

A WALK THROUGH WOOLWICH ARSENAL.

BY J. MUNRO, C.E.

(Illustrated from photographs by Gregory & Co., Strand, W.C.)



IT is just upon the stroke of two o'clock, and the bell is clanging at the main entrance to the great arsenal. Workmen in a stream are pouring in through the open gates, after the dinner hour, and dispersing in hundreds amongst the various laboratories to resume their tasks. They walk with a smart—I had almost said a military—step, and look a well-dressed, superior class of artisan. Several policemen are on duty at the gatehouse watching all who enter, in order to exclude any unauthorised person.

Parties of visitors in charge of the official guides are waiting until the last workman has passed in before beginning their circuit of the factories which are open to them. From one of these guides I learn that the grounds of the Arsenal extend for nearly a mile along the bank of the Thames, on which the

wharves are situated, and cover about six hundred acres, including the "proof butts," where the larger guns and field pieces are tried, and the gunpowder magazines in the Plumstead Marshes. What with the numerous factories and laboratories, foundries and forges, engine-houses belching smoke, saw-mills, railways and canals, store-houses and museums, as well as offices, barracks, hospital, school, mechanics' institution, and so forth, the Royal Arsenal appears a town in itself, an industrial city, devoted to the art of destruction, and dedicated to the God of War.

"How many workmen do you employ just now?" I inquired of a guide, whose military bearing and bluff, hearty speech confirmed the fact that he had retired from long and active service in the army.

"Not many," he replied with Spartan brevity. "Only about sixteen thousand. Half of 'em work by day and half by night."

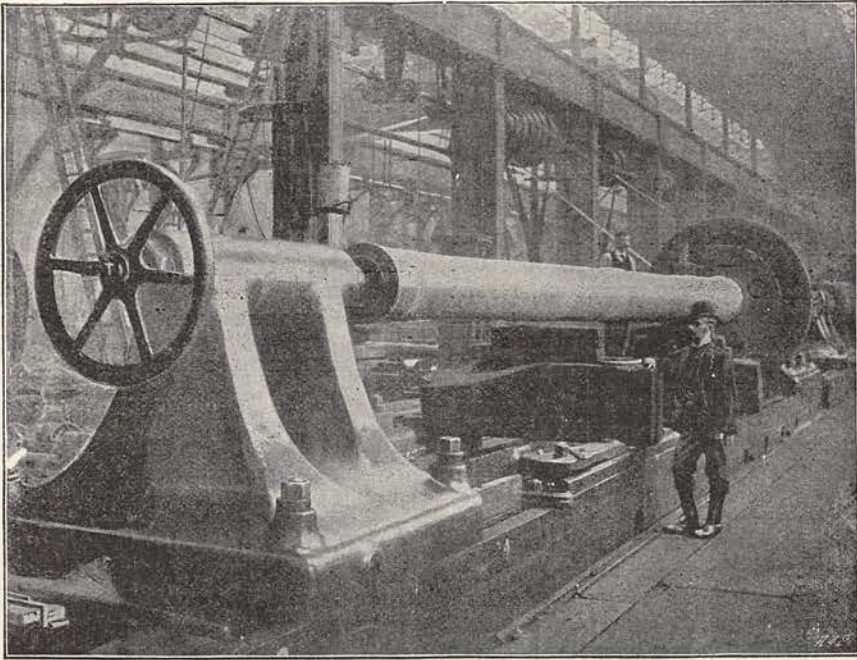
"Sixteen thousand!" said I, rather taken aback by the large figure. "Is that not your full complement of hands?"

"No; we're slack just now," he rejoined. "We ought to have twenty thousand men at work. The fact is," said the fiery old soldier emphatically, "what we want is a war—a big European war—several of 'em—wars in every part of the world. We shall never be right until we get 'em."

Without sympathising with his bloodthirsty aspiration, I could not help feeling that it was perfectly natural to a valiant son of Mars who had been smelling gunpowder all his life, and, moreover, in proper keeping with a locality where the most ingenious and awful instruments of death are forged and fashioned, where the daintiest ornaments are obsolete mortars and Chinese cannon, or piles of round shot, and the very locomotives on the tramways boast such dreadful names as the "Arquebus," the "Hannibal," and the "Basilisk." Indeed, I should have found it quite excusable had the superannuated old veteran himself developed



THE FAMOUS 36-INCH MALLET MORTAR.



ROUGH-TURNING THE TUBE OF A 9.2 IN. 28-TON WIRE GUN.

into a shrapnel-shell or a quick-firing gun.

I do not propose to follow any of the public parties, because through the courtesy of Dr. William Anderson, C.B., F.R.S., D.C.L., the famous engineer and Director-General of the Ordnance Factories, I have been permitted to view the Arsenal in charge of a special guide, and am thus enabled to save the time and intelligence of the reader by taking him through the various works in a convenient order. I am also indebted to Mr. George M. Tapp, the Civil Assistant Director-General, who has very kindly given me some particulars about the Arsenal which I could not have obtained otherwise.

The ordnance factories of the nation, as many people know, comprise not only the Woolwich Arsenal, but the Royal Gunpowder Factory at Waltham, the Royal Small Arms Factories at Enfield and Birmingham, and the Army Clothing Department. The Arsenal is, however, the headquarters, and is divided into the Royal Laboratory, the Royal Gun Factory, the Royal Carriage Department, and the Building Works. The staff consists of the Director-General, with a Civil and two Military Assistants, the Superintendents of the several Factories, Laboratories, and Works, the Medical and other officers. For some

time past the number of hands employed in the Government factories has been gradually diminished, and is now rather over 14,000 men, of whom about 10,000 are engaged in the Arsenal. Only a few hundreds are employed by night at present. Their aggregate wages amount to some £22,600 a week. The earnings of an adult workman average over £2 a week, and no adult labourer receives less than twenty shillings a week. The value of the productions of the Factories is about 2¼ millions sterling a year, and about half of that sum is expended in wages.

I propose to conduct the reader first through the royal laboratory where the cartridges and shells for rifles, guns, and revolvers are manufactured, and then through the gun factory and carriage department.

Most of us have seen a rifle cartridge, and many are aware that the ammunition for the larger guns is made on a similar plan. There is a tube or cylinder to hold the gunpowder or other explosive, such as cordite, having in its base a percussion cap, which, of course, is struck by the hammer or needle of the gun, and over its mouth a conical bullet, sometimes encased in nickel, which the explosion ejects from the gun. At the Arsenal all the cartridge tubes for small and large guns are made of thin metal, step by step, in a series of

wonderful machines, which only require to be fed by the attendants and kept in good repair.

Let us enter one of the roomy workshops where the eye wanders through a wilderness of mechanism, and the mind is lost amidst hundreds of curious lathes and punches, all driven by a multiplicity of belts and pulleys. Each of these iron slaves is busy at his own task, cutting, stamping, and moulding the ductile metal under the eye of his master—a silent example to men of duty done without a murmur or a wandering thought.

A foundry where the brass, copper, and nickel for the cartridges is melted and cast adjoins the workshops, but we may not enter, for the molten metal has a trick of bursting bounds, and not very long ago a crucible boiled over and burned the foot of a workman. Through the open door, however, we can gaze into the dark and shadowy interior, fascinated by the ghostly blue and primrose flames issuing from the furnace mouths, or watch the swart and brawny sons of Vulcan dropping the brass into the red-hot crucibles, or pouring the dazzling streams of liquid metal into the moulds. It is one of those industrial scenes which artists are so apt to neglect, although they are well worthy of the brush of Rembrandt.

Each "pig" of brass as it comes from the mould is about a yard in length, but the ends are sheared off in a powerful machine, which cuts the hard metal as though it were a bit of cheese. By-and-by it is passed through one mill after another until it has been ground to a ribbon or band of the required thickness for making the cartridge case. Each band is then punched into discs, which are moulded into caps, and each of these caps is drawn through dies, and shaped, trimmed, and pierced with "fireholes," little by little, in a long train of self-acting machines. During the process it is necessary to soften the brass again and again, as it hardens in the dies, and that is done by putting the unfinished cases into covered pans and heating them red-hot in gas furnaces, or simply allowing gas jets to play upon them.

The conical bullets are made by melting the pig lead in cauldrons, and running the fluid metal into a hydraulic press, which forces it through a die-hole in the piston, and thus produces a lead rod or wire of the proper diameter, which is coiled upon a reel, and afterwards cut into lengths and moulded into bullets by one machine. To render the bullet capable of penetrating a bone it is encased in a tapering hood of nickel, which is manufactured in much the same way as the cartridge case, by many operations. Each lead is simply dropped by hand into its hood, but the rest

is done by machines, which press and close the two together, flatten the end, form the "canelures," or grooves, to fix it in the cartridge case, and stamp the butt with the "broad arrow."

The cartridges are charged and finished in the East Laboratory, which is isolated from the rest, and not accessible to the public. Owing to the danger of explosion, some of the buildings are separated from the others by huge earthen mounds. The rails of the tramways are of bronze, and the visitor, besides leaving any matches or combustibles behind, must don a pair of large slippers over his boots. It is a quiet and peaceful spot, with the wild geraniums flowering in the grass, and the sparrows twittering in the poplars—a place to lie in the shade and read a love story, or dream away a summer afternoon; and yet it is—shall we say?—a slumbering volcano. As a matter of fact, every precaution is taken to prevent an explosion and make the department quite safe. Most of the little machines which fill and close the cartridges are attended by lads, who seem to enjoy the work, which no doubt has a smack of adventure to their fancy; and some of them, I dare say, would like to follow the cartridges to their destination in the jungles of India, the backwoods of Canada, or the plains of Southern Africa.

After the percussion caps have been put on the cartridge cases they are ready for the charge. One would never suspect that these long yellow threads, which look as harmless as vermicelli where they glide over the tables, are really that dreadful explosive "cordite." See how deftly the small machine clips and packs them into a cartridge case, while the small boy who looks after it is humming a tune to himself. Here is another boy shaking gunpowder into a set of measuring holes, and then dropping it into the large Martini-Henry cartridges below. After the filling is done the wads are inserted, the bullets fixed, and the cartridges cleaned by removing the surplus wax and rolling them in bags oozing with turpentine.

Blank cartridge is made with equal care; but the old paper bullet, which was rather risky, has been discarded, and the case is merely closed up after the charge is put in. The rifles, revolvers, and machine-guns are made at Enfield and Birmingham, but the cartridges are tested at Woolwich by means of rifles mounted on stands, having counterweights for the recoil.

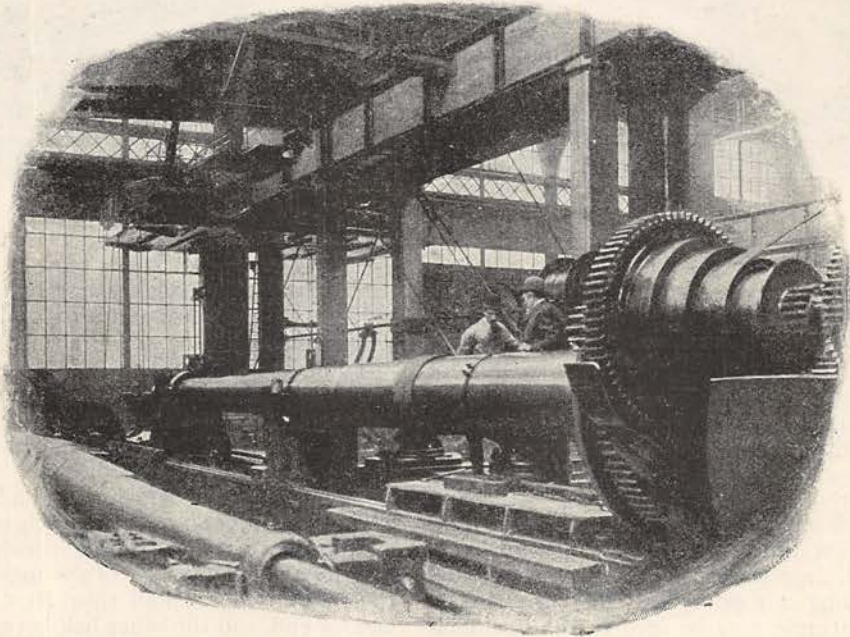
The cartridges for the quick-firing guns and cannon are made in a similar way by larger and heavier machinery in workshops for the purpose. The projectile is fitted with a "gas check"—that is to say, a disc

of metal which expands and keeps the gas from escaping between the shot and the wall of the gun. When the projectile has no studs to catch in the rifling grooves it is put in rotation by means of a "driving band" of copper round the base, into which the grooves cut, and so are enabled to spin the shot.

Shells, as most people know, are virtually explosive shots, which are designed to burst when they have reached their aim and destroy armour-plate fortifications or men. They are made of cast or forged steel, and the hollow interior is charged with explosives, such as gunpowder or melinite, which is fired by a fuse inserted in the top or bottom of the shell. Such a missile bursting between the decks of an ironclad would play fearful havoc with its suffocating fumes and splinters. In shrapnel shells the hollow is filled with bullets as well as gunpowder,

castings with their feet into scales and weighing them. Powerful engines are cutting off the "dead-heads," or waste ends of the castings, and boring or turning them into the proper shape. The detonating and time fuses are, like the percussion caps, manufactured in a separate factory, on the same principle of dividing the labour amongst many different machines, with the help of skilled workmen to fit, finish, and inspect them.

The famous "Mallet mortar," which we illustrate, is to be regarded as an extinct monster of gunnery. It was designed by Mr. Mallet to hurl enormous shells into the Russian lines during the Crimean war, and was adopted by Lord Palmerston on his own responsibility; but, owing to the difficulty of manufacture, the war was over before the contractors could deliver them. The mortar weighs 40 tons, and is built in sections weighing 11 tons. The round shell, 36 inches in



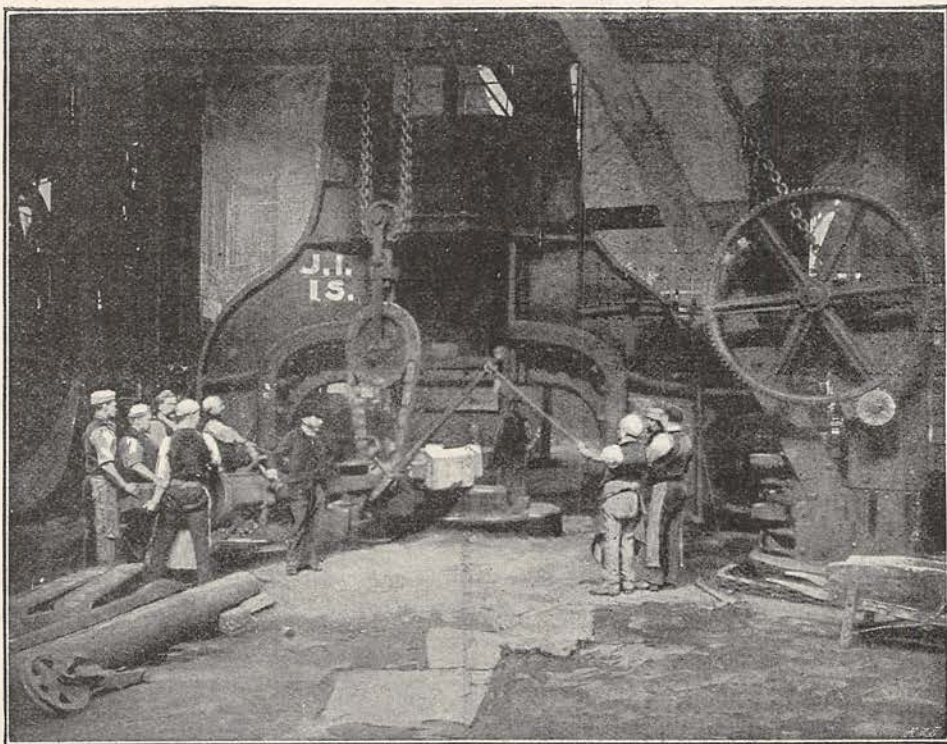
WINDING WIRE ON TO TUBES OF WIRE GUNS.

and these are scattered by the explosion in all directions.

The manufacture of shells is always going on at Woolwich, and as we pass through the factories we can see the foundry at work, shaping the moulds of moistened black sand, which are dried in a kind of oven heated by roaring furnaces, before the liquid steel is poured into them. Close by are men shod in wooden clogs, and rolling the red-hot

diameter, weighs about 2,900 lbs., and holds a bursting-charge of 487 lbs. of gunpowder. The firing-charge was about 80 lbs., and the range was nearly 2,800 yards. One of these mortars was tried at Woolwich with increasing charges, but after the nineteenth round it broke down, and a second mortar, which is preserved as a memorial, was never fired.

Howitzers and rifled artillery have superseded field mortars for firing shells, as they



THE WOOLWICH TITAN.

give a much longer range. A howitzer will send a conical shell 10,000 yards and upwards. They are manufactured in the great forges of the Royal Gun Factory by dint of steam hammers and ponderous machines too numerous and complicated to describe. All I can hope to do in the space allotted me is to give the reader a glimpse of the construction of the new "wire gun," which up till now is the perfection of heavy ordnance.

In olden times, when cannon were made of wood, they were sometimes strengthened by winding a rope round the barrel. The same principle may be seen in the steel coils of the Armstrong gun; and about the year 1850 Brunel and Longridge proposed to apply it in the form of wire. It is only of late years, however, that it has come to the front. The "Woolwich Infant," once so notorious, has, like many another celebrity, outlived its day. Prismatic powder, which is slower of combustion than the old grain powder, has wrought an important change in gunnery, and the short and dumpy Woolwich Infant, with its abnormally strong breech, loaded from the muzzle, has given place to the long and slender wire gun

loaded by the breech. Some of these magnificent weapons are upwards of 40 feet in length and weigh 67 or more tons.

To make a wire gun, a solid ingot of Whitworth steel of the right dimensions is procured from Manchester, and bored, annealed, and turned by irresistible machines, which cut the adamant like wood.

The boring-tool is a steel cylinder, having a ring of knives—or, rather, chisels—on its end, which, as the cylinder revolves, cut a ring-hole along the axis of the ingot. When the ingot is bored half through it is turned end for end, and the other half bored until the two ring-holes meet. The gigantic tube thus formed is afterwards annealed by heating it in a wood furnace and plunging it red-hot in a bath of oil. Step for a moment into this great circular workshop and watch the operation. Under the shadow of a travelling crane, which is capable of picking up a weight of 250 tons and dropping it in any part of the immense building, cylindrical iron furnaces and oil wells 100 feet in depth are sunk into the floor. The massive links of the crane are fastened to the tube, which has been roasting for hours in the fierce heart

of the furnace, and all is ready to draw it forth. A signal is given, and amid the deafening rattle of the machinery the chain is slowly raised until the incandescent mass of iron is lifted out of the furnace and hangs in the air, huge, red, and glowing.

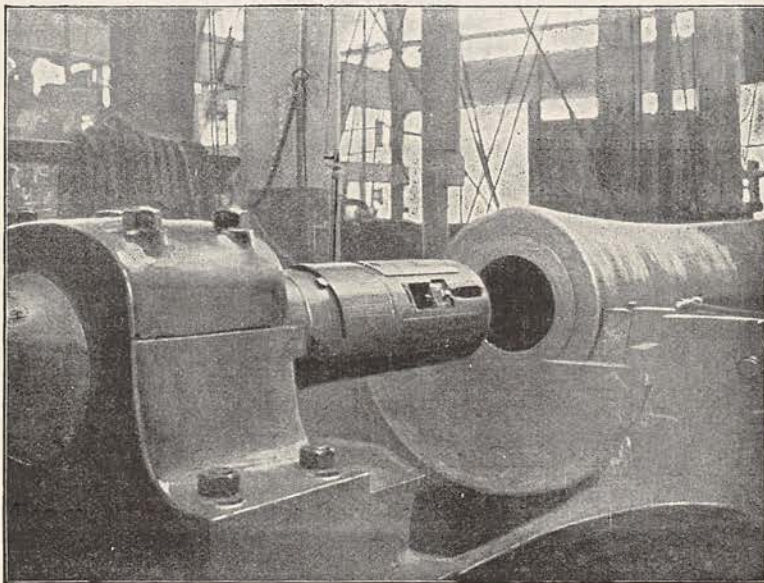
There is, perhaps, a spice of danger; for what if the links should soften with the heat and part? Still following it with our eyes, we see it move towards an oil well and gently sink into the hollow cylinder, amidst a wild uprush of yellow flame.

Cooled in the bath, the softened tube is then mounted on a ponderous lathe, as shown in the figure, and turned to the right gauge. After that it is revolved round its axis and wound with steel wire or "tape" from a reel, which can be seen above the heads of the engineers in our illustration. The wire is under strain by a brake, and each layer is secured at both ends. The covering of wire is, of course, thicker at the breech and thinner towards the muzzle. In some of the guns, I am told, 120 miles of wire are utilised in this manner. When the winding is complete, stout hoops or jackets of steel, red-hot from the forge, are slipped over it, to shrink and tighten as they cool.

In the forging of these hoops the great steam hammer—known as the "Woolwich Titan"—is sometimes brought into play. This prodigious tool is said to be the largest hammer in the world, and cost about £50,000. It was made by Messrs. Nasmyth and Wilson, of Manchester, and, as represented in our

engraving, consists of an arching frame 45 feet in height and 550 tons in weight, which carries a vertical hammer weighing 40 tons, but capable of delivering a blow of 1,000 tons on the anvil beneath, which weighs 100 tons. It is founded on massive blocks of iron, covering 120 square feet, weighing in all 650 tons, and resting on piles and concrete. An immense furnace, four steam cranes, two on each side, together with gigantic tongs and other fire-irons, minister to this Cyclopean monster, whose tit-bit is a mass of white-hot steel. We are just in time to see a "heat," or, in other words, to see the Titan fed. Everything is quiet in the big shop where he dwells in solitary state, and one would never suspect that "a deed was to be done." A couple of blacksmiths are at work in one corner, and a ruddy light streams through the chinks of the furnace door, but otherwise there is no sign of activity. Presently we hear a call, and one by one a little group of workmen appear on the scene and silently take their posts around the hammer. In dress and mien they are more like cooks than forgers, but indeed they are both, for is it not their duty to prepare the Titan's dinner?

When all is ready the door of the furnace flies up and reveals a yawning chasm of flame, belching out volumes of black smoke. Silently and steadily the men thrust a mighty iron beam, swung from the crane, into the scorching fire, and, drawing out a glowing mass of iron, place it gently in the Titan's maw, fairly and squarely between his iron teeth.



12-INCH 50-TON WIRE GUN PLACED IN POSITION FOR RIFLING.

The head forger, who directs the operations by waving his incombustible mittens, gives the signal, there is a hoarse snort, and down comes the mighty hammer on the red-hot metal with a thud that shakes the earth. Blow after blow is delivered, the iron is turned, the cranes rattle, the ground quakes, and we who have never seen it before are fascinated by the spectacle; but, thanks to the skill and discipline of the forgers, we come away with a feeling that after all the Titan is a very "gentle monster." Did he not show

We cannot do more than peep at the factories where the quick-firing guns, the gun carriages, torpedoes, and ammunition cases are made; or the stores where naval and military utensils are kept in stock; or the museum with its models of old shells and arms. We have been obliged to skip innumerable operations and details in the processes we have described; but we must not omit to mention the extraordinary care which is taken to gauge and test the work at every step, since with firearms extreme accuracy is a



TORPEDO FACTORY.

the Prince of Wales that he could chip the glass of a gold watch without injuring the works? Nevertheless, he sometimes does not realise his own strength, and recently shivered a steel block beneath the anvil with one of his tremendous blows.

After the gun-tube is jacketed it is rifled by means of a cutting tool, shown in our illustration, which has a forward and a rotary movement. The gun is then breeched and finished for her destination.

matter of life and death. Indeed, the fate of a battle, and consequently of a nation, may hang upon the failure of a cartridge or the bursting of a gun. I was much impressed, too, by the quiet and orderly way in which the work is carried on; the activity without noise, hurry, or excitement. One would never imagine that he was in the heart of probably the greatest arsenal in the world. Assuredly the admirable discipline reflects the highest credit on the entire staff.

