hibited such satisfactory qualities as constructed by De Laval for this use as to make it a permanent and standard addition to our list of prime movers."

However, satisfactory as these results were, the steam turbine was yet very limited in its application and comparatively wasteful of steam, and to successfully compete with the reciprocating steam engine, it was necessary to introduce means for the complete expansion of the steam. Should the true Branca type be retained, the constructive difficulties arising out of the enormously high speed necessary would have to be overcome. This De Laval accomplished in a remarkable way. By use of the diverging nozzle, which he patented, he secured a complete and adiabatic expansion of the steam and the conversion of its entire static energy into kinetic, and to overcome the impossibility of producing a wheel accurately enough balanced to revolve about its center of gravity at a velocity sometimes as high as 1,350 feet per second, without causing a side pressure destructive to plain bearings and a rigid shaft, he used a flexible shaft.

The De Laval nozzle, the simplest means imaginable for its purpose, and the flexible shaft, daring and ingenious in its application, may well be regarded as among the most remarkable inventions in steam engineering. They have placed the steam turbine in the foremost rank among heat motors. With these improvements the De Laval turbine has steadily progressed, thousands of machines in sizes from 3 horse power to 300 horse power having been built.

A characteristic feature of this turbine is that none of its running parts are subject to the full pressure of the steam, as the steam is fully expanded in the nozzles before it reaches the turbine wheel. This feature is of great value in the direction of using high pressures with resultant increase in economy of fuel. The restriction as to the steam pressure that can be used is found only with the boiler, and as far as the steam turbine itself is concerned, it has been operated successfully with a pressure as high as 3,000 pounds per square inch.

Further and considerable increase in economy can be attained by using superheated steam, this steam turbine having no rubbing parts requiring lubrication, or packing glands in contact with the superheated steam, and, as in the case of high pressures, even here the limit exists alone with the boilers.

The general construction of the De Laval steam turbine will be clearly understood from Fig. 1. It presents no extraordinary departure from every-day engineering practice. However, the workmanship and material used, owing to the high speed employed, must be of the very highest quality.

The turbine wheel is mounted upon the slender flexible shaft, and in such position relative to the wheel case as to revolve entirely free, liberal space being allowed on each side. The wheel case and the wheel-case cover are so shaped as to form "safety bearings" around the hub of the wheel for the purpose of catching and checking its speed in case of an accident to the shaft.

The steam, after passing through the governor valve enters the steam chamber, where it is distributed to the various nozzles. These, according to the size of machine, range in number from 1 to 12. They are generally fitted with shutting-off valves, by which one or more nozzles can be cut out when the turbine is not loaded to its full capacity. This allows steam of boiler pressure to be almost always used, and adds to the economy on light loads.

After passing through the nozzles, the steam is completely expanded, and in blowing through the buckets, as shown in Fig. 1, its kinetic energy is transferred to the turbine wheel. After performing its work the steam passes into the chamber and out through the exhaust opening.

The velocity of the turbine wheel and shaft, in most cases too great for practical utilization, is considerably reduced by means of the spiral gear usually made 10 to 1. The gear is mounted and inclosed in the gear case. The pinion made solid with the flexible shaft and engaging the gear wheel. This later is forced upon the shaft, which with coupling connects to the dynamo or is extended for pulley. The governor is held with a taper-shank in the end of the shaft, and operates the governor valve by means of the bell-crank.

THE NAVAL WAR GAME.

By F. T. JANE.

For the last twelve months or so experiments have been conducted in England, France, Russia, the United States, and Japan, with a view to evolving a new firing system for the Naval War Game, that, while not necessarily displacing the existing system for small actions, shall yet afford something infinitely quicker than the old target method. The requirements were as follows:

- Realism, that is to say, accuracy in fire, corresponding as nearly as possible to actual conditions.
- Full differentiation between ships.
- Speed in firing and scoring, so that the period of time representing one minute shall in no case exceed two minutes with players at all practised in the game.
- Simplicity, so that tactics shall receive the maximum of importance.
- Full allowance for position, speed, and bearing of guns, with, so far as possible, automatic adjustment for the targets of varying size offered by different types of warships, automatic and correct ratio between ships and forts, ships and destroyers, and all kindred cases.
- Other things being equal, preference will be given to the method that puts the greatest individual responsibility upon the captains of ships.
- Automatic adjustment to any other conditions not specified herewith, but which might occur in the fullest possible simulation of real warfare.

On this clause (g), which is, after all, merely a variation on clause a, several of the most promising systems came to grief.

Our readers must by now be fully cognizant of the original target system. By this each gun of or over 6 inches is struck for by an instrument known as a "striker," the size of the target varying with the range. An optional rule artificially increases the range if speed is high enough to alter rapidly bear-

ings. In a general way, and for teaching guns and armor, this system has shown itself the best, and still so remains; but it has the defect of great slowness unless all the players are thoroughly well practised at the game. In practice it has worked out that few players get far beyond the learner stage. A highly-qualified umpire is also an absolute necessity; and, so far, there are only three such in existence in the world. Not only is it necessary to have all the rules and the innumerable addenda off by heart, but great quickness of perception and an ability to apply uniform judgment on widely different cases at sight are absolutely essential. Every possible contingency being provided for in the rules, the slightest divergence on some special case may completely upset other cases.

All this has struck many people as likely to defeat the end sought, and so created a demand for something less of a special science and with more generalization.

The first and most elementary idea that suggests itself to nearly everyone is a system of points. That, however, is already in existence on page 25 of the 1898 Book of Rules. It is a quite unsatisfactory method, because it reduces everything to simple mathematics, and requires only the intelligence necessary for skill at the game of draughts. It is, in fine, nothing but an exercise in mental arithmetic, thought and initiative being replaced by that. It is worthy of note, however, that this is the system favored by the British Admiralty, which, a few months since, served out to all sea-going ships a game consisting almost solely of the rules as to moving on page 8 of the 1898 Book of Rules, and a modification of the first clause on page 25 of the same issue. The arithmetical exercises may help naval officers to qualify for ability in keeping mess accounts, but the maximum of utility is bounded by that. As an exercise in war training, or in causing officers to think out war problems, it is practically useless. That such a system should have been adopted is the more curious in that all officers doing gunnery courses are now set to pursue their studies on the theory of areas of armored and unarmored parts of ships, which is the very keynote and distinctive feature of the Jane Naval War Game.

In pursuance of a solution of the best shooting method to fit requirements *a* to *g* above, no less than seventeen systems were evolved, each with many good points, but none of which answered all requirements in practice. To enter into a detailed account of all these systems would be tedious; it suffices to mention that dice and mathematics were the leading features, and that none accorded with the time requirement, nor were the automatic conditions in clauses *e* and *g* properly met. Out of the chaos, however, a system has been evolved that has so far stood every test satisfactorily, and which is now adopted as the official scale for all actions in which more than three or four ships are engaged on either side. The line followed is one of broad generalization, particularization being left with the umpire. Its main features are as follows:

Axioms.—1. In the battle of the immediate future at least 90 per cent of the projectiles will be high-explosive or common shell. Hence penetration of armor is quite a minor detail.

2. Victory will depend primarily upon the dispositions of the admiral before the battle, and upon the intelligence with which his subordinates grasp the general plan and exhibit initiative when the need occurs.

3. The percentage of hits to be obtained upon an enemy will depend as much or more upon the combined speed—and changing bearings—than on the actual distance.

4. Most ideas of modern warfare are based on "moral effect." Dice are, therefore, absolutely unsuitable, and mathematics must be strictly limited. Long experience indicates that the "striker" system gives an equivalent to moral effect; therefore, the "striker" must be used.

These ends have been obtained by the following revolutionary methods. All guns are commuted to 6-inch quick-firing; those of 8-inch, etc., quick-firing, being reckoned as 1½; those of 9.2, 12-inch, etc., varying from 1½ to 2½, according to the type of gun and mounting. Each ship, so long as she has a single gun left, is allowed one stroke per move, the spot hit being taken as the center of the area of damage, guns in it being affected whether protected by armor or not. As an example we may take the "Majestic." Her fire—excluding small pieces—commutes to 14, and this, upon the percentage of hits, is allowed for as seven sections destroyed at 2,000 yards or under if the ship fired at is stationary or nearly so. At 7,000 or 8,000 yards, however, only 1-20 of that damage is allowed; at 6,000—5,000 yards, 1-10 to 1-6; at 4,000 yards, ¼; at 3,000 yards, ½—i. e., 3½ sections.

For long ranges, i. e., 4,000 yards or over, the medium target—the old "3,000 yards" one—is used should bearings be absolutely unchanging, but if there is any change, then the "4,000-yard target." Every combined change of 15-knot speed makes the range reckoned as 1,000 yards greater than it actually is. For nearer ranges, inside 4,000 yards, the biggest target is used for a stationary ship, or one when bearings do not alter. When they alter only a little the medium—3,000 yards—target is employed. If they alter from 15 to 30 knots per move—as, for instance, two fleets passing each other at 12 knots—then the smallest target is employed. Beyond that speed the range is reckoned 1,000 yards greater for each 15 knots difference, and the damage correspondingly reduced. Boldly conventional as this system may seem, it embodies the strongest facts of actuality, and impresses—indirectly possibly—on players how important an item is the speed of the enemy.

For firing at destroyers mathematics are now employed—guns scoring from 8 to 1, according to the destroyer's speed. Range, so long as it is within the prescribed distance, is not counted, neither is position. Safety lies in speed, and defense lies in tactics to neutralize that speed. The new rule is simple as can be, but gets all the salient features and "things that matter."

Torpedoes have had to be readjusted. The assumption now is that a stationary ship can be hit at any range, and though nearness counts, speed and position count as much or more.

The automatic allowance for forts is as follows: Each fort gun is given the destructive power of two ship guns, or, if it is more than 500 feet above sea level, of three ship guns. Otherwise the range rules are the same.—The Engineer.

CONTEMPORARY ELECTRICAL SCIENCE.*

METALLIC CONDUCTION.—E. Riecke attempts the question: Is metallic conduction attended by a transport of metallic ions? Such a transport of ions was suggested by the observed diffusion of metallic ions through solid metals, and was consistent with the author's electro-thermal theory. The apparatus used by the author consisted of three equal cylinders, two of them being of copper and the third of aluminium. They were firmly pressed together, with the aluminium cylinder in the center, and provided with copper leads. The apparatus was kept in the closed circuit of a battery of accumulators for a whole year, during which time it was traversed by about 958 ampere-hours. In an electrolytic cell this would have meant the deposition of 1.14 kg. of copper. But on weighing the cylinders at the end of the year it was found that, within experimental errors, their weight had not altered. The author, therefore, answers the above question in the negative, and concludes that in metallic conduction no electric charges are conveyed by positive metallic ions.—E. Riecke, *Physikal. Zeitschr.*, August 3, 1901.

EFFECT OF GRAVITY AND PRESSURE ON E. M. F.—When an electric current is passed through an electrolytic cell the anode is dissolved while the cathode is plated. If the cell is made in the form of a tube, with the electrodes in the ends, the law of the conservation of energy would require a greater consumption of energy when the current passes up through the tube than when the tube is horizontal or when the current passes down. This greater consumption of energy will express itself as a difference in the E. M. F. required for a given rate of deposit, and this difference may be regarded as a counter E. M. F. and detected as such. Some experiments in this direction have recently been made by Rolla R. Ramsey. Starting with the tube in horizontal position, the tube was turned to a vertical position and reversed repeatedly in unison with the galvanometer needle until a maximum deflection was obtained. Zinc or cadmium amalgams were used as electrodes, and the sulphates, either in solution or in paste, as electrolytes. The most consistent results were obtained with cadmium. The additional E. M. F. per centimeter height of a 10 per cent solution was found to be 4.78×10^{-8} volts, with a migration ratio of 0.02. The authoress also measured the effect of pressure, and found that the E. M. F. increased in a linear manner with the pressure up to 300 atmospheres, and to a larger extent in a Clark cell than in a cadmium cell.—R. R. Ramsey, *Phys. Review*, July, 1901.

THE BRAUN TUBE AS AN ELECTROMETER.—Braun's cathode-ray tube has been used with much success for studying the period of alternating currents. W. I. Milham has found it useful for measuring electrostatic fields, but in a somewhat indirect manner, for when the tube is placed between the electrodes, there is no deflection of the cathode beam; when, however, the field is suddenly commutated, the fluorescent spot jumps aside, and then returns to its normal position, quickly at first, and then more slowly. On repeating the commutation the throw is in the opposite direction, and the return is as before. The explanation is obvious. The field traverses the tube, but the cathode rays within the tube render the gas conducting, and the charges on the walls are thus neutralized. That this is the true explanation may be proved by interrupting the cathode rays during their returning motion by stopping the current. The luminous spot then disappears, and when the beam is restored the spot reappears, not in its normal position, but at the point it had reached when the rays were cut off. The speed of return is proportional to the throw, and the latter is proportional to the field. Under favorable conditions the author claims an accuracy to within 1 per cent for the measurements.—W. I. Milham, *Physikal. Zeitschr.*, August 3, 1901.

HIGH POTENTIAL CURRENTS.

A COMMITTEE of the New England Insurance Exchange is considering the question of increased fire hazards incident to the establishment of high potential systems by electric street railways. Before any action is taken by the Exchange it is probable that the subject will be referred to the National Underwriters' Association, which draws the national electrical code. It is said here by C. M. Goddard, the secretary of the Exchange, that the fire insurance companies do not wish to put up the rates, and they will not act unless they have to. If there is a permanent increase of hazard, then the insurance companies, in order to be able to pay their losses, must increase the rate. Thus far the use of extra high potential systems has not been carried very far. There is one in Hartford, one in Providence, one in Brockton, and one in Maine.

The increased risk is due to the extension of the business of the trolley companies. They add more territory to what they have been operating and must have more power for the larger service. The extra high potential system is used, it is said, in order to save copper, and there is no imperative need for increasing the insurance hazard, if the trolley companies go to the necessary expense to avoid it. It is impossible, says Mr. Goddard, to guard against the hazard by means of insulation, but in the congested portions of cities, or on roads where there is much travel, the wires should be put under ground. In other localities the remedy proposed is to have the trolley cars obtain a right of way over private land, so that the wires shall be beyond danger of coming in contact with streams of water thrown upon fires, or in contact with the firemen themselves. It would be practically impossible for firemen to cut these wires of high potentiality. While there might not be accident, there

*Compiled by E. E. Fournier d'Albe in *The Electrician*.