This was preceded by a hailstorm and rain, with occasional breaks in the clouds, through which we observed four meteors between 5 and 6.30 A.M.

On the evening of the 14th the sky was only half covered with clouds from 5 to 8 P.M., and eight meteors were observed between 5.48 and 6.40; one at 6.2 was of a brilliant red colour, with a pale greenish white train.

From 7.40 to 8.35 five other meteors were seen. The sky cleared for a short time towards 8 P.M., but at 9 a mist came on which obscured the heavens during the remainder of the night, clearing off, however, occasionally for a short time. I will not trouble you with the path of each separate meteor, though each was carefully noted. From the above observations I should be inclined to think that we had passed through the maximum during the afternoon of the 14th. Had there been any brilliant display during the night of the 14th, I think it would hardly have escaped me in spite of the mist.

Stonyhurst Observatory S. J. PERRY

SPAIN AND THE ECLIPSE EXPEDITION

THE following is a translation of a letter which appears in the *Astronomische Nachrichten* for Nov. 15, on the facilities offered by the Spanish Government to such foreign astronomers as purpose visiting Spain on the occasion of the approaching eclipse:—

"MADRID, *Nov.* 5.

"I have the honour to inform you that the Spanish Government, at the request of the Observatory at Madrid, and in accordance with the resolution taken at the time of the eclipse of the sun in 1860, has just agreed that similar measures shall be adopted for facilitating to foreign astronomers the observation of the approaching solar eclipse on the 22nd of December of the present year. The Government has in consequence resolved,—

"'That at the Spanish Custom Houses no duty or deposit shall be demanded on the astronomical or physical instruments that astronomers bring into Spain for the observation and study of the eclipse.'

"But as this privilege, which has been granted with readiness to astronomers, might be taken advantage of by persons noways connected with Science, the Government has deemed it necessary to adopt certain measures of precaution, the principal one of which is, to be made cognisant of the names of the persons who are making preparations to come to Spain to observe the eclipse. In consequence thereof, the Minister of Finance has directed 'that such astronomers as purpose availing themselves of the resolution above spoken of should have the goodness to make known in writing to the Observatory at Madrid their names, the number and the class of instruments which they bring, and the point of the coast or frontier where they purpose entering Spain.' These particulars will be communicated by the Observatory to the Government, which will send orders to the Custom-houses to pass without difficulty all the instruments entered on the lists the astronomers furnish. Foreign astronomers may, moreover, reckon on the sedulous protection of the provincial governors and of the local authorities, from whom they will receive all the co-operation necessary to enable them to devote themselves with entire liberty to their scientific labours.

"In the Almanac of the Observatory of Madrid for 1870 (which you have not received owing to the want of communication with Germany for several months) there is contained a somewhat detailed account of the approaching eclipse, accompanied by two maps. As you will observe, in the zone of the total eclipse there have been inserted all the principal towns, in order to assist astronomers in the selection of their stations for observing. This central line is not of great dimensions in Spain (about sixty nautical miles) yet, nevertheless, there are numerous important towns in proximity to the central line, as, for instance, San Lucar, Jerez, Puerto de Santa Maria, Puerto Real, San Fernando, Cadiz, Medina Sidonia, Estepona, and at those places observers will meet with all the resources requisite for carrying out their labours with facility. The sole disadvantage of so short a line is, that if the weather should prove unpropitious at one station, it will probably be so at the others as well.

"If you think any further details necessary, or in the case of any astronomer wishing to consult the map of the eclipse, nothing more will be necessary than to apply to the Director of the Observatory at Madrid, who tenders his services to such foreign astronomers as require them, and to whom it will afford great pleasure to aid his colleagues in bringing their scientific mission to Spain to a successful result. ANTONIO AGUILAR"

THE CONSTRUCTION OF HEAVY ARTILLERY

IN few other manufactures has it been found necessary to search so deeply into the materials nature provides in order to find out the best and strongest, and then to apply it skilfully, so as fully to develop its strength, as in the manufacture of guns. The construction of the amazingly-powerful ordnance which modern naval warfare employs is pre-eminently a question of strength of material; indeed, it may be termed *the* question of strength of material. In nothing else does man employ forces even nearly so powerful and violent. The force of steam, even when doing its mightiest work, is but faint and small compared with that of the exploding charge of gunpowder that sends from the gun a 300lb. or 600lb. shot with a velocity which carries it through thick armour plates of wrought iron. A 600lb. shot will pierce twelve inches of iron at 200 yards distance. This gigantic force is imparted to the shot in the brief fraction of a second that it is moving down the barrel of the gun. Remembering that "the gain in power is loss in time," and consequently that when the time is diminished the power is proportionately increased, we may form some conception how enormously great is that force which is exerted within the breech of a heavy gun, and which is resisted by it every time it is fired. It is a force which, if turned into foot pounds, would represent the steam power not of a ship but of a navy. Yet all its work is to be done in the space of a few inches, and it must be surrounded with iron strong enough to resist it. Here we have the skill of man grappling with enormous difficulties, searching out the strongest and most suitable material that nature supplies, and exerting all his art to apply it to the utmost advantage. The construction of these exceedingly powerful guns has been entirely developed within the last few years. The gun now manufactured in Woolwich Arsenal is more unlike the gun of 1850 than the gun of 1850 is unlike that of Queen Elizabeth's reign. The progress of twenty years surpasses that of three centuries. And the change has not been so much in enlargement of size as in difference of construction. Queen Elizabeth's pocket-pistol is not more unlike a 600-pounder in external appearance than in internal structure. The gun which is carried in the turret of one of our ironclads, and which, at a single discharge, expends as great a weight of powder and shot as the whole broadside of a good-sized frigate of our own early days, does not surpass the gun which peeped from that frigate's ports so much in size and power as in the superior scientific principles of its manufacture. We propose in the present article to give a general view of these principles. The method of manufacture will be first explained, and afterwards the principles which guide the selection of the best material. Although the material must be selected before it is manufactured, yet a knowledge of the construction of a heavy gun, and of the qualities sought by construction to be developed, will very greatly facilitate our comprehension of the reasons of choice and preference among the many kinds of iron that might be and that are used.

In explaining the construction of modern ordnance as made for the British Government, it will be best to notice the gradual progress in the manufacture since wrought-iron began to be used instead of cast-iron. This was the first great change, and from it dates a new era in this branch of industry. And it was not only a great change, but a great advance. Wrought iron is a very much superior material to cast-iron, and one which demands very much more skill in its manufacture. Cast-iron is of a granular or crystalline nature; wrought-iron is fibrous: cast-iron is hard; wrought-iron tough. The difference between them may be illustrated by the difference between glass and wood. One is strong to resist a statical strain or pressure, the other to resist a dynamical strain or blow. There is a vast difference between the two kinds of strength. A brick which is at the foundation of a lofty factory chimney supports an enormous weight, but it would be broken by a blow that would not injure a stout walking-stick. Wrought-iron having that kind of strength which resists dynamic force

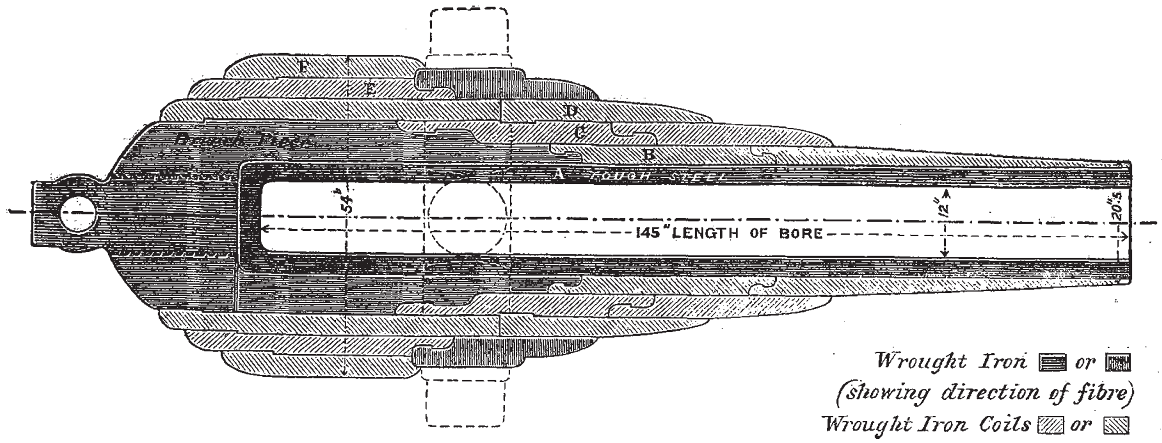

FIG. 1

is therefore far preferable to cast-iron for resisting the violent and sudden shock of explosives, the most powerful dynamic strain with which man's art has to grapple. It averages three times the dynamic strength of cast-iron, that is, it will bear three times as great weight without breaking. It will yield sooner; but when cast-iron yields it breaks. In this another great advantage is gained. When a cast-iron gun breaks it does so explosively; it breaks up into fragments, and gives no warning, no indications of yielding beforehand. But a wrought-iron gun shows when its use is becoming dangerous.

Though this discussion seems rather at variance with the plan laid down, yet it is necessary to have a general knowledge of the material used in order to understand the method of manufacture. Wrought-iron, while it is so much better a material for the construction of heavy

Scale 3/8" = 1 Foot.

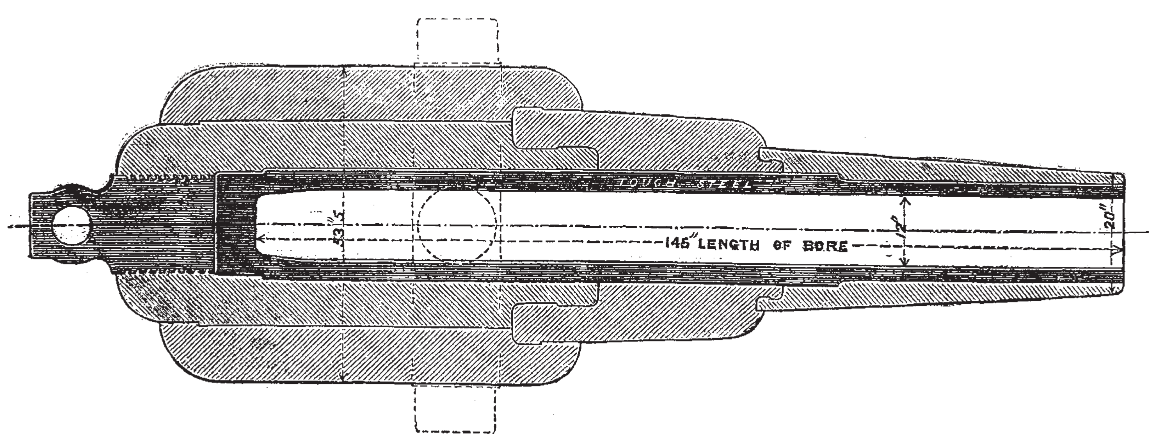

FIG. 2

guns, is yet very difficult and expensive to work. The wrought-iron gun cannot be made as easily as the gun for which the molten metal was run into a mould and then bored out and finished exteriorly. It requires large furnaces, huge steam-hammers, and skilled workmen to give it shape. Before the wonderful appliances of modern science and machinery were invented, wrought-iron could only be made and worked in comparatively small quantities. And even now to forge the mass necessary for a gun 7, 12, or 25 tons weight, would be a most difficult and costly, perhaps in the last case an impossible undertaking. No doubt there are larger forgings used in large steam ships for cranks and shafts, and in other machinery; but these masses of wrought-iron are not heated and hammered the whole at once. Separate parts are welded together or successive portions are heated and hammered. It is needless to say that these methods would not do for the construction of a gun. The fiercely expanding gas of the exploding powder would speedily and fatally detect any plane or point of weakness. Moreover, wrought-iron is not equally strong in all directions; being fibrous in its texture, it is twice as strong with the grain as across the grain. As in the case of wood, which it is much more easy to split than to break, so it is much easier to tear the fibres of wrought-iron from each other than to break them across. It therefore follows that a gun forged in a solid mass, and bored out, would not put the strength of wrought-iron at its greatest advantage. Such a gun would be very strong along its longitudinal section, very strong to resist the strain of the gunpowder to tear out the breach; but it would be only half as strong in its transverse or cross section to resist what may be specially termed the burst-

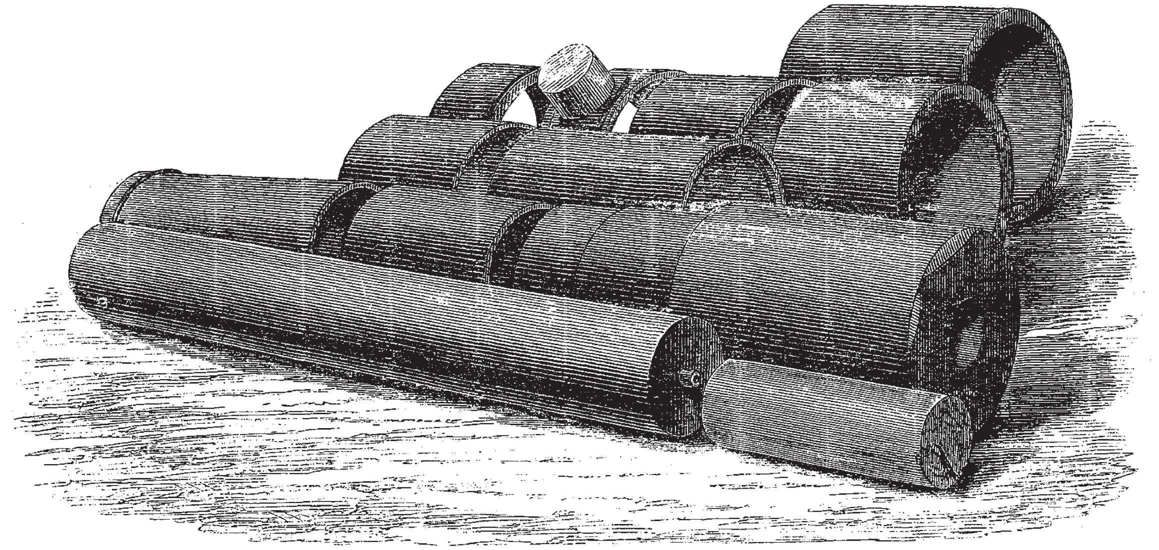

Fig. 3

ing strain. These difficulties were entirely overcome by Sir William Armstrong's system of making a gun of coils of wrought iron bars. By that the difficulty of forging a large mass is altogether put away; and the fibre of the iron passing round the bore of the gun instead of along it, gives the greatest possible resistance to the bursting strain of the powder's explosion. This was a very great advance, a most valuable improvement in the manufacture. It took away the difficulty and expense which were the great obstacles to constructing ordnance of wrought-iron, and at the same time applied it in such a manner as to increase, or rather put at the utmost advantage, its strength in resisting the transverse or bursting strain of the powder's explosion, which is the most difficult and important strain to overcome. It is for this last that this invention deserves its highest praise; for gun-making is

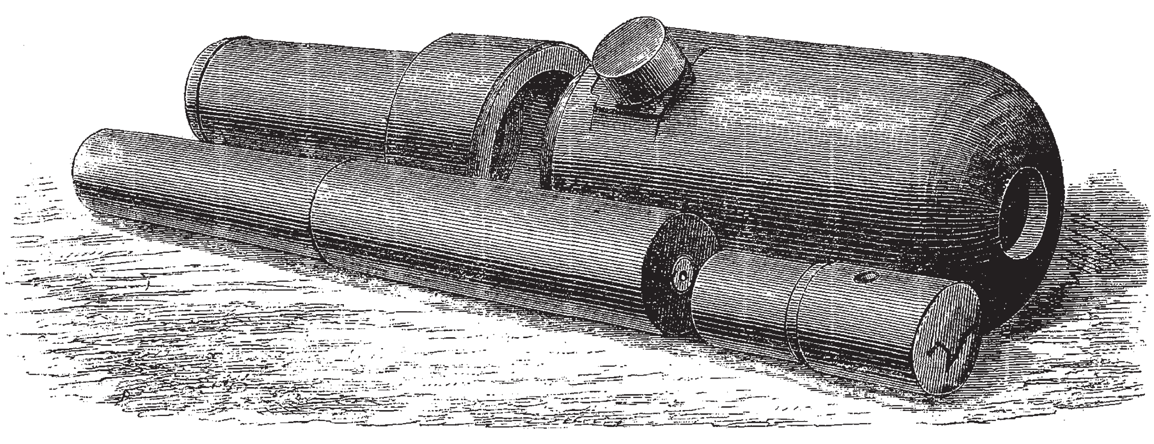

Fig.

above all a question of strength of material. The best material applied in the best way is hardly strong enough to resist the enormous charges behind the enormous shot which are required to pierce the armour-plated vessels of modern warfare.

The method of making the coils is as follows: A long bar of iron is heated to nearly a white heat in a long low furnace, and when thus rendered soft, it is hooked on to the side of what resembles a gigantic reel of iron. This reel or core is then turned by machinery, and the glowing bar is wound upon it; being drawn from the furnace upon a travelling groove, which, aided by blows on the bar from a heavy hammer suspended above and guided sometimes by two men, keeps the bar in its proper position as it is coiled. When that is completed, it is removed from before the furnace, the reel or core taken out, and the coil allowed to cool. Afterwards it is heated in a reverberatory furnace, and welded together by blows on the ends from a steam-hammer; the edges of the coiled bar are melting from heat, and therefore unite when thus forcibly pressed on each other, so that it forms a complete hollow cylinder or tube of wrought-iron, the fibre going round the circumference. The rough surfaces are afterwards turned off in powerful lathes. These coils are made of various sizes, and several of them are required for each gun. They are *shrunk on*, that is, the outer ones are not quite large enough to go over the inner ones, but are heated, and when thus expanded are placed over their smaller brethren, whom, as they cool, they clasp in a tight embrace. Thus all the coils are in a state of tension inwards, and this was supposed to increase their power of resisting the shock of the discharge which came from within outwards. However, this theory very decidedly admits of question. Even a little observation seem sufficient to show that anything in a state of tension is thereby weakened to resist a shock in any direction. A shock produces a kind of undulation or vibratory action, so that its effect returns back in the direction in which it was imparted. In Sir Joseph Whitworth's guns the hoops were made accurately to fit each other, so that no shrinking was required; but a little shrinkage, we believe, was used to ensure close fitting. It will be seen further on that this question of the advisability of shrinkage does not apply to the guns now made for the British service. Hitherto we have only spoken of coils, which, though a main part and distinctive feature of the Armstrong gun are not the whole of it. A gun made altogether of coils would lack strength in resisting the longitudinal strain, or tendency of the discharge to tear out the breech endways, and this would be an awkward event for the gunners, if the gun fired, so to speak, at both ends. To prevent this, Sir William Armstrong had a large forged piece of iron, like a great cap, placed on the breech end of the inner tube and under the coils. The fibres of this, running longitudinally, made it strong in that direction, and guarded against a catastrophe so much to be dreaded. This, however, was a large forging, and therefore very expensive; and, also, while it strengthened the gun longitudinally, it weakened it transversely, by taking up the space nearest the bore where the greatest part of the strain was sustained, and filling it with iron whose fibres were in the direction of the bore instead of around it, as those of the coils. It is easy to see how much this took from the power of the coils to resist the lateral, transverse, or bursting strain of the discharge. The force which the expanding gas exerts on the material of the gun must necessarily be inversely as the square of the distance from the centre of the bore. A coil removed from the tube by the thickness of the forged breech-piece cannot resist the full strain of the explosion nearly so effectively as if it came at once round the tube. Its strength is applied at a disadvantage represented by the ratio of the square of the radius of the coil round the forged breech-piece to the square of the radius of a coil round the inner tube.

Besides, there is another large forging in the Armstrong gun, the trunnion-piece, which is placed round the middle, and carries the trunnions or short arms by which the gun rests on its carriage.

An Armstrong gun may be thus summed up. (The section of a 600-pounder is shown in Fig. 1 as an example.) First there is a tube of steel (A); this metal is always used for the inner part, as its hardness and closeness of grain make it better adapted for the rifling—the grooves would be quickly worn by the friction of the studs of the shot in softer metal—and also better to resist the action of the violently expanding gas of the exploding charge of powder. All attempts to make the inner tube of coils were unsuccessful; the gas at its enormous pressure searched out and took advantage of the most microscopic flaws. Next comes the large forged breech-piece behind the steel tube, and extending some distance along it. Then come the coils (in 5 sets, B, C, D, E, F), shrunk on one over another. And lastly, the trunnion piece round the middle.

The Armstrong gun, as described in our former paper, was the pattern on which all our guns were made for the British service till 1866, when very important changes, which had been proposed by R. S. Fraser, member of the Institute for Civil Engineers, and Deputy-Assistant-Superintendent of the Royal Gun Factories, after a prolonged series of trials, were approved and adopted by Government. This gentleman, not long before, introduced into the manufacture of ordnance a cheaper, and, at the same time, a better kind of wrought-iron than that before used, and he has imported into the construction of the Armstrong gun very considerable modifications, by which the country is provided with a stronger gun, one-third cheaper, and more quickly made.

These are three very important items of improvement; viz. strength, cheapness, and rapidity, because simplicity, of manufacture. The saving effected is from 35 to 40 per cent. on the vast sums expended on heavy ordnance. Most of our readers have heard of the Fraser gun, but few, perhaps, know where or how it differs from the original Armstrong gun, although all our heavy ordnance is now made on this pattern. The information, therefore, may be not uninteresting, and a comparison of Fig. 2 with Fig. 1 will help to make the difference clearer. Instead of the forged breech-piece, the many small coils, and the forged trunnion-piece that form the Armstrong gun over the inner steel tube, Mr. Fraser uses one immense coil, of which the trunnions are part, and which is closed behind the tube by a large screw forming the cascable, and which is the only forging used in his gun. This will show at once how the economy is effected. Both the large forgings of the Armstrong gun, the breech-piece, and the trunnion-piece are got rid of; and instead of having many coils to be turned, and have their inner and outer surfaces reduced, upon which labour and time were expended, in addition to the waste of metal, there are only the two surfaces of the one great coil to be turned. In the 600-pounder, on the old principle, there were sixteen coils, and twice that number of surfaces, each representing labour and loss. For these reasons also the guns may be made much more quickly. This is a very important advantage, as in an emergency the country could be more quickly armed. Strength is also gained to resist the transverse strain in two ways, because the coiled iron comes next the steel tube, where the forged breech-piece used to come formerly, and so the coils are applied at greater advantage, and secondly, because the one thick coil is stronger than several thin coils, just as a triple deal is stronger than three inch deals. And further, the gun is stronger to resist the longitudinal strains, because the breech and trunnions are all of one piece, and so the force of the discharge upon the gun acts through the trunnions on the carriage, and has not, as in the old pattern, a tendency to destroy it by tearing one piece or part of the gun from another. It is converted from a longitudinal bursting strain into recoil.

It only remains to describe how this immense coil, which is the marked feature of the Fraser gun, is made. A long and thick bar, much thicker than the one used in the Armstrong pattern, is heated and coiled in the manner before described. When this has cooled, another bar, somewhat longer, is coiled upon it in an opposite direction, that is, if the first coils go from right to left, the second go over them from left to right, just as the boa constrictor overlaps his coils on the prey which he is crushing. And then a third bar is coiled in the same direction as the first. The whole is then heated in a large reverberatory furnace, and a few blows from a powerful hammer weld them into a thoroughly combined mass.

This principle of construction seems to apply the iron to the utmost possible advantage in resisting the force of the exploding charge. There is an eloquent testimony to the excellence of the system in one of the first guns made on the Fraser principle, which was tested to destruction in the preliminary trials that took place before the system was adopted, and is now to be seen in the *cemetery*, or place where such guns are preserved for inspection in the Royal Arsenal. This gun, a 64-pounder, having fired a greater weight of powder and shot than any other of its own size, and latterly with charges increased till it was destroyed, burst in this way: part of the tube, which was worn through, and the coil round the front of the tube came out and left the entire mass of the trunnion and breech-piece uninjured, so that not only would this bursting have done no injury to those who served the gun, but if a new tube and fore-part were put in, the trial might have commenced again.

Welding a coil, however large, is a much easier and less expensive process than forging and hammering into shape a mass of iron of much smaller size. However, the great size of the coils of Fraser guns of large calibre necessitated the employment of correspondingly large furnaces and machinery. These difficulties have been very successfully overcome in the Royal Gun Factories. The furnaces have been enlarged from a cubical content of 60 feet to 600 feet. At present a gun is being made of 35 tons weight, which will hurl a shot of 700lb. weight with a charge of 120lb. of powder (the battering charge for the ordinary 25-ton 600-pounder being 70lb.) All the coils for this enormous weapon have been welded without accident or hindrance. In one case as much as 28 tons of iron have been heated in one piece in the furnace, seized by the tongs, and placed in a glowing mass beneath the hammer. This is an achievement unprecedented in iron manufacture, and which reflects the highest credit on this most important Government department. Nowhere else, and for no other purpose, have such gigantic masses of metal to be heated and manipulated.

Figs. 3 and 4 show the parts of an Armstrong gun, and of a Fraser gun, before they are put together. Both are 300-pounders, and the engravings have been made from photographs of the actual guns.

NOTES

WE are in a position to state that the arrangements of the Eclipse Expedition are rapidly progressing,—thanks to the untiring labours of the strong Organising Committee, which meets almost daily. As we stated before, the Government are bringing all their power to bear in favour of the work, and, should the weather be favourable, we may expect such a series of observations as has never been made of an eclipsed sun. As at present arranged, there will be four parties. Beginning with Spain, we have one to Cadiz, in charge of the Rev. S. J. Perry, and one to Gibraltar, under Captain Noble. The English branch of the Anglo-American Expedition will be under the charge of Mr. Lockyer; while there will be a fourth small expedition, under the charge of Mr. Huggins, to Oran; the Cadiz, Gibraltar, and Oran parties will leave Portsmouth on the 5th of December in the *Urgent*. The Sicilian party will leave London on the night of the 7th by the Brenner pass, a ship of war meeting them at Naples. Although not a single official astronomer has volunteered to go, there will be lack of neither skill, discipline, nor organisation; and arrangements are already being made which will ensure a full and early publication by the Organising Committee of the scientific results obtained. Printed instructions are being prepared by the Committee for each class of observations. So much for the English Government Expedition. With regard to the American one, we may add that it has been no less strongly and carefully organised, with the distinct advantages that astronomy is more cultivated in America than it is here, that the official observatories are fully represented, and that as all the observers were present at the Eclipse in 1869, they therefore may be regarded as veterans. Professors Young, Pickering, Newcomb, Peters, Watson, Harkness, and others are at present in London, and are daily affording most valuable information to the Organising Committee and the various observers.

THE following memorial to Her Majesty's Government on the danger to which the scientific, literary, and art collections of Paris are now exposed, has been forwarded to the Earl of Granville from the University of Dublin:—"We, the undersigned, Provost, Fellows, and Scholars of Trinity College, and Professors of the University of Dublin, desire to express our satisfaction with the efforts made by Her Majesty's Government to restore peace in Europe, and our earnest hope—shared, we believe, by the nation at large—that these efforts may be eventually successful. But if, unhappily, our desire should not be realised, your memorialists venture to urge that the interposition of Her Majesty's Government may be directed to preserve, if possible, the great scientific, literary, and art collections of Paris, which are, in truth, the property of the whole civilised world. It is impossible to contemplate calmly the irreparable loss which the destruction of these collections, or even any serious injury to them, would inflict upon students of every nation. To avert, if possible, such a calamity, is now the duty of all; it is more especially the duty of every scientific and literary institution. Your memorialists would, therefore, in the name of our ancient University, earnestly entreat Her Majesty's Government to interpose their good offices with the belligerents, for the purpose of saving these matchless treasures from a danger which the fate of the Library of Strasburg proves to be only too real."

WE understand that Dr. Neil Arnott, in addition to his recent munificent donations to the Universities, has just presented 500*l*. to the Aberdeen Mechanics' Institution, to aid in maintaining lectures in Physical Science.

AT the examination for Foundation Scholarships, held in the week after Easter, 1871, one or more scholarships will be obtainable by proficiency in the Natural Sciences, at Trinity College, Cambridge. Should one scholarship only be so assigned, preference will be given to the candidate who shows the greatest proficiency in physiology and the allied subjects. The Examination in the Natural Sciences is open to all undergraduate members o the Universities of Oxford and Cambridge. The value of the scholarship is about 80*l*. per annum for five or six years.

DR. MICHAEL FOSTER (the newly-appointed Prælector of Physiology at Trinity College, Cambridge) commenced on the 14th inst. his course of lectures in a part of the new museums, which has been temporarily fitted up as a Physiological Laboratory. He gave a lucid and able exposition of the three great factors of life—contractility, as evinced chiefly in muscles; irritability, as evinced chiefly in the nervous system; and secretion. Dilating upon the much-vexed question, how far these are attributable to physical agencies, or are to be referred to another agency called "Life," he compared the latter view to a fortress closely besieged by an able band of investigators who are ever narrowing its area, and pressing the physical forces closer and closer upon it. But it has not yet capitulated. No one has a right to say that it will or will not capitulate; and till it has done so we are perfectly justified in regarding it as an entity, as a something to be taken into account in the investigation and the attempts at the explanation of living processes. He should still, therefore, use the term without committing himself to either view. He gave definitions of Physiology and Morphology. He spoke of the enormous importance of vivisection to the advance