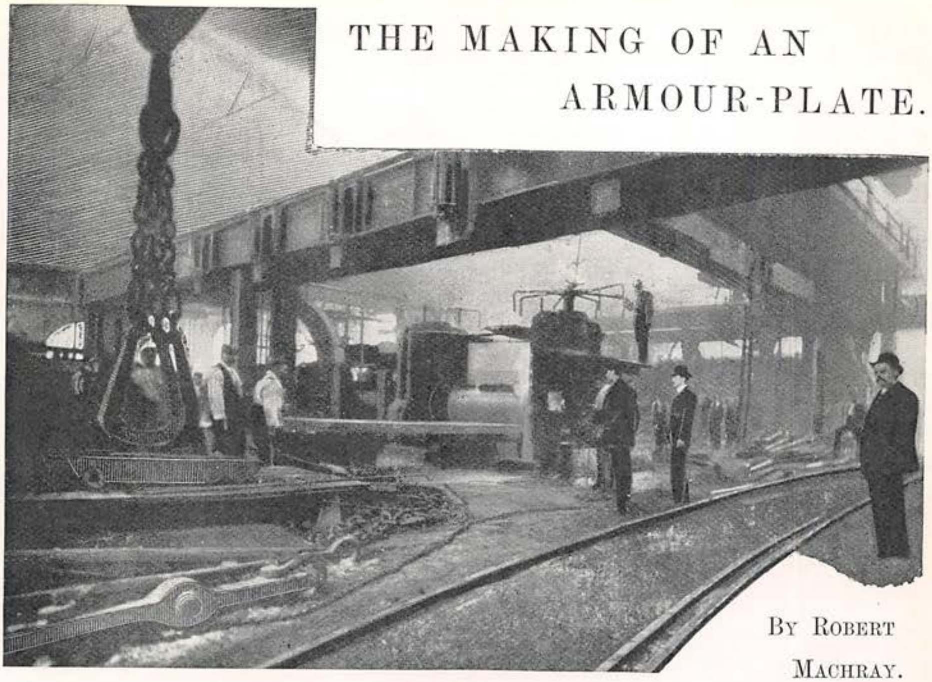


THE MAKING OF AN ARMOUR-PLATE.

By Robert Machray.

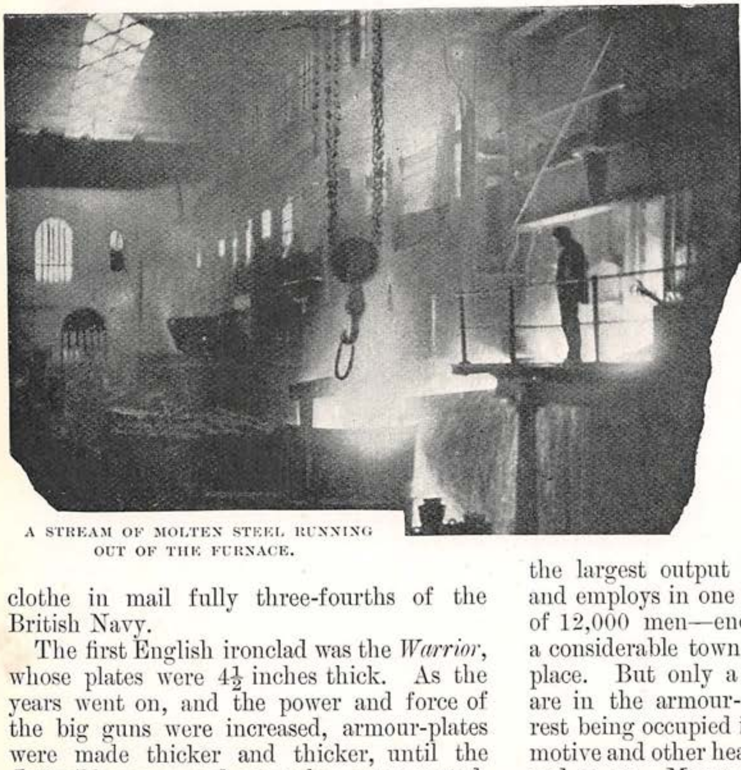
Illustrated from Photographs by C. Pilkington.

ONCE upon a time, and that not so long ago, the "wooden walls of Old England" were alike the safeguard and the glory of the Empire. The great man-of-war, with its tall masts, its gallant spread of canvas, and its many guns, lives no more save in song and story. Its place has been taken by the armour-clad, which has no masts to speak of, nor sails, and but few guns—a thing which, according to our unromantic Premier, is very like a whale with two sticks standing out of it. And in very truth there is not much poetry about a modern battleship, although all that the skill of man can compass goes to the making of it. But it is built for business, and nothing else.

A battleship is not only a first class fighting machine built to attack and destroy, it is also a floating castle built to resist and defeat assault. For the former purpose it is armed with the terrible six-inch and twelve-inch guns, for the latter it is practically made impregnable by being clad with steel armour, against which the most powerful projectiles will be hurled in vain. And that the armour shall be "efficient" is quite as important as that the guns shall be. This is a point on which the nation can afford to take no chances. Hence the Admiralty imposes the severest tests, and its inspectors are constantly going in and out of the vast works where this armour is manufactured, watching every stage of the process with sleepless vigilance.

The question of the capability of iron as a material for building and protecting ships was raised as far back as 1834 by Admiral Sir George Cockburn. One or two vessels were "ironed" to some extent—amongst them the *Birkenhead*, of immortal memory—but the idea was lost sight of until 1855, when, thanks to the late Mr. Samuel Beale, M.P. for Derby, of the Parkgate Iron Works, Rotherham, the making of iron-plates was begun with some approach to system. However, little more was done in this direction for several years. It was in 1860 that a seemingly fortuitous circumstance—the visit of a Sheffield steel-maker to France—brought about that complete revolution in naval shipbuilding which has led to the universal use of armour in the construction of fleets.

This gentleman was Sir John Brown. Happening to be in Toulon that year he saw a French ship, *La Gloire*, come into the harbour. This vessel was a timber-built 90-gun three-decker, which had been cut down into a sort of corvette, with forty big guns. It had the further peculiarity of being protected by hammered-plate armour, 4½ inches thick, 5 feet long, and 2 feet wide. Sir John asked permission to go on board, but was not allowed. He had to content himself with a close inspection of the sides of *La Gloire*, but he did so to very excellent purpose, for on his return to England he informed the authorities, who were a little bit nervous about the French ship, that he could make much better armour than that it had. His plan was to roll, not to hammer the iron-plate. He maintained that a rolled plate would be more reliable, tenacious, and uniform in quality than the other. He so succeeded in impressing his views upon the Admiralty that by 1863 they had decided to clothe in mail fully three-fourths of the British Navy.



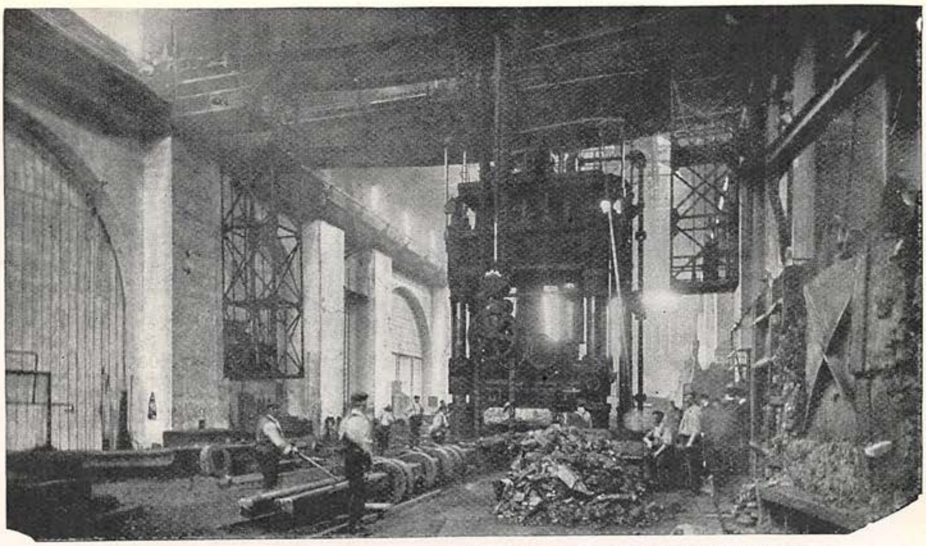
A STREAM OF MOLTEN STEEL RUNNING OUT OF THE FURNACE.

The first English ironclad was the *Warrior*, whose plates were 4½ inches thick. As the years went on, and the power and force of the big guns were increased, armour-plates were made thicker and thicker, until the *Inflexible* was coated, or rather great-coated, with 22 inches of iron. But it was, of course, impossible to go on increasing this thickening indefinitely — the weight of the armour threatened to be more than the ship could carry. In 1877 a forward step was made by the invention of compound armour by Mr. (now Sir) Alexander Wilson, the present head of the firm of Charles Cammell and Company, the largest armour-making establishment in the world. The new material consisted of a facing of hard steel, with a backing of tough wrought-iron. This kind of armour was developed and improved until the introduction of the "Harvey" process, which, with further improvements, is that in use at the present time.

The making of armour is a very important industry, and so far as the heavier plates are concerned is a monopoly of Sheffield, where the three great firms of Messrs. Cammell, Messrs. Vickers, and Messrs. Brown are engaged in it. Messrs. Beardmore, of Glasgow, also make armour, but, I understand, the plates rolled there are lighter than those manufactured in Sheffield.

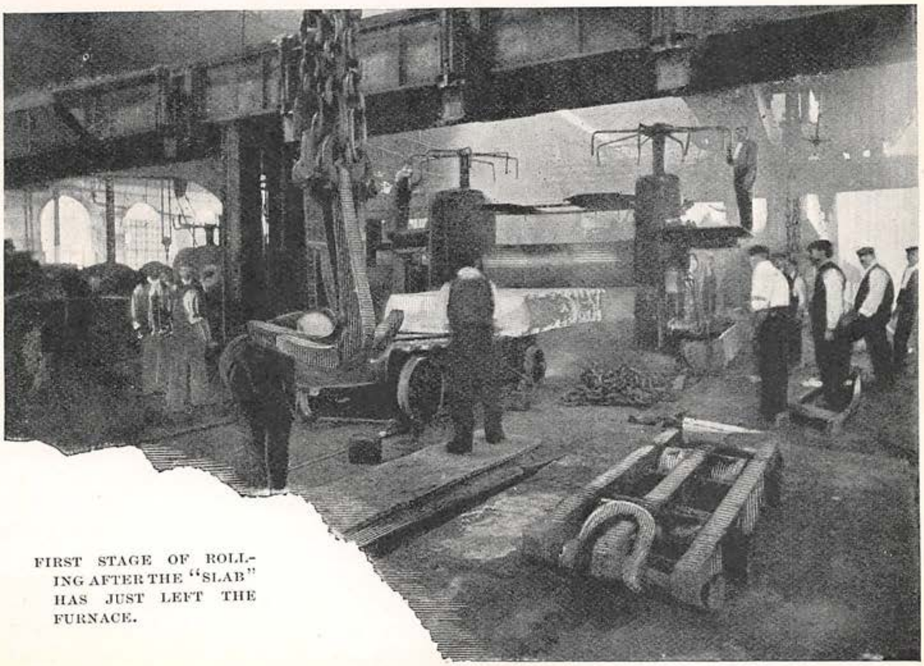
When I requested permission on behalf of the WINDSOR MAGAZINE to go over the works of Messrs. Cammell and Company, with a view to an article on "The Making of Armour," a courteous reply in the affirmative was immediately received. And here, perhaps, I may be allowed to express my grateful acknowledgments for the kindness with which I was treated by all those with whom I came in contact in the course of my journeyings through the Cyclops Works, as they are very appropriately named. This firm has, as I have already said, the largest output of armour in the world, and employs in one way or another an army of 12,000 men—enough to "furnish forth" a considerable town did they all live in one place. But only a portion of the workmen are in the armour-making departments, the rest being occupied in making steel rails, locomotive and other heavy tyres, marine shafting, and so on. Messrs. Cammell have also their own coal and iron mines. A gigantic, truly imperial enterprise this, conducted, if large and increasing dividends be a test, with conspicuous success. A still better criterion may be found in the fact that over two hundred ships of war of all kinds afloat to-day have been armoured from these works. This record is unique.

The first operations in this firm's armour-making are not conducted at the Cyclops Works, but at Grimesthorpe, in the suburbs of Sheffield. Here in vast buildings, through



A INGOT OF RED-HOT STEEL BEING PRESSED INTO SHAPE IN THE "CATHEDRAL."

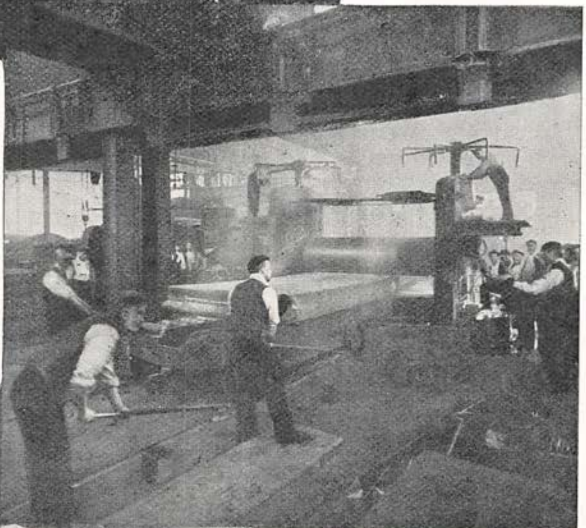
which one walks warily, are the "melting shop," with its "open-hearth" furnaces, in which the steel is made and cast, and the "press shop," to which, from its magnificent distances, has been given the name of the "cathedral." The "melting shop!" Well, if you get too near one of these huge furnaces you will understand without any words one sense in which the term might be used; the furnace from which I got away most expeditiously had a temperature of 2,300 degrees of heat! From a safe distance, my eyes protected by blue spectacles, I gazed fearfully at the back of it, from which issued, when the door was opened, an almost intolerable splendour of golden flame. Presently we walked round to the other side of it and witnessed the casting of the molten steel. As the metal poured itself in a curving stream of fire of ineffable radiance into the receiver—



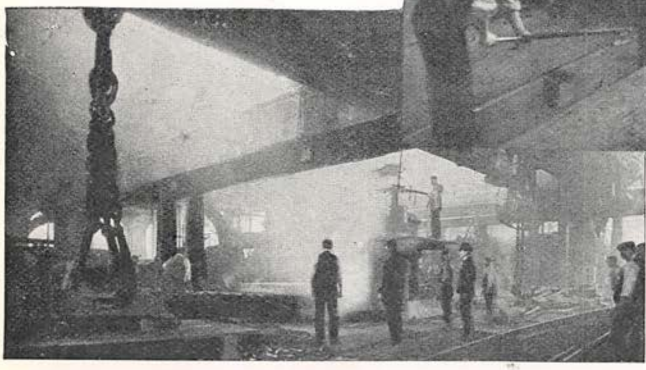
FIRST STAGE OF ROLLING AFTER THE "SLAB" HAS JUST LEFT THE FURNACE.

or "ladle," as it is called—there shot up from it showers upon showers of sparks, bright, sparkling, flashing, falling—a gorgeous display, which I am sure would cause the Crystal Palace pyrotechnic man, clever as he is, to curl up and die of sheer envy.

At one end of the melting shop there are a number of these furnaces, each of them being capable of dealing with a charge of forty tons, and they are so arranged that when required all can be tapped into one enormous central casting pit. When it is remembered that for the manufacture of a 14-inch "Harvey" steel armour-plate, such as those used in the case of H.M.S. *Magnificent*, an ingot of steel weighing fifty tons has to be cast, some idea will be gained of the kind of operations which take place in this part of the works. Not that the finished plate in the instance referred to weighed fifty tons—the various processes it underwent before it became part of the ship reduced it by one-half.



ROLLING AN ARMOUR-PLATE.



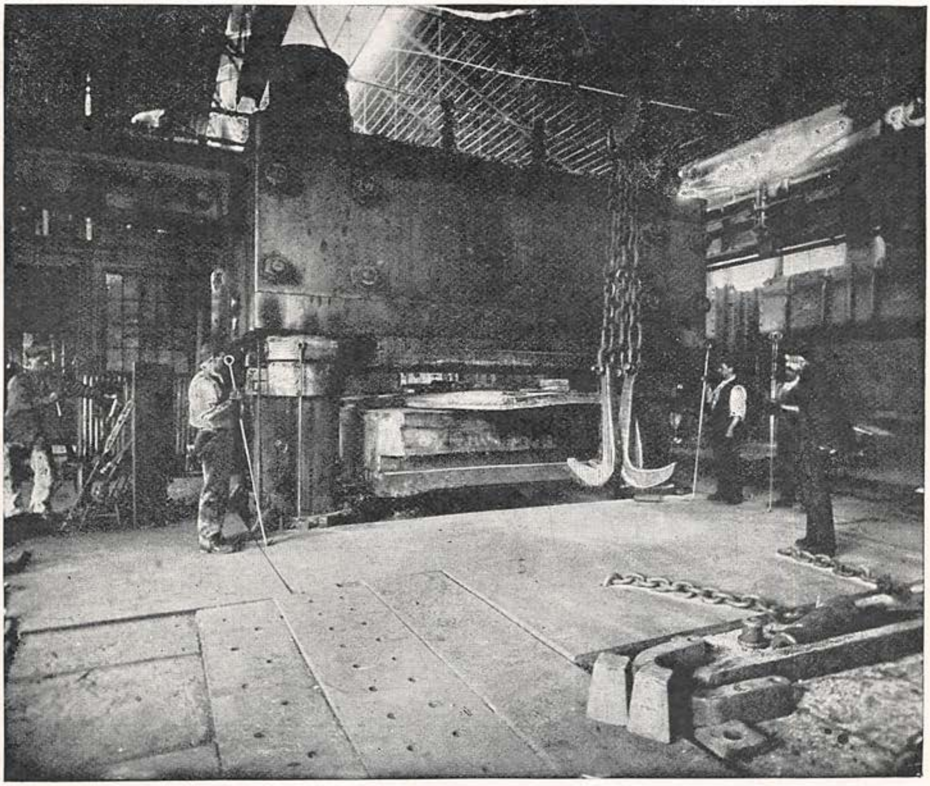
POURING WATER ON THE ROLLERS TO KEEP THEM COOL.

The steel used in the making of armour is of the highest quality. "You may rest assured," I was told, "that there is no better steel in the world than that which is put into armour-plates." The best Swedish iron is the foundation of the metal. Certain alloys are added to the iron, and the whole is converted by the Siemens-Martin process into steel. Coal-gas, which gives a more even temperature than coal, is brought into requisition for heating (the word seems rather inadequate) the furnaces to the necessary degree. That it is possible to take two views of the capabilities of the furnaces is indicated by the following little story which was told me by a foreman. A facetious American, who was being shown over the works, remarked on being told that the temperature of one of these furnaces was over two thousand degrees, "I should say that was hot enough for Old Harry himself!" "Oh, no," was the reply, delivered no doubt with a shrewd twinkle of the speaker's eye, "oh, no! I'm afraid he would catch cold up here!"

When the steel is "made," it is run into a mould, in which it solidifies and becomes an "ingot." It is next taken out of the mould, and conveyed by means of a tramway to the press shop, an exceptionally fine building, 60 feet high and 63½ feet wide, while its length is 260 feet. Here the ingot is first subjected to about twenty-four hours in a furnace, when it is ready for treatment by the press—a name which in this particular case stands for one of the most powerful forging implements in existence. A "tool" they call it in Sheffield, and a nice little tool it is. It exerts a pressure of two-and-a-half tons to the square inch, and has a total pressure of 6,000 tons! The ingot having been heated to the proper temperature, it has now to receive the "tender embraces" of this mechanical monster. The door of the furnace is opened wide, and great tongues of smoke and flame in glorious tones of colour issue forth, as the ingot, balanced upon a colossal "porter-bar" (the name explains itself), is swung out by an enormous travelling crane capable of lifting 150 tons. As the crane moves there is a thunder of machinery. Swiftly enough the mass of glowing metal is placed between the rams, the jaws of the press which manipulates it silently, irresistibly — as a baker might handle a piece of dough or a potter a bit of clay—until it is reduced to the requisite thickness—"squeezed into a slab," they word it in Sheffield, with admirable economy of phrase.

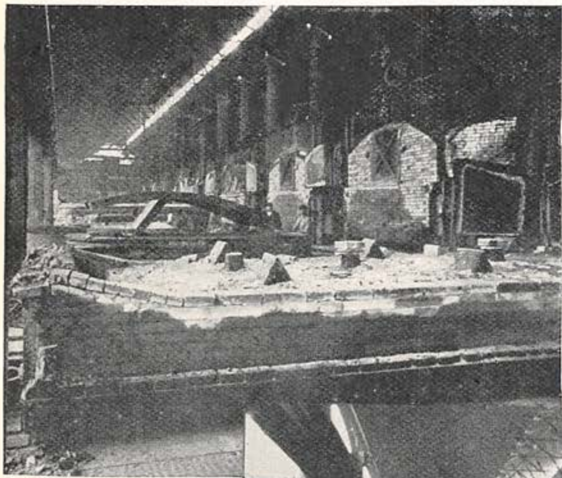
It is an interesting and a wonderful sight. It is a magnificent illustration of what man can do by the aid of the machines he has made, but as a spectacle it is not so striking as that which is seen when the "slab" is rolled into a "plate"—the succeeding stage in the making of armour.

The slab is now taken to the rolling mill which is in the Cyclops Works. First of all it is heated again in another furnace—and it may be noted that each of these furnacings is toughening the fibre of the material—and rendered sufficiently ductile. When the time is come the slide of the furnace is gradually raised amid smoke and flame, and a pair of gigantic pincers grip the white-hot metal. The pincers are attached to a ponderous chain passing round the rolls, which act as a windlass to draw the slab from the furnace. While this is being done the workman who stands nearest the mouth of the furnace wears a garment made of asbestos, in appearance not unlike the cowl and hood of a monk, to protect him from the awful heat; in his hands he holds a long,



MACHINE FOR BENDING ARMOUR-PLATES TO REQUIRED SHAPE.
The "shape" is at the top, and the plates are pushed up from below.

wide piece of iron for the purpose of shielding the man who seems to guide the pincers, and when the slab is drawn on to the bogie, which is in front of the furnace to receive it, liberates the pincers from the chain to which they are attached. To show the ponderosity of the pincers I may say that a couple of horses are required to draw them out of the way, so as to permit the bogie, which moves on rails, to pass down an incline to the rolls, which anon get to work on the great golden mass of steel amid the jar and tumult of the big-wheeled engine which drives the mill.



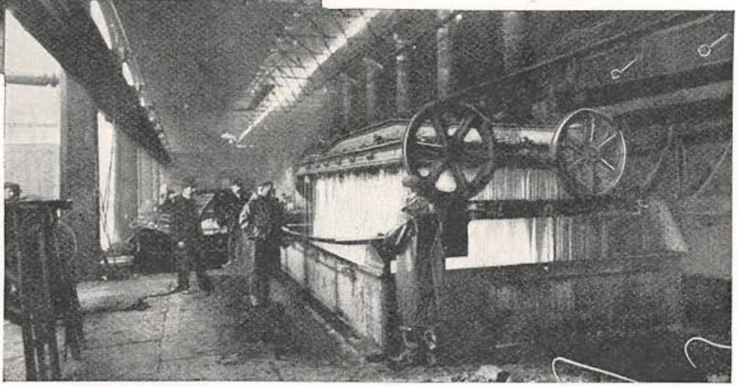
A ROW OF FURNACES.

There is something strangely fascinating in watching this part of the process, and the eye follows with extraordinary interest the lengthening of the plate as it moves forwards and backwards between the rollers. What makes it more striking as a spectacle is that as the operation continues bundles of wet broom are thrown upon the plate, and as the roller passes over them they appear to explode with a noise like that of a volley of musketry, while bright, orange-coloured flames wrap the massy mill with unearthly fires. The wet broom is used in order to remove a sort of scale which forms on the surface of the plate, but it makes a splendid show in doing it.

The plate is rolled to the specified thickness—or thinness, I should perhaps say—in a few minutes. Thereafter it is pressed flat and, generally, "surfaced"—that is, the top is planed smooth. Next, it is put into the carburising furnace for the Harvey treatment.

At this point it may be observed that the average thickness of most armour-plates—at any rate, for belt armour—is about six inches, although plates of as much as twelve-inch thickness are made for special positions. This is a very different state of things from that which obtained in the days of the old ironclads, with their 22-inch armour. Recent improvements have all tended to making armour thinner, while, at the same time, a much higher degree of impenetrability to projectiles has been secured. But, for all that, the weight of a ship's armour is still very great, that of a first class battleship being not much less than 3,000 tons.

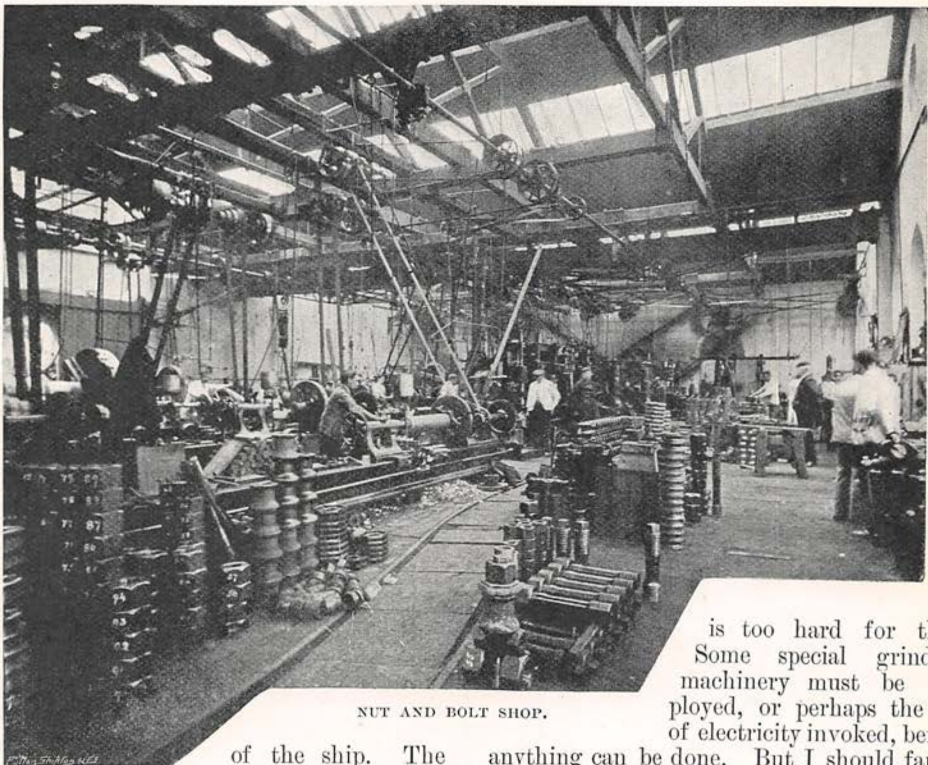
The "Harvey" process (I was told that the process was in essence an ancient Sheffield method, but that Sheffield had forgotten to patent it, and so pays toll for it to America with something of a grudge) is one by which the planed face of an armour-plate acquires the most intense hardness and toughness. The plate is placed in a special furnace with the planed surface upwards and covered with a layer of charcoal; another similar plate, with its planed surface downwards, is laid on the charcoal. Heat from coal-gas is then applied and maintained at a uniform temperature for a considerable time, during which the carbon in the charcoal is gradually drawn from it and absorbed by the steel surfaces to a certain depth of the plates, the rest still remaining what is technically styled



THE "SPRINKLER."

"ductile," though it seems to me a good deal less ductile than one of the Pyramids. The combined result of Harveying the plates is that the surface presents a practically impenetrable front to any projectile, while the ductile or soft steel of the balance acts as a kind of cushion, or buffer, if you like.

The armour-plates are now bent by an hydraulic press, nearly as powerful as the monster we saw in the "cathedral," into whatever shape may be necessary for the particular vessel they have been ordered for, and then planed, slotted, and drilled for the bolts which hold them to the framework



NUT AND BOLT SHOP.

of the ship. The last-named processes are extremely interesting, and involve the use of a large number of expensive and elaborate machines, to describe which at all adequately would take up too much space. Suffice it to say that nothing is left to chance. Moulds, or "templates," taken from the given ship are supplied to the armour-makers in order that there shall be no mistakes, and naval architects are exceedingly exacting—as, indeed, one can well imagine they would be—in requiring that all their specifications are fully complied with.

But it is only after the carburised plates have been thoroughly chilled in an enormous sort of shower-bath, called a "sprinkler," that the process is complete. The sudden chill, I understand, does the business.

In addition to being carburised the plates are further subjected to various treatments, including what is known as the Krupp treatment, all of which are kept a close secret, so that no information can be given about them. But their sole purpose is to give increased density, and therefore greater resistance to the shells of an enemy.

Should any change be necessary on the finished plate, the alteration cannot be effected by the use of any tool—the plate is too hard for that. Some special grinding machinery must be employed, or perhaps the aid of electricity invoked, before anything can be done. But I should fancy, from the care with which everything is thought and worked out, both by the designers and the makers of the armour, that this is seldom necessary.

The plates are fixed into position on the ships by means of big, thick bolts—some of them I saw were two feet long—in the making of which special care is taken. At one end of the bolt is the screw which fits into the hole drilled in the ductile part of the plate; next to the screw is a length of polished steel, which goes through the wood or other framework of the vessel's side; and then come the washer, nut, and rubber packing and other devices for holding it immovably in its place.