis Dickson noticed that when the summit was clear a current came up the mountain, and that the reverse was the case when the summit was enveloped in mist. Similarly, on Vesuvius, the observations of Palmieri go to show that during a fall of rain or snow the current is, in direction, downward, and when the mountain is clear, in most instances the opposite occurs.

Beyond the probability that vapor movements alter the atmospheric potential, there are other facts which ought to be considered in this relation. Kelvin has