Marey and Müllenhoff are all easily accessible in print, they will not be repeated here; but the following table is considered more valuable than any of them. It has been compiled from "L'Empire de l'air" of Mr. Mouillard, a very remarkable book, published in 1881, which contains descriptions of the flight of many birds and accurate measurements of their surfaces and weights.

Mr. Mouillard adopted a more rational method than other observers. Instead of merely measuring the surface of the wings, he laid the bird upon its back on a sheet of paper, projected the entire outline, and then measured the total area from which it gains support. The compilation has been made by Mr. Drzeweicki for a paper presented to the International Aeronautical Congress at Paris in 1889, in which he states the general law more accurately than his predecessors, by calling attention to the fact that the ratio of weight to surface will vary somewhat with the structure of the bird, and that the result will be that those possessing the lesser proportionate surface must fly faster in order to obtain an adequate support at the same angle of incidence.

I have added the last column in the table, showing the speed required to sustain the weight of a flat plane loaded to the same proportion of weight to surface as the bird, at an angle of incidence of 3°. This speed merely approximates to the real flight of the bird, because it takes no account of the concavity of the wings, which, as previously explained, increases the effective bearing surface of the animal; but it would require experimenting with each and every bird tabulated in order to give the true and varying coefficients.

(TO BE CONTINUED.)

THE ARMOR-PLATE TRIALS.

THE last of the series of armor-plate tests, to which reference has been made in our columns, took place at the Indian Head proving grounds on January 13. Two plates remained to be tried—a low-carbon, untreated plain steel, and a high-carbon nickel-steel treated by the Harvey process; both plates were made by Carnegie, Phipps & Company. These plates were originally of the same size as the others treated, 6 × 8 ft., and 10½ in. thick. In consequence of a defect in the nickel-steel plate 20 in. were cut off, leaving it that much shorter; while to take out a warp in the plain steel plate, caused by successive temperings, the edges had been planed down about 1 in., leaving the center of the plate of full thickness. To offset the difference in the size of the plates, only three 6-in. shots were fired at the nickel-steel plate, these being aimed at the points of an isosceles triangle, 2 ft. from the upper edge and the two sides; this was one shot less than in the other tests. One 8-in. shot was fired at the center.

In the tests alternate shots were fired at the two plates, beginning with the plain steel. That plate was practically wrecked, all four of the 6-in shots having gone through it and lodged in the backing. The second shot broke off the upper right-hand corner, and the others, besides fracturing, produced cracks in several directions. The 8-in. projectile went through the plate and backing, and was picked up 50 ft. distant, having been very little injured.

The first of the three 6-in. projectiles fired at the nickel-steel plate penetrated it to a depth of 9 in. and rebounded. The second shot acted very much the same way as one of the shots at the nickel-steel plate in the previous trials. The point of the projectile was apparently welded to the plate, and the remainder was broken up into pieces. The penetration was estimated at about 4 in. The third 6-in. shot at this plate remained in the plate, the base projecting 6½ in. It is stated that no cracks were developed by any of these shots. The fourth shot, which was from the 8-in. gun, and which was fired at the center of the plate, went through the plate and backing and remained imbedded in the sand beyond. After this shot three cracks appeared, one extending from the center to the top of the plate, and the other to the lower right and left-hand corners; each crack passed through one of the marks left by the 6-in. shot, practically separating the plate into three parts. It should be borne in mind that the shots at this plate were grouped more closely together than had been done upon any of the other plates tested.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

CHEMISTRY APPLIED TO RAILROADS. XXV.—BEARING METALS.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page* 16.)

THE question as to what metal to use for bearings under cars is one which will be recognized when mentioned as of the very highest importance to railroads. It is believed by many that the bearing metal is largely at fault for those annoying delays in transportation due to what are known as "hot-boxes," and although our studies and investigations have hardly led us to such a conclusion as this, yet it cannot be denied that the metal itself used in the bearings has a good deal of influence upon the successful movement of trains. The importance of the question is likewise re-enforced by another consideration—namely, loss of the metal by wear. When it is considered that the bearing metal is expensive, costing possibly anywhere from 12 to 20 cents per pound, and that each car, on the average, loses eight pounds of this metal for every 25,000 miles that it runs, it is readily seen that the item of wear of bearing metal comes in as quite an important factor in the cost of operating a railroad. It only requires a little calculation based on the above data to show that on any large railroad the loss of bearing metal by wear might readily amount to from $100,000 to $150,000 per year.

In view of both of these considerations we have devoted a good deal of time and experimentation to the question of what kind of bearing metal is the best to use. Some 20 years ago the standard bearing metal was a copper-tin alloy, seven pounds of copper to one pound of tin, commonly known as "cannon bronze." This alloy is, even to this day, possibly with slight modifications in the proportions, largely used for bearings, but, as will be seen a little later, we think, not at all wisely. The first experiments made with bearing metal alloy were to compare this copper-tin alloy with what will be called the standard phosphor-bronze bearing metal, and which will be described in detail a little farther on. The results of these experiments, which were quite extended, proved conclusively two things: First, that the copper-tin alloy was much more liable to heat under the same state of lubrication than the standard phosphor-bronze bearing metal, and, second, that the rate of wear with the copper-tin alloy was nearly 50 per cent. greater than that of the standard phosphor-bronze bearing metal—that is to say, if the standard phosphor-bronze lost a pound of metal every time a bear-

* These articles contain information which cannot be found elsewhere. No. I, in the JOURNAL for December, 1889, is on the Work of the Chemist on a Railroad; No. II, in the January, 1890, number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the Method of Purchasing Oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints; No. XII, in the October number, on the Working Qualities of Paint; No. XIII, in the December, 1890, number, on the Drying of Paint; No. XIV, in the February number, on the Covering Power of Pigments; No. XV, in the April number, on How to Design a Paint; No. XVI, in the May number, on Paint Specifications; No. XVII, in the June number, on the same subject, and No. XVIII, also in June, on the Livering of Paint; No. XIX, in the July and August numbers, on How to Design a Paint; No. XX, in the September number, on Disinfectants; No. XXI, in the October number, on Mineral Wool, and No. XXII, in the same number, on Wood Preservative; No. XXIII, in the November and December numbers, on Soap; No. XXIV, in the January, 1892, number, on Steel for Springs.

ing went 25,000 miles, the copper-tin alloy would lose 1½ lbs. under the same conditions. These experiments led to the adoption of what has already been called the "Standard Phosphor-Bronze Bearing Metal," as the almost exclusive metal to be used for car bearings on the Pennsylvania Railroad, and for a period of years following these experiments nothing else, practically, was used for this purpose.

The *Phosphor-Bronze Bearing Metal* will bear a few words of elucidation and explanation. It is well known by those who are informed on the progress of metallurgy that Messrs. Levy and Kunzel made experiments, now nearly 20 years ago, with the idea of developing an alloy which could be successfully used in making cannon. These experiments were carried on on a large scale, and the results have been published in a *brochure*, which has been furnished to most of the large governments of the world. The experiments of these gentlemen culminated apparently in the development of an alloy of copper, tin, and phosphorus which had quite remarkable properties. The addition of phosphorus to a copper-tin alloy seems to increase the tensile strength and elongation, and to make it a very much easier metal to manipulate in the foundry—that is to say, phosphorus being present in a copper-tin alloy, a very much larger percentage of sound castings will be obtained than if the phosphorus is not present; also, these castings will have greater tensile strength and greater elongation. Following the knowledge of this fact came another one which, so far as bearing metals are concerned, is perhaps of equal importance—namely, Mr. C. J. A. Dick, of London, discovered that the addition of lead to a copper-tin-phosphorus alloy gave a resulting alloy which under abrasion was very much superior to anything at that time known, and he accordingly took out a patent for a phosphor-bronze containing lead to be used as bearing metal. It is practically this metal which was used, as above referred to, for a period of time as the standard bearing metal of the Pennsylvania Railroad Company.

For quite a long time while Mr. Dick's patent was in force this metal was made of standard composition and quality by the Phosphor-Bronze Smelting Company, of Philadelphia. Ultimately, as the time of the patent was about to expire, and as other manufacturers recognized the value of the phosphor-bronze bearing metal and began to prepare to make it, it became essential for the Pennsylvania Railroad Company, in order to protect its interests, to prepare specifications for this metal, which was accordingly done. These specifications are as follows:

PENNSYLVANIA RAILROAD COMPANY.

Specifications for Phosphor-Bronze Bearing Metal.

From this date Phosphor-Bronze Bearing Metal will be purchased in amounts of 20,000 pounds, or some whole multiple of this number. Manufacturers will be required to notify the General Superintendent Motive Power, at Altoona, when they are ready to ship 20,000 pounds, and await the arrival of the Company's Inspector, and have proper assistance and all facilities ready for shipping the metal as soon as the Inspector arrives.

The Inspector will see the metal weighed and shipped, and will select three half pigs to represent the shipment. He will also be at liberty to reject any pigs in which want of uniformity in the constituents is evident to the eye.

Mixed borings from the three half pigs will be analyzed, and the shipment will be accepted or rejected on this analysis.

The metal desired has the following composition:

Copper	79.70 per cent.
Tin	10.00 "
Lead	9.50 "
Phosphorus	0.80 "

Shipments will not be accepted if the analysis as above described gives results outside the following limits: Tin, below 9.00 per cent., or over 11.00 per cent.; Lead, below 8.00 per cent., or over 11.00 per cent., and Phosphorus below 0.70 per cent., or over 1.00 per cent., nor if the metal contains a sum total of any other substances than Copper, Tin, Lead, and Phosphorus in greater quantity than 0.50 per cent.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., June 14, 1889.

The above is the second revision of these specifications. The specifications seemed to be sufficiently clear on inspection and very little difficulty has arisen in regard to them. All the manufacturers, of whom there are now some five or six, seem to be competent to make metal which will come within the limits given at the end of the specifications, and it is very rare indeed that we have occasion for complaint or to reject a shipment. Since the phosphorus is the most expensive constituent in the metal, it might be thought there was no real reason why there should be an upper limit, and that in reality we would be glad to have as much phosphorus as possible. In the first specifications issued no upper limit was provided, and it was found that, either on account of carelessness or of unequal distribution of the phosphorus, we occasionally got metal considerably higher than the limits given. A direct experiment with this high phosphorus metal showed that it was so extremely fluid that it was difficult to hold it in the sand, and accordingly we placed an upper limit of phosphorus.

We believe the manufacturers use phosphorus enough, so that if all of it should get into the metal it would make about 1.00 per cent. The average of our analyses shows not far from 0.80 per cent. in the finished metal as we receive it, the balance being lost in the process of introducing the phosphorus.

It will be observed that practically no other substances are allowed to be present in this alloy except copper, tin, lead, and phosphorus. There is a twofold reason for this: First, zinc is a very much cheaper constituent than any of the others except lead, and the tendency of the manufacturers would be to introduce zinc to the extent of a few per cent. There would be two reasons for this tendency: First, the diminution in the resulting cost of the alloy; and, second, it is well known that the quadruple alloy of copper, tin, lead and zinc is a much easier manipulated metal than a copper-tin alloy, or, indeed, than a copper-tin-lead alloy. The phosphorus undoubtedly facilitates the foundry manipulation of the metal, but so does the zinc; and without any control over the metal, and limitations moderately rigidly enforced the tendency would be to give a copper-tin-lead-zinc alloy with very much less phosphorus. While we believe in the value of zinc in copper-tin-lead alloys, we think it advisable to introduce it ourselves in our own foundry, if we decide to put it in, and accordingly, as will be observed, the limitations are moderately strict on this point. There is still another reason for excluding the introduction of other substances than copper, tin, lead and phosphorus—namely, according to present experience a copper-tin-lead alloy containing phosphorus is the best bearing metal known. If now we allow other substances to be introduced it becomes more difficult to locate the cause of trouble when hot-boxes arise than if we have a standard bearing metal. It is not uncommon for the laboratory to receive bearings from the service which have heated with the request to know if there is anything in the bearing metal which will account for the difficulty. If old junk and miscellaneous metals are allowed to be used in the bearing metal we would, of course, find it very difficult to say that the cause of the hot-boxes must be looked for otherwheres than in the bearing metal. The effect of this on the efficiency of the service will be readily appreciated by any railroad operating officer.

It is perhaps worthy of note that the success of the phosphor-bronze bearing metal has been so great that attempts have been made by a number of parties to secure the same metal in other ways. The most notable attempt of this kind has been the effort to sell to the railroad companies a phosphor-tin and then allow them to make their own bearing metal by using the proper proportions of the phosphor-tin to secure the right amount in the resulting alloy of both tin and phosphorus. So far as we know there is really no objection to this method of making the bearing metal, but, so far as our experience has gone, it is extremely difficult to obtain in the market a phosphor-tin rich enough in phosphorus so that the amount required in our specifications would appear in the finished bearing. The manufacturers of the phosphor-tin alloy do not apparently sufficiently understand their work to enable them to make an alloy containing 7.00 or 8.00 per cent. of phosphorus, at least at a price which will enable this alloy to compete with the phosphor-bronze as it is now ordinarily made. Of course, if the consumers of the phosphor-bronze bearing metal are willing to accept less phosphorus than is characteristic of the metal described in the above specifications it is undoubted that a good alloy could be made in this way. The lower limit of phosphorus in our specifications is more a commercial question than one of actual value in the service so far as we know. Our position in this matter is as follows: Every melting of the metal causes a little loss of phosphorus, and as we do not know how many times we may want to remelt this metal we start with a good lot of phosphorus, the lower limit being 0.70 per cent. We have no experiments to prove that if the finished bearing has 0.40 per cent. of phosphorus in it the bearing would not be just as good in service, but as the scrap bearings are remelted we are sure the scrap would not be as valuable as it would if it had 0.70 per cent. It is entirely probable that the makers of phosphor-tin will learn within a short time how to make an alloy of phosphorus and tin which shall meet every requirement, and if this is possible it will introduce another source of competition in bearing metal material which will undoubtedly redound to the benefit of the consumers.

Notwithstanding the successful results obtained with the standard phosphor-bronze bearing metal it was not deemed advisable to allow the question to rest here, and accordingly with more or less frequency during all the time since the phosphor-bronze bearing metal was established as standard experiments have been made with other alloys to see if any improved results could be obtained. It is entirely possible that not less than 20 to 25 different bearing metal alloys have been experimented with during the past 15 years. The usual method of experimentation is to have either eight, or twelve, or sixteen bearings cast of the standard phosphor-bronze and a like number of the metal under trial. These bearings are all carefully weighed and stamped, a record being made in a book kept for the purpose of these weights and numbers. They are then put in service, usually on engine tenders, a standard phosphor-bronze bearing and a trial bearing being on opposite ends of the same axle. Also one-half the trial bearings and one-half the standard bearings are on each side of the tender, so as to eliminate as much as possible any conditions favoring one bearing or the other. This arrangement, as will be observed, brings a standard bearing, we will say, on one side of the tender next to the engine. Following down that side the next would be a trial bearing, the next a standard bearing, and the next a trial bearing, and on the opposite side the reverse. This method, it will be observed, is strictly a comparative one. No attempt is usually made to keep a record of the mileage, since it is found that the wear of bearings is very variable compared with the mileage, possibly due to location where the work is done—that is, whether the work is largely on grade or curves, also due to the state of lubrication, and also due to the variation in the load in the tender. On the other hand, the loss of metal by wear of the trial bearing is strictly comparative with the standard bearing metal, and the results obtained in this way are believed to be very valuable indications. If the trial on tenders shows that the proposed new alloy has promise, a second trial may be made more extended on locomotive tenders, or possibly two or three hundred bearings of each kind may be put on cars. This has been done in several cases. At the end of the trial the bearings are removed from service and re-weighed and the loss of metal of each trial bearing is compared with the loss of metal of its opposite standard bearing. Averages, of course, are made of the whole lot. It frequently happens that, owing to the exigencies of the service, a trial bearing or its opposite may be lost, and in making up the averages these odd bearings are rejected. During the trial, of course, careful attention is paid to the heating, which is regarded as of great importance. Some trial alloys have actually not run three days without one-half or two-thirds of them heating. Under such conditions the trial is, of course, discontinued at once.

It would hardly be worth while to go into the details of all the experimental alloys that have been tried in the manner described above. It is perhaps sufficient to say that three points have been brought out quite clearly so far as we are concerned—namely:

First, the loss of metal by wear under exactly the same conditions diminishes with the increase in lead.

Second, the loss of metal by wear under the same conditions diminishes with a diminution of tin.

Third, the phosphorus in a copper-tin-lead-phosphorus alloy, apparently is very much more valuable in the foundry than in the service; indeed, its principal value, so far as the service is concerned, consists in the help that it gives in getting sound castings.

We have no evidence to show that the phosphorus has any valuable influence on the wear except as stated above. In other words, if we had two bearings of practically the same proportions, one made of copper, tin, lead alone, and the other made of copper, tin, lead and phosphorus, and both were equally sound castings, we have no experiments that indicate that the one containing phosphorus would wear any better than the one without phosphorus.

In view of the results stated above, the question arose some three or four years ago with some prominence as to how much lead and how little tin we could get along with. Quite a number of experiments were made on this point, with the result of finally reaching the following composition as the best that could be obtained with our present knowledge—namely:

Copper	77.00 per cent.
Tin	8.00 "
Lead	15.00 "

This alloy from the letter assigned to it in the experimental work done is known as "Ex.B" metal. It will be observed that in the figures given above there is no phosphorus, and this was the case with the experimental alloy which led to the adoption of the figures mentioned. On the other hand, as will be readily understood, there are considerable amounts of phosphor-bronze scrap constantly coming back to the foundry for remelting. Accordingly, such a formula was devised as would enable this scrap to be used in making the standard Ex.B metal, and at the same time would give the advantage in foundry practice of having a small amount of phosphorus in the alloy. We give below working formulas which enable a foundry to use larger or smaller amounts of scrap, depending on the amount received from the service. It will also be fair to state that we deem the presence of a small amount of phosphorus in the alloy as of sufficient importance in the foundry, so that if there is no scrap we recommend to put in new standard phosphor bronze. These points are covered in the working formulas as follows:

Copper	105 lbs.	90 lbs.	72½ lbs.
Phosphor-Bronze, New or Scrap.	60 "	80 "	100 "
Tin	9¾ "	7½ "	5½ "
Lead	25¼ "	22½ "	22 "

These formulas all give a bearing metal of about the following composition:

Copper	76.50 per cent.	to 76.80 per cent.
Tin	8.00 "	
Lead	15.00 "	
Phosphorus	0.50 "	to 0.20 "

The above formulas enable the foundry to make a standard bearing metal which, so far as our knowledge at present goes, is the best one known; but there is one point still not covered in these formulas—namely, it is clear, of course, that after awhile the foundry would begin to receive Ex.B scrap, and it would not do to put this in in place of the phosphor-bronze scrap, because the proportions of the constituents are different, and also because the amount of phosphorus in the Ex.B metal is small. Accordingly, a working formula has been calculated out which enables the foundry to dispose of the Ex.B scrap which comes to it. This formula is as follows:

Ex.B Scrap	80 lbs.
Phosphor-Bronze, New or Scrap	20 "
Copper	76 "
Tin	7 "
Lead	17 "

It will be observed that, even in this formula, which was calculated out for the sake of enabling the foundry to use large quantities at one time of the Ex.B scrap, some new or scrap phosphor-bronze is used, the object being to keep up the phosphorus in the bearings to not less than about 0.2 per cent.

The above series of working formulas will enable any foundry to make bearings like the standard bearings of the Pennsylvania Railroad without any difficulty and provide for the use of their scrap bearing metal. It is perhaps advantageous to add that the formulas calculate for 200-lb. pots, and that in the melting it is not essential to add the copper to the pot and melt it down before adding the other constituents. In actual practice the copper and scrap together with the new phosphor-bronze are all charged at once, care being taken to keep the pot covered with powdered charcoal during melting. The lead and tin are not added until after the pot is taken from the fire. It is also fair to say that there is one characteristic in regard to the foundry practice, which it is important to observe—namely, the metal must not be cast at too high temperatures. A very injurious segregation of the constituents takes place if the metal is cast, even in as small a casting as a car bearing, at too high temperatures. Instead of the fine-grained fracture, which is characteristic of metal properly treated, bearings that are poured too hot are coarse crystalline, and in every sense inferior. In the early days of the use of phosphor-bronze very serious difficulty arose from this cause. It is customary in a well-organized foundry to temper the metal, as it is called, for pouring, by the addition of borings from previous bearings. It is, of course, understood that no bearings are sent to the service with the foundry skin on the part that rests on the axle. This is always taken off and the bearing bored out to the proper radius before the bearings are turned out. These borings are used for tempering. Of course the tin and lead added to the metal after it is taken from the fire always temper it a little bit. We know of no rule by which the actual temperature fit for pouring can be determined, but the general practice should be to cast at as low temperatures as will give successful work.

While upon the subject of bearing metal it is perhaps fair to discuss a little the question of lead lining. It is doubtless well known that the common practice now made use of, and which is recommended everywhere for bearings, is to lead line everything which goes into the service. The principal reason for this lining of lead on the inside of the bearing is to furnish a layer of soft, rather easily displaceable metal which will enable the bearing to adapt itself to the worn journal without giving an excessive pressure per square inch. There seems little doubt but that the practice of lead lining diminishes the difficulty of adapting the bearings to worn journals very greatly. It is obvious that it will be impossible to have the bearings turned to the same radius as every worn journal in service, and the lead-lining device meets this difficulty in a very satisfactory way.

It has been stated once or twice in the course of the preceding remarks that it is believed the Ex.B metal represents the best composition for bearing metal now known. It is not at all intended to claim that it is the best that can be developed. All we can say is that all the experiments made show that, both in regard to heating and in regard to loss of metal by wear no other bearing metal that we have experimented with gives as good results as the Ex.B metal. It is entirely possible that a still further diminution in tin, and increase in lead, might give better results. Just where the line should be drawn as a finality it is impossible to say at the present moment. Experiments have been made diminishing the tin in the Ex.B metal one-half, but a very funny difficulty was met with in attempting to make bearings of such an alloy. It is well known that lead and copper do not alloy, and on trying to make a bearing with about 20 per cent. of lead and 4 per cent. of tin, the remainder being copper, it was found almost impossible to get a homogeneous alloy due to the separation of the lead. Apparently one function of the tin, in the triple alloy of copper, tin and lead, is to hold the lead alloyed with the copper. It is quite probable that a small diminution in tin from what is characteristic of the Ex.B metal might take place, and also possible that a small increase in lead might take place. We have not yet finally put this question at rest. It is also possible that the introduction of other constituents into the bearing metal alloy, or, indeed, other combinations of the five or six metals available for bearing metal purposes—namely, copper, tin, lead, antimony and zinc, either with or without phosphorus, might give a bearing metal better than anything else we now know of. This field still remains for experiment.

The question of the crushing or distortion of the bearing under the pressures used is one that has received considerable attention in the course of our experiments. No difficulty has been experienced on this point, either with the standard phosphor-bronze, or with the standard Ex.B metal. Some of the white metal alloys, however, notably the alloy of lead and antimony, either with or without a small addition of zinc, or a little bit of copper, or an alloy of lead, tin and antimony, or, indeed, any of the white metal alloys made from zinc, tin, lead and antimony, have so much difficulty from this cause, that we do not know of any successful car bearings made wholly from white metal. Accordingly, it is customary when trying to use any of these white metal alloys for bearings, to put them inside of a stronger shell, giving rise to the well-known filled car bearing. There is a good deal of chance for experiment in this field yet, and we are frank to say that our experiments have not covered as much ground in this direction as we could wish. There is some knowledge which indicates that the use of a white metal alloy of the right composition would possibly diminish some of the difficulty now experienced with the present standard bearing metal —notably, a less tendency to heat, and possibly a diminution in friction. This field remains, however, for further experiment, and experiments on this point are in progress. Experiments on bearing metals containing aluminum have been undertaken, but no results have yet been obtained.

In the next article we will try to answer the question, "How to Make a Specification," and hope to follow this by another article on "Sampling and Enforcement of Specifications."

(TO BE CONTINUED.)

Foreign Naval Notes.

A NEW Russian armored ship has recently been completed at Sebastopol, and will be added to the Black Sea fleet. This ship, which has been named *George the Victorious*, is 340 ft. long, 69 ft. beam, 26 ft. deep, and 10,280 tons displacement. The engines will work up to 16,000 H.P. with forced draft, and will give, it is expected, a speed of 14 knots with natural draft, and 17.5 knots with forced draft. The main battery consists of six 12-in. guns mounted in barbette, and seven 6-in. guns on the battery deck. The secondary battery includes eight Baranooski rapid-fire guns and six 37-mm. rapid-fire guns; there are also seven torpedo-tubes.

ON December 18 a test of a Cammell solid steel armor-plate was made on the *Nettle*, at Portsmouth, England. The plate was 10½ in. thick and weighed 10 tons. Five rounds were fired from a 6-in. gun at a distance of 30 ft., a charge of 48 lbs. of powder being used, with projectiles weighing 100 lbs. Three of these were Holtzer armor-piercing shell, and it is stated that two of them rebounded, doing but slight damage, while the third remained in the plate, but did not crack it. The other two projectiles were Palliser chilled shot, and did no damage to the plate. The plate was made by a new process, which is kept secret.

A NEW ENGLISH CRUISER.

ONE of the latest additions to the English Navy is the cruiser *Thetis*, which is one of three built by James & George Thompson, of Clydebank, Scotland. This vessel is a second-class cruiser of the following dimensions: Length, 300 ft.; breadth, 43 ft.; depth, 22 ft. 9 in.; average draft, 16 ft. 6 in.; displacement, 3,400 tons. She has a protective deck extending the whole length of the vessel in the form of a flat arch, the crown of which rises about 1 ft. above the water-line at the center of the ship, and slopes down to a point about 4 ft. below the load-line at the sides. This deck is 2 in. thick on the slope and 1 in. on the crown, and covers the engines, boilers and other machinery and the magazines. Protection for the parts of the engine which are above this deck is obtained by a belt of 5-in. armor with teak backing surrounding the engine hatchway. The ship is divided into 80 water-tight compartments, and has an inner bottom under the engine and boiler space.