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

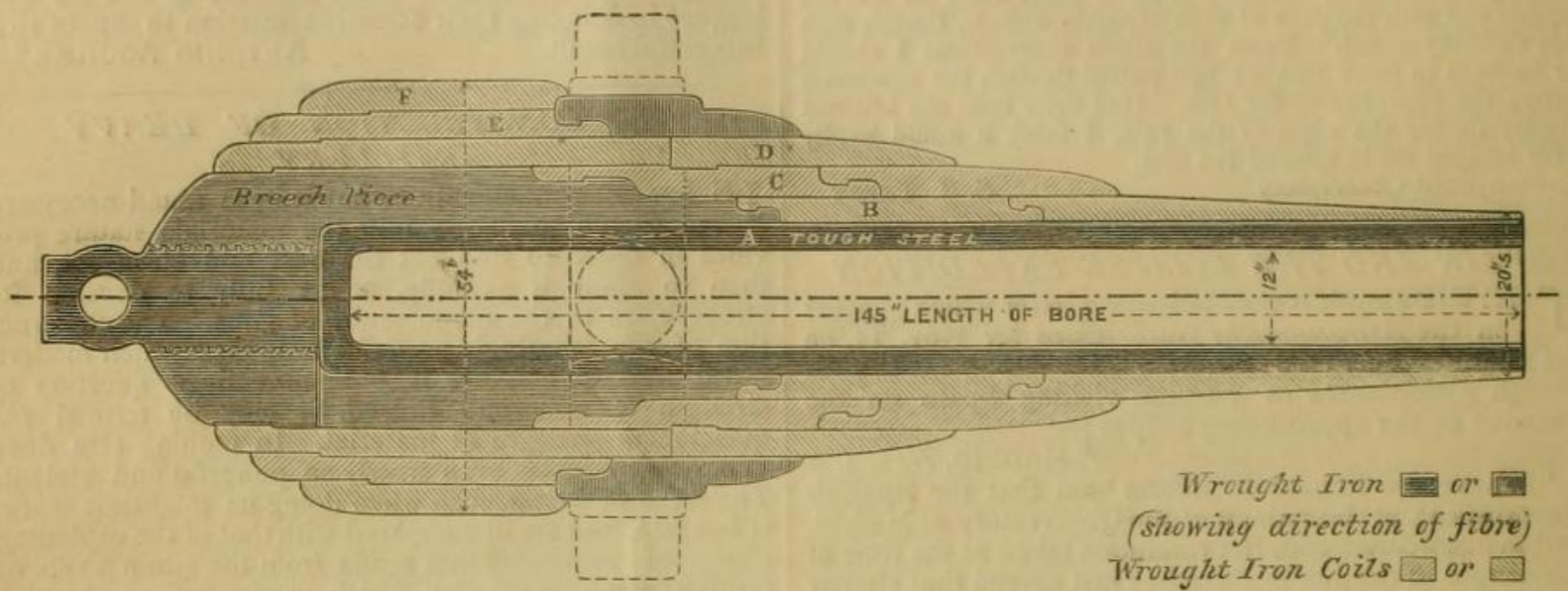

FIG. 1

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.

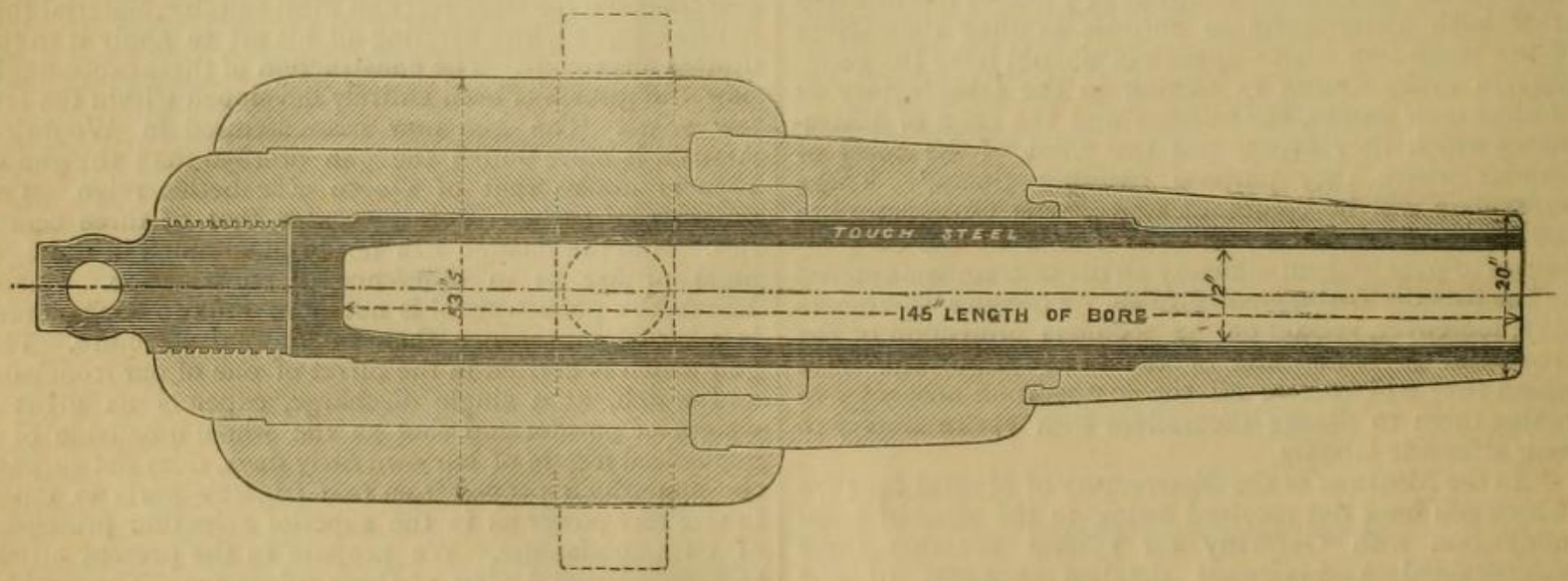

FIG. 2

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