

OF THE

MANUFACTURE OF ARMOR PLATE

FOR THE

UNITED STATES NAVY.

COMPILED BY

THE AMERICAN IRON AND STEEL ASSOCIATION.

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ARMOR PLATE FOR THE NAVY.

Congressional Legislation Relating to the Price of Armor for United States Naval Vessels.

THE first contract for armor was made by the Navy Department with the Bethlehem Iron Company on June 1, 1887. This contract was for the armor for the battleships *Maine* and *Texas* and for the monitors *Puritan*, *Amphitrite*, *Monadnock*, and *Terror*. The amount of armor contracted for was estimated at about 6,700 tons, at an average price of about \$536 per ton. This armor, as contracted for, was of plain steel, oil-tempered and annealed. Later, and after careful experimenting by the Navy Department, the introduction of nickel into steel for armor was specified on account of the increased ballistic resistance which could thus be obtained. Armor treated by the Harvey process, whereby the faces of the plates are hardened, having been found to be far superior to homogeneous or soft-faced armor, the Navy Department ordered the application of this process to all armor not completed at that time. For each of the above new features an additional price was paid.

In the Report of the Secretary of the Navy for the year 1890 Secretary Tracy gives the reasons for making the first armor contract with Carnegie, Phipps & Co., Limited. In the fall of 1890 other armor was needed, or would soon be needed, for vessels then authorized, in addition to the armor contracted for with the Bethlehem Iron Company, and it appeared to the Department that it

was necessary to induce another steel manufacturing company to go into this business. Accordingly negotiations were opened by Secretary Tracy with Carnegie, Phipps & Co., with a view to the establishment of another plant for the manufacture of armor.

The proposition was promptly declined, as the manufacture of armor was not considered a profitable business; but, at the urgent solicitation of the President and of Secretary Tracy, the proposition was reconsidered, resulting in a contract being made with the company named, dated November 20, 1890, for 6,000 tons of plain steel armor, oil-tempered and annealed, the prices to be paid being those named in the contract with the Bethlehem Iron Company. A provision was inserted in this contract that nickel-steel armor might be ordered instead of plain steel armor. An additional agreement was afterwards made which provided for the Harvey treatment of the armor. All the armor made under this contract was of nickel-steel, and part of it was Harvey treated, as in the case of the armor furnished under the contract with the Bethlehem Iron Company, the same allowance being made to both companies for these extra requirements to cover the additional cost of manufacture.

ADDITIONAL ARMOR CONTRACTS.

On the 28th of February, 1893, a second contract for about 3,000 tons of nickel-steel armor, to be treated by the Harvey process, was made with the Carnegie Steel Company, Limited, which had purchased in the meantime the works of Carnegie, Phipps & Co., and on March 1, 1893, a second contract for about 3,500 tons of similar armor was made with the Bethlehem Iron Company. The prices at which all of this armor was contracted for were about the same for nickel-steel armor as had been

paid in the former contracts for plain steel armor, the Department furnishing the nickel and paying an additional amount for the Harvey treatment.

In the Report of Hon. Hilary A. Herbert, Secretary of the Navy, for the year 1896, page 27, the following paragraph appears:

While the Department, during the summer of 1895, was preparing advertisements for armor for the *Kearsarge* and *Kentucky* I had a prolonged interview with the representatives of the Bethlehem and Carnegie companies, in which I insisted on lower prices. After much discussion and some altercation these companies agreed in writing that their prices should be at least \$50 per ton lower than they had previously received. This was before the Congress met in December. When Congress had convened the Committee on Naval Affairs of the Senate began for itself an investigation into the prices of armor, pending which the advertisement was held up, until the committee, seeing that its investigation was likely to be prolonged, suggested that the Department should proceed with its contracts. The companies both complied fully with their agreements, and the armor for the *Kearsarge* and *Kentucky* was all let at prices averaging a reduction of \$59.54 per ton from previous contract rates, although the requirements were greater. A still further reduction of \$9.98 per ton in the price of this armor is due to the decreased cost of the nickel used.

The armor for the *Kearsarge* and *Kentucky* thus contracted for amounted to about 5,600 tons.

INQUIRY INTO THE COST OF MAKING ARMOR.

In the act making appropriations for the naval service for the fiscal year ending June 30, 1897, and for other purposes, approved June 10, 1896, three sea-going coast-line battle-ships were authorized. These ships, since called the *Alabama*, *Illinois*, and *Wisconsin*, are now building. In the same act it is provided further:

That the Secretary of the Navy is hereby directed to examine into the actual cost of armor plate and the price for the same which should be equitably paid, and shall report the result of his investigation to

Congress at its next session at a date not later than January first, eighteen hundred and ninety-seven, and no contract for armor plate for the vessels authorized by this act shall be made until after such report is made to Congress for its action.

In accordance with the above-mentioned provision the Secretary of the Navy wrote to the Bethlehem Iron Company and the Carnegie Steel Company asking that such data be furnished as would assist him in arriving at a fair conclusion. The companies, apprehending that any statements made might be erroneously construed and distorted to their disadvantage, and reluctant to expose private affairs to business rivals, decided after due consideration not to take any steps that would seem to admit the right of a customer to examine the cost of manufacture with the view of disputing prices. The Secretary then proceeded to secure the information desired by the appointment of a committee of naval officers, referred to as the Rohrer Board. In addition Lieutenant Rodgers and Ensign McVay, inspectors of armor at the works of the Bethlehem Iron Company and the Carnegie Steel Company, respectively, were each called upon to make a separate estimate. The Report of the Secretary of the Navy, under date of December 31, 1896, based upon the information thus obtained, was transmitted to the Speaker of the House of Representatives (See document No. 151, H. R., 54th Congress, second session.) The Report of the Rohrer Board, including the reports of the naval officers, was dissented from by the Secretary, who reached entirely different conclusions concerning the cost of armor and the price to be paid for it.

SECRETARY HERBERT'S REPORT.

While accepting the naval officers' estimates for cost of labor and material Secretary Herbert made an allowance

for maintenance of plant based not upon the actual cost of each plant but upon an estimated value which was less than one-half its cost. The allowance for maintenance was also based upon an output of about 3,000 tons a year for each plant, which is nearly 50 per cent. greater than the actual average output has been. On this basis the Secretary estimated that \$400 per ton would be a fair price to be paid for the armor for the *Alabama*, *Illinois*, and *Wisconsin*.

On page xix of Senate Report No. 1,453 the price of \$400 as proposed in Secretary Herbert's Report is summarized by Senator Chandler as follows:

	Per Ton.
The Secretary takes as the cost of labor and material in double-forged, Harveyized, nickel-steel armor the sum of.....	\$196.00
He assumes that a plant costing \$1,500,000 would need \$150,000 per year for maintaining it, or \$50 per ton upon 3,000 tons of armor, and adds to the price.....	50.00
Making	\$246.00
Or in round numbers.....	\$250.00
He then adds for profit 50 per cent., or.....	125.00
Making	\$375.00
He then adds for nickel, to be furnished hereafter by the contractors.....	20.00
Making	\$395.00
Or in round numbers.....	400.00

THE SECRETARY'S REPORT ANALYZED.

On the face of the above statement the allowance of 50 per cent. profit on the cost of manufacturing is altogether deceptive, the fact being overlooked that, with a small output from a large and costly plant, a manufacturing company producing difficult shapes may have a large profit on the cost of manufacturing and yet realize

very small returns on the capital invested. The lowest estimate of cost of plant and working capital of either the Bethlehem or the Carnegie Company is \$4,000,000. The estimated profit of \$125 per ton on 3,000 tons of armor amounts to \$375,000, or 9.37 per cent. on the money actually invested. Deducting therefrom the legal rate of interest, 6 per cent., there remains but 3.37 per cent. to cover all the risks incurred in manufacturing. It will be noted that in Senator Chandler's estimate for maintenance it is assumed that the plant cost \$1,500,000, whereas the actual cost of the Carnegie Steel Company's armor plant, as subsequently reported by Secretary Herbert in his Supplementary Report, (document No. 151, part 2, H. R., 54th Congress, second session,) is given on page 5 as \$3,376,000, and, in his Report, Secretary Herbert states that the Bethlehem plant must have cost about \$1,000,000 more than the Carnegie plant, this difference being in part accounted for by the cost of the 125-ton hammer, the largest ever built in the world, which was put in by the Bethlehem Iron Company at the suggestion of the Navy Department, and, after less than three years' use, was discarded and replaced by a 14,000-ton forging press.

With respect to the assumed valuation of a plant at \$1,500,000, Secretary Long, in a letter to the Chairman of the Committee on Naval Affairs of the United States Senate, dated May 6, 1897, gives the views of the Chief of the Bureau of Ordnance thereon :

It is also the Bureau's opinion that the sum named for the purpose of establishing a Government armor factory would be entirely inadequate. Although \$1,500,000 is the sum estimated by the Department as the present cost of an armor plant it must be remembered that such a plant, separated from the plant for the manufacture of steel ingots themselves, would be useless; consequently if the Government proposes to go into the business of making armor plate it must establish a plant complete in every respect. To obtain the necessary

stock of material for working on a large scale and for the unavoidable experimental work in the beginning it is thought that \$3,000,000 would be more nearly the sum required than \$1,500,000.

The estimated value of the Carnegie armor plant as reported by the Rohrer Board is \$3,537,000. From the actual cost of this plant, viz: \$3,376,000, as reported by Secretary Herbert in his Supplementary Report, there should be deducted the value of the land, amounting to \$240,000, leaving in round numbers \$3,000,000 as the cost of the plant on which to allow maintenance. This, at 10 per cent., the rate adopted by Secretary Herbert, amounts to \$300,000 per annum. In the foregoing statement the maintenance charge is also estimated on an output of 3,000 tons of armor per annum, while the average output of either the Bethlehem Iron Company or the Carnegie Steel Company is to this date hardly 2,000 tons per annum. Estimating this at 2,000 tons per annum makes \$150 per ton for maintenance. The preceding statement, omitting the item of profit, would then read as follows:

Cost of labor and material in double-forged, Harveyized, nickel-steel armor, per ton.....	\$196.00
Allowance for maintenance at 10 per cent. on plant costing \$3,000,000 would be \$300,000 per annum, which, on an output of 2,000 tons per annum, would amount to, per ton.....	150.00
Add for nickel, to be furnished hereafter by the contractor, per ton.....	20.00
Making	<u>\$366.00</u>

Armor sold at \$400 per ton would thus yield a profit of \$34 per ton, amounting, on 2,000 tons per year, to \$68,000, or 1.7 per cent. on the capital invested, nothing being allowed for interest on the capital. Senator Chandler has dissented from the allowance of 10 per cent. for maintenance made by Secretary Herbert, and has estimated that 6 per cent. would be sufficient. This would reduce the maintenance charge per ton to \$90, making the total cost

\$306 per ton of armor, or a profit of \$94 per ton, which, on an annual output of 2,000 tons, would be \$188,000, or 4.7 per cent. on the investment.

CONGRESSIONAL LIMITATION OF PRICE.

With these estimates before it Congress, on March 3, 1897, established an arbitrary price of \$300 per ton to be paid for armor. To show approximately what this price means let it be assumed that for three years there have been manufactured 2,000 tons of armor per year, which is about the average quantity, and which, at the price of \$300 per ton, would yield the gross sum of \$1,800,000, or \$600,000 per year. The cost of the plant, with a fair allowance for working capital, would amount to about \$4,000,000. If, therefore, armor should cost nothing to make, the above gross receipts per year would be only 15 per cent. on the capital invested in a plant which may within a few years be worthless. Foreign governments are satisfied to pay for the same quality of armor over \$500 per ton. American armor manufacturers have so successfully worked out sundry improvements in the manufacture of armor that the Government now receives armor of the same resistance as formerly, at the same price per ton, but with one-third less thickness and weight, thus reducing the actual cost of armor for the same amount of protection 33 $\frac{1}{3}$ per cent. These improvements cost the armor makers heavily, both in higher actual cost of manufacture and in royalties for patents.

REPORT FROM THE SENATE COMMITTEE ON NAVAL AFFAIRS.

A Report of an investigation made by the Committee on Naval Affairs of the United States Senate, which was ordered by resolution of December 31, 1896, will be found in Senate Report No. 1,453, 54th Congress, second session.

The recommendation of the committee concerning the price to be paid for armor as contained in this report is as follows: "That a fair average price be paid for armor for the three new battle-ships authorized by the act of June 10, 1896, which will be between \$300 and \$400 per ton of 2,240 pounds." This recommendation was based upon Secretary Herbert's Report, but proposed to reduce still further the amount allowed by Secretary Herbert for maintenance and profit.

ACT OF MARCH 3, 1897, LIMITING THE PRICE.

The act making appropriations for the naval service for the fiscal year ending June 30, 1898, and for other purposes, (H. R. 10,336,) as it passed the House of Representatives, provided:

That the total cost of the armor according to the plans and specifications already prepared for the three battle-ships authorized by the act of June 10, 1896, shall not exceed \$3,210,000 exclusive of the cost of transportation, ballistic test plates, and tests; *And provided further*, That no portion of this armor shall be purchased until it has all been contracted for: *And provided further*, That the Secretary of the Navy is authorized in his discretion to contract with either or all of the builders of the hulls and machinery of these vessels, or with one or more bidders, for the furnishing of the entire amount of said armor, if he shall deem it to the best interest of the Government.

The above limitation of the cost of the armor, namely, \$3,210,000, is at the rate of \$400 per ton.

In this act, as it finally passed both Houses of Congress and was approved March 3, 1897, the amount appropriated for the armor for these three battle-ships was reduced to \$2,407,500, and it was further provided "that no contract for armor plate shall be made at an average rate to exceed \$300 per ton of 2,240 pounds." The above provision, "that no portion of this armor shall be purchased until it has all been contracted for," was stricken out.

NO CONTRACTS AT THE PRICE FIXED.

The Secretary of the Navy, under date of April 9, 1897, transmitted to the Speaker of the House of Representatives a letter from the Illinois Steel Company inclosing two propositions in answer to the Department's advertisement, also a letter from the Bethlehem Iron Company and one from the Carnegie Steel Company, together with a Report of the Chief of the Bureau of Ordnance of his visit to the works of the Illinois Steel Company. This correspondence is all printed in H. R. document No. 20, 55th Congress, first session. The Secretary of the Navy says :

The communication of the Illinois Steel Company contains a bid in the form of two general propositions, neither of which the Department feels that it has any authority to consider with the view of acceptance or rejection ; while the other two communications received are not bids, but are statements of reasons why bids are not submitted.

The other two communications referred to were those from the Bethlehem and the Carnegie companies. The proposition of the Illinois Steel Company reads as follows :

We hereby offer to furnish about 8,000 tons of nickel-steel armor plate and appurtenances for battle-ships Nos. 7, 8, and 9 at an average price of \$300 per ton of 2,240 pounds, free on board cars at our South Chicago works, conditioned upon Congress awarding us a contract for the entire wants of the United States Government for armor plate for a period of twenty years from this date, at an average price of \$240 per ton of 2,240 pounds, the Government to agree that the total tonnage of armor plate, ordered as above for the period of 20 years, shall not be less than 6,000 nor more than 12,000 tons in any one year.

Should we be unable to furnish said minimum or maximum quantity of armor plate in any one year we agree to pay as damages the sum of \$100 per ton for any such quantity as we may be in default of, the Government agreeing that, should it not require the minimum quantity in any one year, it will pay us \$100 per ton as liquidated damages for the difference between the amount ordered by it and the above-named minimum.

SECRETARY LONG'S RECOMMENDATION.

Secretary Long appeared before the Committee on Naval Affairs of the United States Senate on May 19, 1897, and informed the committee that the Bethlehem Iron Company and the Carnegie Steel Company would make the armor for the three battle-ships then building at \$425 per ton, and recommended that this price be paid.

ACT OF JULY 19, 1897, FURTHER LIMITING THE PRICE.

The Committee on Appropriations of the United States Senate reported back the "act making appropriations to supply the deficiencies in the appropriations for the fiscal year ending June 30, 1897, and for prior years, and for other purposes," with a provision authorizing the Secretary of the Navy to contract for the armor for these three battle-ships at an average price of \$425 per ton. This act, however, as passed by the Senate and House of Representatives, and approved July 19, 1897, provided under the head of armor plate:

That the total cost of the armor according to the weights prepared for the three battle-ships authorized by the act of June tenth, eighteen hundred and ninety-six, shall not exceed two million four hundred and seven thousand and five hundred dollars, exclusive of the cost of transportation, ballistic test plates, and tests; and no contract for armor plate shall be made at an average rate to exceed three hundred dollars per ton of two thousand two hundred and forty pounds; *And provided further*, that the Secretary of the Navy is authorized in his discretion to contract with either or all of the builders of the hulls and machinery of these vessels, or with any one or more bidders, for the furnishing of the entire amount of said armor, at a cost not exceeding the aforesaid three hundred dollars per ton, if he shall deem it for the best interests of the Government.

In case the Secretary of the Navy shall find it impossible to make contracts for said armor within the limits as to price fixed he shall be, and hereby is, authorized and directed to take steps to establish a Government armor factory of sufficient capacity to make such armor.

In executing this authority he shall prepare a description and plans and specifications of the land, buildings, and machinery suitable for the factory; and shall advertise for proposals to furnish such land, buildings, and machinery as a whole plant, or separately, for the land or buildings, or the whole or any part of said machinery, and to report to Congress at its next session. The Secretary shall also appoint an armor factory board, to consist of competent naval officers of suitable rank, to advise and assist him in executing the authority hereby conferred.

REPORT OF ARMOR FACTORY BOARD.

The Board appointed by the Secretary of the Navy under the foregoing provision made a thorough investigation of the entire subject, devoting four months to its work. The findings of the Board were submitted in a report filed with the Secretary on December 1, 1897. This document was presented to Congress, and gives ample proof of the armor manufacturers' statements relative to the cost of their plants, the Board finding from estimates of leading engineers and ordnance specialists, who were employed to submit plans and estimates, that it would require at the minimum \$3,747,912 to establish an efficient plant capable of producing sufficient armor for two battle-ships per year. This estimate, however, embraced only the armor plant and steel furnaces, and omitted many essentials necessary to form an independent plant. From the statements submitted it is evident that the Board considered that a Government armor works would be a failure economically, because its product would likely be far more expensive than a similar product purchased from armor manufacturers engaged in the commercial branches of the steel industry.

The report of the Chief of the Bureau of Ordnance for 1897 says with reference to the armor factory proposition:

The Bureau is of the opinion that the Government can purchase armor more cheaply than it can manufacture it, and regards the mak-

ing of armor as a proper adjunct to a great commercial steel plant. Foreign practice confirms this view; and even should the Department acquire a plant of its own the chances are that it would be at a great cost, and that it would lie idle a large part of the time and thus suffer deterioration, and that the expense and difficulty of operating it when needed would more than offset any advantage gained by such ownership.

THE WASHINGTON NAVY YARD AND WATERVLIET ARSENAL.

The advocates of a Government armor works have largely based the claim that such an enterprise could be successfully operated and cheaper armor obtained on the fact that the Government produces heavy ordnance at the Washington Navy Yard and at Watervliet Arsenal. But all the guns produced by these Government shops are made from forgings supplied by private companies, whose work on them embraces all the metallurgical features of the process of manufacturing, beginning with the raw materials, and who supply them to the Government rough machined and fully treated, after which they are simply machined to finished dimensions, assembled, and so completed. These considerations have evidently been overlooked by the advocates of a Government armor plant.

A Government armor plate factory which would be comparable with the two Government plants above mentioned would require the purchase of the armor plates all completed except finished machining; and, since the armor plates must be practically otherwise finished before being hardened, it will be seen that no comparison can be made between the manufacture of guns and the manufacture of armor plate, the processes being entirely different, and that no convincing argument in favor of a Government armor plate factory can be deduced from the fact that the Government completes the manufacture of guns from the rough machined forgings furnished by private manufacturers.

FAILURE OF RUSSIA'S ARMOR PLANT.

Another claim frequently made in Congress in support of a Government armor factory is that various European governments have successfully established armor works and supply their own requirements cheaper than would be possible by purchase. This claim is refuted by the following facts.

Every naval power of Europe has, at different periods since the advent of the armor-clad ship, contemplated the step the United States has been urged to take, only to find that armor could not be manufactured successfully under State administration, or that the cost in the event of successful production would be much higher than the price at which it could be purchased from private manufacturers. Great Britain, which has bought, and may continue to buy, more armor than any other three naval powers in the world, determined this question negatively long ago as the result of an investigation by an Admiralty Commission. As a result the naval powers of Europe continue to buy armor from European manufacturers at unquestioned and much higher prices than the United States has paid American manufacturers for armor of superior quality.

Russia, being dependent upon foreign sources of supply, owing to the limited development of her metallurgical industry and the unwillingness of private capital in that country to invest in such a hazardous undertaking as armor manufacturing, established a government plant at Kolpino, near St. Petersburg, as a measure of national safety, for, in the event of war, Russia would, of course, be obliged to rely entirely on its own resources for armor and ordnance. The Kolpino works, it is said, have cost from \$8,000,000 to \$10,000,000 and are still incomplete. This is the only government armor plant in the

world, and the Russian ordnance engineers concede that it can never be operated as economically as private establishments in America and Europe, but, as a home resource, it is invaluable, and it is to be maintained by the Russian Government regardless of cost, to be put in operation whenever the exigencies of war and the neutrality laws preclude the purchase of armor and ordnance from foreign countries.

A large percentage of the armor produced at the Kolpino establishment has failed to meet the ballistic standard, and much of it has been discarded as useless. Russia undertook to produce a large quantity of armor at its own works for some of its vessels now building, but, after many failures, the Government was compelled to abandon the work, the orders being withdrawn and contracts placed with European and American manufacturers for the armor, the Bethlehem Iron Company and the Carnegie Steel Company each receiving a share of the work thus unsuccessfully attempted, and at higher prices than the United States was then paying these companies for the same class of armor.

The Russian Government has now adopted the most advanced armor process of the present period and will almost entirely remodel the Kolpino plant at an additional cost of many millions to keep pace with the improvements in armor manufacture, but, judging by its past experience, it is reasonably certain that the plant will never produce armor as cheaply or of so reliable quality as the works under the control of commercial steel manufacturers.

IMPOSSIBLE TO OBTAIN ARMOR AT \$300 PER TON.

Secretary Long appeared before the Senate Naval Committee in February, 1898, and stated that it was impossible to obtain bids for the armor for battle-ships 7, 8, and

9 at the limit of \$300 per ton fixed by the Act of March 3, 1897, and the Act of July 19, 1897, and recommended that the price be increased to \$400 per ton. Congress adopted the Secretary's recommendation in the Act of May 4, 1898, making appropriations for the naval establishment for the fiscal year ending June 30, 1899, and authorized the payment of \$400 per ton for armor for battle-ships 7, 8, and 9, exclusive of royalty for the face-hardening process, which price the Navy Department finally induced the armor manufacturers to accept, the contracts being closed on June 3, 1898. Fortunately the war with Spain was of short duration and the new battle-ships were not required, but, if hostilities had been prolonged, the ships could not have been available for that war, and by reason of the delay will not be finished in the contract time. The dilatory action of Congress may also result in claims for damages from the shipbuilders in consequence of the Government's neglect to provide the armor on schedule time.

RUSSIAN CONTRACTS FOR AMERICAN ARMOR.

The extremely low price, \$249 per ton, at which the Bethlehem Iron Company contracted in December, 1894, to furnish the Russian Government with about 1,500 tons of nickel-steel armor, of which only about one-third was Harveyized, and which was mainly of very plain and easily made shapes, was one cause of bringing the question of the price of armor to the attention of Congress, and has led many persons to feel that our own Government should be able to purchase its material from home manufacturers at an equally low price. Plausible as this contention may appear a fair consideration of the facts will justify the action of the Bethlehem Iron Company.

The great improvement in armor made in the United States by the introduction of nickel, and continued by the application of the Harvey process, was well known to the Russian Government and made it desirous of putting American-made armor on its ships. When the invitation to bid on armor plates was received from Russia in December, 1894, work on pending contracts with the United States was rapidly drawing to an end, and there was no prospect of receiving other orders from that source until additional ships should be authorized by Congress. Thus the Bethlehem Iron Company was about to suffer grievously by being compelled to shut down its armor plant because of the course pursued by the Government in establishing a second plant and dividing its orders, whereby neither plant could be kept steadily employed. Under these circumstances it was extremely desirable to obtain outside work in order to employ and keep together specially trained labor and to prevent the demoralization of plant and organization. The situation was one with which every business man and manufacturer is familiar, that under the circumstances it was better to take the work, even if at a loss, without reference to fixed charges, than to have no work at all. In addition to this it was recognized that the placing of an order for armor by Russia with a United States concern, in competition with all the European manufacturers, would be a notable event in the rapid march of the steel industry in this country, and would be the best possible method of heralding to the world that, though young in the business, the United States manufacturers had mastered the art and were ready to compete with all the world for the supply of armor plates of the highest quality. These motives induced both the American companies to send their agents to Russia with instructions to take the work.

The European manufacturers were, of course, much averse to the advent of American makers into the field, and determined to offer a stout resistance by bidding low prices. These prices were, however, met by the American companies, between which an active competition followed, resulting in the contract being awarded to the Bethlehem Company at the ruinously low price above mentioned. To make armor continuously at such a price could only bring disaster, for a great expenditure of capital, energy, and skill would have been made without returns. Surely the Government of the United States, the reputation of whose warships was raised by this transaction, can not, when dealing with its own manufacturers, whose continued prosperous existence must form the corner-stone of national defense, justly consider as a precedent for its future action a price made under the circumstances above described.

It should be noted that the contract as originally made with the Russian Government was for 1,264 tons, with the proviso that this amount might be increased by 300 tons at the option of the Russian Marine. The order was so increased, and the total amount furnished at the low price was 1,561 tons. It was, as has been said, armor of comparatively simple shape, much less difficult to manufacture than the average armor for our own ships, and only part of it was to be Harveyized. It was delivered promptly at the date fixed by the contract, and met successfully the severe requirements imposed by the Russian specifications. The Russian Government was so well pleased with these plates, and generally with the manner in which the contract was executed, that subsequently, in December, 1895, it made a contract with the Bethlehem Company for about 1,100 tons and with the Carnegie Company for about 1,000 tons of hard-faced, nickel-steel

armor at average prices of \$527 and \$530 per ton respectively. These prices are still about the average market prices of the world for armor plates of the same quality.

KRUPP'S NEW PROCESS ARMOR.

The Act of May 4, 1898, authorized the construction of three battle-ships, subsequently named the *Maine*, *Ohio*, and *Missouri*, requiring on the revised plans about 2,730 tons of armor each, and four harbor-defense monitors, *Arkansas*, *Florida*, *Connecticut*, and *Wyoming*, requiring about 538 tons of armor each, at the same price limit of \$400 per ton, as stipulated for the *Alabama*, *Illinois*, and *Wisconsin*. The advertisements for this armor were withheld beyond the usual time, as the Navy Department learned that Herr Krupp had perfected a new process for the fabrication of armor at his ordnance works at Essen, Germany, that gave a product much superior to Harveyized armor and revolutionized the ballistic standard. The Navy Department, after a thorough investigation, decided to adopt Krupp armor for the ships, but could not do so without Congressional authority, and, as Congress did not meet until December, 1898, the contracts were held over.

Krupp's new process armor, as it is now generally styled, is the result of years of experiment and the expenditure of a large amount of capital. The tests of the first plates were made on Krupp's proving ground in Meppen, Germany, in 1895, but the records were not announced at that time. Subsequent tests made before the ordnance engineers of the European admiralities showed from 20 to 30 per cent. more resistance to the attack of armor-piercing projectiles than Harveyized armor. As a result of these tests the new armor was immediately adopted by England, France, Russia, Japan, and Germany.

Herr Fried. Krupp then offered the manufacturing

rights to the armor makers of the world, stipulating the payment of a large sum for the license, and, in addition, from \$45 to \$50 per ton as royalty on every ton manufactured. The Carnegie Steel Company and the Bethlehem Iron Company, the two American armor manufacturers, contracted for the exclusive manufacturing rights in America under Herr Krupp's terms, which have also been accepted by the armor makers of England, France, and Italy. The American manufacturers sent their experts to the Krupp works in Essen to be instructed in the details of the new process, which, under the contract with the inventor, is held a secret, and, therefore, the metallurgical details have not been patented.*

TESTS OF KRUPP ARMOR.

The Carnegie Steel Company, Limited, manufactured the first armor plate made by the Krupp process in America. This plate was tested by the Bureau of Ordnance of the Navy Department on the Indian Head proving ground, on July 13, 1898, and it successfully withstood a heavy gun fire of 25 per cent. greater severity than the best Harveyized armor plate of equal thickness ever tested. The results of this remarkable test were reported by Commander A. R. Couden to the Navy De-

* The patent granted by the United States for a furnace of improved design used at the Krupp works for carbonizing or face-hardening armor plates, referred to in Congress by Senator Butler (Congressional Record, March 1, 1899, p. 2,844,) and by Representative Albert M. Todd, (Congressional Record, February 22, 1899, p. 2,863,) is not an essential part of the process for making the new armor, but describes an improved furnace in which two armor plates may be supercarbonized instead of one, as heretofore, by well-known methods of applying hydro-carbon gases, illuminating gas, paraffine vapor, etc., the improvement in this case consisting of making the armor plates to be thus treated a part of the furnace structure. This patent does not include the secret metal amalgamation feature employed in making the new armor, a knowledge of which is absolutely essential, nor does it deal in any way with the various complicated treatments entering into the manufacture of Krupp armor.

partment and the data are now part of the Department records. The plate showed a capacity to resist projectile perforation at the unprecedented velocity for a six-inch armor test of 2,350 feet per second from a six-inch gun fired at point-blank range. In October of the same year a twelve-inch experimental Kruppized plate manufactured by the Carnegie Steel Company, Limited, was tested by the Bureau of Ordnance. Rear Admiral Charles O'Neil, Chief of the Bureau of Ordnance, the highest authority in the United States Navy, and one of the leading ordnance engineers of the world, in a letter to the Senate Naval Committee referred to these tests as showing marked qualities of excellence and of superiority over the ordinary face-hardened armor.

In November, 1898, a plate six inches thick, manufactured by the Bethlehem Iron Company by the Krupp process, was tested at the Redington proving ground under the supervision of the United States Naval Inspector and in the presence of the Commission representing the Imperial Russian Marine stationed at the ship yard of the William Cramp and Son's Ship and Engine Building Company. This plate was attacked with an eight-inch instead of a six-inch gun, six shots being fired at it with a striking velocity varying from 1,521 to 1,823 feet per second. It showed a resistance to penetration much in excess of Harveyized armor of the same thickness, and, notwithstanding this tremendous attack, when the successive impacts were considerably closer together than were required by the Government specifications, no cracks whatever were developed.

In the month of December, 1898, an experimental Krupp plate seven and three-quarters inches thick, made by the Bethlehem Iron Company, successfully withstood a very severe test of five shots from an eight-inch gun,

the striking velocities being unusually high, developing a total energy of 36,432 foot tons, and no cracks resulting.

GREATER COST OF KRUPP ARMOR.

The material of which Krupp armor is made is exceedingly sensitive to the varying conditions inherent in the process of manufacture, such as melting, forging, rolling, heating, cooling, etc.; hence all these processes must be carried out with the greatest possible accuracy and uniformity as to detail. In other words, the process represents a scientific refinement of metallurgical methods quite unknown heretofore in the treatment of such large masses of metal. As a result it can be stated that the application of this process to the manufacture of armor is much more difficult and is accompanied by greater uncertainties and liability to loss than is the case in applying the Harvey process to nickel-steel armor. Furthermore, the number of separate operations is far greater than in the application of the Harvey process, and the metal is more difficult to machine in all stages of manufacture.

To summarize, the following reasons can be given why armor made by the Krupp process costs more to manufacture than the hard-faced, nickel-steel armor heretofore purchased by the Government:

1. Greater cost of materials used.
2. Greater number of operations through which each plate has to pass, by which charges are increased and product reduced.
3. Greater percentage of loss, due to uncertainties and liability to errors in manufacture.
4. Greater difficulty in cutting the metal cold, whereby the product of machine tools is decreased.
5. Reduction in the average thickness of plates, corresponding to greater ballistic resistance, whereby the num-

ber of individual plates in a given total tonnage is increased. This causes a corresponding increase in the number of operations to be performed and the amount of machine work to be done, and materially decreases the weight of the product that can be produced by a given plant within a given time.

In response to a request from the Bureau of Ordnance for information as to the price of armor manufactured by the new process the manufacturers agreed to furnish it to the United States for \$545 per ton, which included the royalty to be paid the inventor. It should be borne in mind that the price named was for armor having a ballistic resistance 25 per cent. greater than that of Harveyized armor, and that this price is less than that paid for Kruppized armor by any other government in the world.

The Navy Department communicated this information to Congress in a letter from Rear Admiral O'Neil, who stated that positive evidence had been received by the Navy Department that British armor manufacturers were receiving not less than £117 sterling (\$568.62) on large domestic and foreign contracts, and that the Carnegie and Bethlehem Companies will receive \$575 per ton for the armor for the Russian battle-ship now building at Philadelphia. Admiral O'Neil urged that only the best armor that could be manufactured should be procured, and concluded his report (Congressional Record, March 1, 1899, pp. 2,835, 2,836, and 2,837) thus:

The Bureau of Ordnance desires to be placed on record as recommending to the Department that only the best quality of armor that can be obtained in this country shall be placed on vessels of the United States Navy, regardless of price. To do otherwise will destroy the prestige of our naval vessels, and the Bureau trusts that such steps will be taken by the Navy Department as will absolve it entirely from responsibility in the matter if it is forced to procure armor of a quality inferior to the best that can be manufactured.

IMPROVEMENTS IN QUALITY OF ARMOR.

Admiral O'Neil recently submitted a table of ballistic velocities, showing that the proposed tests for Kruppized armor would be such as are now applied to Harveyized plates of 25 per cent. greater thickness; that is, the same test will be applied to a six-inch Krupp plate that has heretofore been applied to a Harveyized plate of seven and one-half inches; to an eight-inch Krupp plate that which has been applied to ten-inch Harveyized armor; to a ten-inch Krupp plate that which has been applied to Harveyized armor of twelve and one-half inches; and to a twelve-inch Krupp plate that which has been applied to Harveyized armor of fifteen inches; the difference in requirements being illustrated in the following table of minimum velocities of feet per second for the Harveyized and the Kruppized armor—one shot at the Harveyized plate and three shots at the Kruppized plate at given velocity. The test of Harveyized plates also provided for a previous shot at a lower velocity.

Calibre of Gun.	Thickness of Plate.	Harveyised Armor.	Krupp Armor.
4 inch	4 inch	1,676 f. s.	1,818 f. s.
5 inch	5 inch	1,717 f. s.	2,045 f. s.
6 inch	6 inch	1,659 f. s.	1,885 f. s.
8 inch	8 inch	1,558 f. s.	1,772 f. s.
10 inch	10 inch	1,502 f. s.	1,765 f. s.
12 inch	12 inch	1,469 f. s.	1,661 f. s.

In another official communication upon this subject Admiral O'Neil said :

The advantages to be derived from the use of Krupp armor are obvious and need not be enlarged upon, it being sufficient to state that a twelve-inch plate of the new process armor would be equivalent to a fifteen-inch plate of the quality now being used, thus affording equal protection on 25 per cent. less weight, or 25 per cent. greater protection with present weights.

As only a limited weight can be assigned for armor for hull and gun

protection (23 per cent. of displacement in the *Maine* class of vessels) it will be readily understood how essential it is that the best and most resisting armor obtainable should be procured, in order that the greatest possible area of the vessel may be well protected, especially the water-line, machinery space, and gun emplacements, within the limits of weight allowable for such purposes.

The maximum thickness of the side-belt armor on the *Alabama* class is sixteen and one-half inches, whereas on the *Maine* class (authorized December 12, 1898,) it is proposed to have a maximum thickness of twelve inches for the same armor, thus obtaining the same protection on about 25 per cent. less weight, and to utilize the weight thus saved by increasing the thickness of the casemate armor which protects the six-inch guns to seven inches, as against five and one-half inches on the *Alabama* class, thus greatly improving the vessels of the *Maine* class as regards the distribution of armor, this being upon the assumption that the new process armor will be supplied to the latter vessels.

The Russian battle-ship of 12,500 tons' displacement now being built at Cramp's shipyard is to carry the new process armor, one-half being supplied by the Carnegie Company and the other half by the Bethlehem Company, and these companies state that the price they are to receive for this armor is greater than that they would ask of this Government—that is, more than \$545 per ton.

At the present time there are four battle-ships being built for the British Government in England, namely, *Vengeance*, *Canopus*, *Albion*, and *Glory*; also four battle-ships for the Japanese Government and four armored cruisers for the British Government and three for Japan. In addition to the above vessels, all of which it is understood are to be supplied with the new process armor, the British Admiralty has asked for tenders for four battle-ships and two large armored cruisers, all of which will have armor similar to that to be provided for the other ships referred to above.

The special features which characterize the new process armor are its depth of hard face, extreme toughness of back, and its ability to resist numerous impacts at high velocity without perforation or crack to a marked degree as compared with the present service armor.

The House Committee on Naval Affairs, unwilling to recommend a change in the law regulating the price to be paid for armor without ample justification for such action, summoned Admiral O'Neil to give his opinion

with respect to the merits of the new process armor more fully than he gave in the several communications quoted. Admiral O'Neil accordingly appeared before the committee and conclusively established the fact that the new armor was all that it was claimed to be by the manufacturers. The committee accepted Admiral O'Neil's recommendation and thereupon reported a bill increasing the limit of price to enable the purchase of the improved armor for the new ships. Congress, however, would not accept the recommendation of the Government's ordnance experts and the committee's recommendation was rejected. It was claimed, in justification, that no evidence had been presented that Krupp armor was superior to the Harveyized grade, notwithstanding the existence of the official record containing such evidence.

Despite the ascertained facts concerning the quality of Kruppized armor and the prices paid therefor by European governments, Congress, instead of increasing the price as urged by the Navy Department, reaffirmed its limit of \$400 per ton, exclusive of royalty, for the armor for the vessels provided for by the Act of May 4, 1898, amounting to about ten thousand tons; and for the armor for the ships authorized by the Act of March 3, 1899, amounting to about fourteen thousand tons, it reduced the price to be paid to \$300 per ton, including royalties. Under this limitation the Navy Department advertised for proposals on March 29, 1899, but specified the Kruppized armor ballistic standard instead of the Harveyized, or, to be more precise, the Department called for plate which would pass a test that only Kruppized armor could withstand, as it was determined to have none but the best armor, but, at the same time, the Department was limited to a price which could not even buy Harveyized armor for the ships authorized in March, 1899.

CONTRACTORS DECLINE TO FURNISH THE ARMOR SPECIFIED.

This advertisement was before the steel manufacturers of the country for two months, and not a manufacturer in the country offered to take this contract, which is one of the largest ever authorized, for the obvious reason that the business was regarded as unprofitable at the figure set by Congress, and that it was realized that the high standard of excellence demanded could only be attained with the Krupp process.

The Carnegie Steel Company, Limited, and the Bethlehem Iron Company declined to tender under the price conditions and ballistic requirements, stating that to manufacture the quality of armor specified in the Department circular would necessitate the employment of the Krupp process, which involves greatly increased cost. Both contractors, however, offered at the same time to furnish all or any part of the armor under the same conditions and prices stipulated in the armor contracts for the *Alabama*, *Illinois*, and *Wisconsin*, which specified the Harveyized quality, at a price of \$400 per ton. The Department rejected the offers, but contracted, however, for Harveyized armor at \$400 per ton for the monitors *Florida*, *Connecticut*, *Wyoming*, and *Arkansas*, this quality of armor being regarded as sufficiently good for the low free-board harbor-defense vessels.

Since Congress has thus interrupted the construction of United States warships the selling values of all customary forms of iron and steel have more than doubled. Not only have the prices of iron ore, fuel, pig iron, and labor greatly risen, but even at these higher prices it is extremely difficult for iron and steel makers to meet the urgent demands upon them. It is under these circumstances that Congress must now consider what course it will take in regard to authorizing purchases of needful armor.

APPENDIX.

EXHIBIT A.

The following letter from the Carnegie Steel Company fully answers the charge which has been made that, under the prices heretofore paid for Harveyized armor, unusual profits have been made by the manufacturers, sufficient, in excess of a fair return, to reimburse them for the cost of their plants.

SIR: There seems to be an impression prevalent that we have made unusual profits on armor. We beg your kind perusal of the following statement, which we believe must correct this most fallacious belief.

IN THE MATTER OF THE COST OF ARMOR PLATE.

Deductions from the figures now before Congress in the Report of the Hon. H. A. Herbert, late Secretary of the Navy.

Total value of the Carnegie armor plant.....	\$3,376,019.77
Average date of expenditure, determined from same Report: March, 1892.	
Armor shipped October, 1891, to March, 1897, inclusive, 12,482 gross tons—an average of 2,270 tons per year.	
Proceeds of same, \$6,764,476.87, or \$541.94 per ton.	Per Ton.
Secretary Herbert's basis of cost of manufacture, labor, and material, excluding maintenance.....	\$197.78
Maintenance, 10 per cent. on cost of plant, excluding land and interest, \$306,101.97 per annum, or, on 2,270 tons*.....	134.84
Total cost of armor plate as established on Secretary Herbert's basis.....	\$332.62

SUMMARY AND DEDUCTIONS.

12,482 tons of armor shipped.

Proceeds, per ton.....	\$541.94	\$6,764,476.87
Cost, per ton.....	332.62	4,151,762.87
Profit, without allowance for depreciation.....	\$209.32	\$2,612,714.00
Or \$475,039 per annum.		

* It may be explained that 10 per cent. of cost of plant for maintenance means all repairs to plant and new machinery required by reason of change in methods, which are very frequent in the manufacture of armor, but does not include any charges for interest or depreciation.

Investment—Plant	\$3,376,019.77
Working capital	750,000.00
Total	\$4,126,019.77
Annual return, without allowance for depreciation or for interest on investment, about 11½ per cent.	
Total cost of plant	\$3,376,019.77
Deduct—Land	\$240,000
Salvage †	1,000,000
	<u>1,240,000.00</u>
Loss when Navy shall have been completed in, say, 15 years	\$2,136,019.77

Or \$142,401 per annum.

Net revenue for manufacturing, \$332,638 per annum, or 8 per cent. per annum on capital invested.

As you will see by this statement it is impossible for us to make more than a moderate return from this the most difficult branch of steel manufacture. This is largely true because the Government only orders from us, on an average, sufficient armor to run our enormous plant to one-third of its capacity. Quantity, in the manufacture of armor, is the most important item in determining the cost of armor. This was clearly shown by the bid of the Illinois Steel Company, in which they specify that a minimum of 6,000 tons per year should be provided and that they should receive \$100 per ton as a premium on all under 6,000 tons per year. If this had been a condition of our contracts with the Government we would have been paid \$2,280,000 during the past six years for this one clause alone.

As you will clearly see from the above statement it is impossible for us to make even a moderate return where only 2,000 tons of armor per year are ordered, even at present prices.

If the Government will give us an average of 2,000 tons of armor per year, at present prices, we will very gladly make all over that quantity at \$400 per ton.

In conclusion we beg you will give the above statement careful consideration, and note especially that no charge has been made for depreciation in value of plant when the Navy shall have been completed, nor any charge for interest on investment. It will be seen by the rate of profit that the assumption that the plant has been paid for out of armor plate contracts is unfounded.

Very Respectfully Yours, THE CARNEGIE STEEL COMPANY, LIMITED.

PITTSBURGH, PA., April 17, 1897.

† Salvage here means what can be saved out of the wreck when the works built for armor plate making shall be no longer used for that purpose.

EXHIBIT B.

Table showing the Cost of Harveyised Armor Plate as estimated by the Navy Department, and Profits to the Manufacturers, with Harveyised Armor selling at \$400 and \$540 per ton respectively.

	Rohrer Board.	Lieut. Rodgers.	Ensign McVay.	Secretary Herbert's summary.
Cost of labor and material only.....	\$167.30	\$178.59	\$161.54	
For material rejected in process of manufacture, viz: 10 per cent.	16.70	17.86	16.15	
For reforging.....	12.45	12.40	12.40	
	\$196.45	\$208.85	\$190.09	\$197.78
Cost for Nickel.....	20.00	20.00	20.00	20.00
Total cost of labor and material.....	\$216.45	\$228.85	\$210.09	\$217.78
Maintenance on plant costing \$3,000,000, taking Senator Chandler's low estimate of 6 per cent., and making 2,000 tons of plates per year.....	90.00	90.00	90.00	90.00
	\$306.45	\$318.85	\$300.09	\$307.78
Plates at \$400 per ton would show a profit per ton of.....	93.55	81.15	99.91	92.22
Or total profits on 2,000 tons of.....	187,100	162,300	199,820	184,440
Would show the investment of \$4,000,000, in property and working capital, returning annually.....	4.68%	4.06%	4.99%	4.61%
On the basis of 10 per cent. for maintenance, as allowed by Secretary Herbert, the profit per ton of armor selling at \$400 would be.....	\$33.55	\$21.15	\$39.91	\$32.22
Making the annual return on investment from a product of 2,000 tons.....	1.68%	1.06%	1.99%	1.61%
On the basis of 10 per cent. for maintenance and armor selling at \$540 per ton the profit per ton would be.....	\$173.55	\$161.15	\$179.91	\$172.22
Making the annual return on investment from a product of 2,000 tons.....	8.68%	8.06%	8.99%	8.61%

The New American Warship Armor that is a Veritable Miracle in Metal.

From The New York Journal.

Tests made lately by the Government of the new Krupp armor for our warships show results that astound even naval experts. It has been proven that armor metal has at last been devised that is practically perfect. In the trials made at Indian Head the Krupp plates showed that they had greater resistance than the hardest of the present Harveyized, nickel-steel armor, and, unlike the Harveyized plates, they did not crack or break up under the most terrific fire.

Although but 12 inches or less in thickness most of the heavy projectiles fired at close range merely indented the plates, shattered themselves, and fell outside the armor. Even the biggest shells, that struck with an impact of thousands of tons and finally penetrated the armor, did not shatter or crack the plates at all.

Hitherto the cracking of armor plates has been their chief defect. But the new Krupp process shows that an armor has now been made that is at once of the greatest resisting quality and at the same time perfectly malleable. It is almost a miracle in the metallurgist's art. A vessel covered with this plating could pass under the fire of the greatest man-of-war afloat, resist all but the biggest shells, and be pierced by a dozen of the latter as if she were a wooden ship, and yet not have her sides broken up or her plates displaced.

A huge plate of this new Krupp armor was tested at the Indian Head proving grounds recently. The plate was 8½ feet wide by 10 feet long and 12 inches thick. The gun used for firing carried a 12-inch projectile, next to the largest size used in the Navy. The projectile weighed 847 pounds. At the first shot it was discharged at a velocity of 1,833 feet per second, and struck the armor plate with a force of 19,797 tons. The shell penetrated to a depth of 8½ inches and then broke up. The plate was not cracked, and looked as a piece of lead would if struck by an old-fashioned cannon ball.

In the second shot the velocity of the projectile was increased to 2,022 feet per second, with a striking energy of 24,000 tons. The projectile passed through the armor and broke up, but there were no cracks in the plate.

The third shot struck with a force of 21,302 tons and just barely passed through the plate and broke up. Some of the pieces fell in front of the plate. Still no cracks appeared.

Other shots were fired upon this Krupp plate. Many made only a rough spot on the malleable armor. Others that succeeded in penetrating the plate made clean cut holes through it within two or three feet of one another. Yet no cracks appeared. The new plate had stood the test as had no other kind of armor ever made.

It will now be used for all the new warships and will make them capable of resisting the most fearful battering that an enemy could inflict upon them.

A Champion Krupp Process Plate.

From The New York Iron Age.

THERE WAS recently tested in England by John Brown & Co. a plate manufactured by the Krupp process, representing part of the armor for the Japanese battle ship *Asahi*, with the following results, the thickness of the plate being 8.8 inches, and the projectile used being 8-inch armor piercing, made by the American Wheeler-Sterling process:

	Striking velocity.	Striking energy.
First round.....	1,859 feet per second.	5,991 foot-tons.
Second round.....	1,964 feet per second.	6,687 foot-tons.
Third round.....	2,039 feet per second.	7,208 foot-tons.

All the projectiles were completely shattered, the points of all three being welded into the plate. There were absolutely no cracks whatever, and the penetration was very slight.

As a comparison a plate 9 inches in thickness, manufactured by the Harvey process, which is 0.2 inch thicker than the above Krupp plate, representing the turret armor for the United States battle-ships *Kearsarge* and *Kentucky*, was tested at the Indian Head proving grounds, with the following results, the projectile used being an 8-inch Wheeler-Sterling armor piercing: Striking velocity, 1,734 feet per second; striking energy, 5,217 foot-tons; penetration, 4.5 inches.

This is the best Harveyized plate of this thickness of which there is any record, yet it will be readily seen how much inferior it is to the above mentioned Krupp plate.