previously been attached to the iron plate; and it is pressed against the surface of the iron plate by a cover carried by an hydraulic ram, until the welding is complete and the steel has solidified. Messrs. Brown prefer first to roll a steel face-plate as well as an iron back-plate, and then to raise both to a welding heat; the molten steel is afterwards poured into a space left between the two, and hydraulic pressure is applied until the solidification has taken place. The remaining processes are similar in the practice of both firms. After welding has been completed, the whole mass is reheated and rolled down to the finished thickness of the armour plate. The steel face is usually about one-half the thickness of the iron back, and it is a curious fact that the iron and steel maintain their relative thicknesses as the rolling proceeds, even when the reduction in thickness during rolling is very considerable. This reduction varies from one-half for thin armour-plates, up to 10 or 11 inches in finished thickness, to one-third with 18 to 20 inches of finished thickness. Some competent authorities consider that too little work is done in the rolls on the thicker plates, but there is a need for further experiment to show whether this view is correct. Whatever may be the cause, it would seem that the best results so far have been obtained with steel-faced plates below 12 inches in thickness.

Simultaneously with the Spezia experiments another competition was proceeding, near St. Petersburg, between steel-faced and steel armour. The plates tested were 12 inches thick, 8 feet long, and 7 feet wide. They were first fired at with the 11-inch breech-loading gun, throwing a 550-lb. chilled cast-iron projectile, with a powder charge of 132 lbs. The velocity of the shot was 1500 feet per second. Messrs. Schneider supplied the steel plate, which was fastened with twelve bolts. Messrs. Cammell made the steel-faced plate, which had only four bolts in it. The first blow on the steel plate broke it into five pieces; the projectile was destroyed, but it penetrated 13 inches into the target. A blow of equal energy on the steel-faced plate produced only a few unimportant cracks in the steel, and the penetration was about 5 inches only. Three out of the four bolts were, however, broken. A second shot was then fired at each plate with 81 lbs. charge. The steel plate was broken into nine pieces, and the penetration was 16 inches: whereas on the steel-faced plate the principal effect produced was to break the only remaining bolt and to let the plate fall to the ground, face downwards. The back of this plate was perfect, and the target behind the plate was uninjured. In this trial the steel-faced plate proved greatly superior to the steel, but had insufficient fastenings. It is proposed to increase the bolts in number, re-erect the plate, and continue the trial, of which the further results cannot fail to be interesting.

This contest between steel and steel-faced armour must not be allowed to withdraw attention from the great superiority of both, in certain respects, to iron armour. Even as matters stand, either of these modern defences is greatly to be preferred to their predecessor. Against this hard armour chilled cast-iron projectiles break up in a manner never seen with soft iron. Projectiles of this kind are virtually impotent, and must be replaced by more expensive, harder projectiles, if steel or steel-faced armour is to be attacked. Even with steel projectiles results cannot be obtained such as were possible with iron armour. Perforation of armour by shells carrying relatively large bursting charges is no longer a possibility: and the heaviest gun yet made cannot drive its projectiles through a thickness of hard armour only three-fourths as great as the thickness of iron which it it could perforate.

The use of steel and steel-faced armour will involve many experiments to determine not merely what descriptions of projectiles are best adapted to damage or penetrate it, but what are the laws of the resistance of such armour to penetration and disintegration. All the formulæ based on experiments with soft iron armour and chilled cast-iron projectiles are inapplicable under the new conditions. Perforation is no longer to be feared as the most serious damage likely to happen to armour plates: more moderate thicknesses of hard armour suffice to stop the projectiles from the heaviest guns than would have been considered possible a short time ago. Instead of perforating 19 inches of steel or steel-faced armour, the projectile of the 100-ton gun with a given velocity only penetrates 8 inches into the plates. But, on the other hand, the possible disintegration and fracture of the armour plates are becoming important matters. Makers of armour plates have to endeavour to produce materials which shall resist fracture as well as penetration, and the only proof of their success or failure is to be found in the results of actual trials. Experiments are equally essential to progress in the manufacture of guns and projectiles. The example set by Italy must be followed; the necessary experiments must be on a large and costly scale, and they may lead to many departures from former practice. But if real progress is to be made in the armour and armament of ships, it must be prefaced by experiments beside which those of the former Iron Plate Committee will appear insignificant.

In conclusion it may be stated that although iron armour has been practically superseded for the sides and batteries of war ships, it is still preferred for decks. Experiments have shown that for angles of incidence below 20 degrees, and for such thicknesses—not exceeding 3 or 4 inches—as are used on decks, good wrought-iron is superior to both steel and steel-faced plating. The explanation of this departure from the laws which hold good for thicker plates and greater angles of incidence cannot be given here, but the fact has been established by elaborate trials made in this country and abroad.

SMOKE ABATEMENT

Report of the Committee of the Smoke Abatement Exhibition. (London: Smith & Elder, 1883.)

THIS volume, which has just been issued, presents many points of interest, as it is the outcome of the labours of a Committee formed in 1881 with a view to ascertain what means could be adopted to check the growing evils arising from the evolution of smoke which attends the combustion of bituminous coal. It may be said to be the continuation of work undertaken by the several Parliamentary Committees which met in 1819, 1843, and in 1845. In the previous efforts attention appears to have been mainly directed to lessening the nuisance arising from smoke from factory and other furnaces, but in the present movement it is evident that the importance of the domestic fireplace as a foe, if not the chief one, to the purity of the air of cities, has been generally recognised and has been the main object of attack.

It is not a little remarkable that, although elaborate experiments have been made from time to time with a view to ascertain the nature and composition of the gases generated in furnaces, but little attention has been devoted to the gases given off from stoves and grates. On the Committee of the recent Smoke Abatement Exhibition chemists were well represented, and this brief notice will mainly refer to the general chemical results that have been obtained.

The examination of the gases withdrawn from flues to which stoves and grates were attached, was intrusted to Prof. Chandler Roberts, who at first considered that the analysis of representative samples might best be made by the aid of the rapid methods of gas analysis arranged by Orsat. In view, however, of the peculiar conditions under which the tests had to be made, and bearing in mind that more than one hundred appliances were submitted for testing in the limited time during which the Exhibition was open, Prof. Roberts submitted a plan to the Committee which received its approval.

He points out in his report that the first researches on chimney gases are due to Péclet, who published some results of analysis in 1828, but Péclet's results and those of different experimenters who followed him were open to the objection that the samples submitted to analysis were only small fractions of the total gases in the flues, and as the samples were not taken with sufficient frequency they could not represent the mean composition of the gaseous mixture passing up the chimney. This grave defect was, however, remedied by Scheurer-Kestner in an elaborate research on the composition of the flue-gases of boiler furnaces, which will always be the basis of future experiments in this direction, and to which frequent allusion is made in the Report. The details of the method adopted are given in the Report itself; it will be sufficient to say here that the gases were withdrawn through a fine slit in a tube extending across the flue, an arrangement which rendered it possible to draw the gases uniformly from the entire diameter of the ascending current of gas in the flues. The effluent gases were withdrawn by aspiration through a tube loosely filled with asbestos to retain the solid particles of carbon and soot; they then passed through a U-tube filled with chloride of calcium to absorb water, and thence through three U-tubes filled with soda-lime to absorb carbonic anhydride; the gases were then led to a tube of porcelain filled with cupric oxide and heated to redness by means of a small furnace. The complete combustion of the remaining gases was thus effected, the carbonic oxide being burnt to carbonic anhydride, and the hydrocarbons and free hydrogen to aqueous vapour and carbonic anhydride; the water was retained in a U-tube filled with chloride of calcium, and the carbonic anhydride in two other soda-lime tubes; the residual gases (unconsumed oxygen and nitrogen) then passed to the aspirator, a chloride of calcium tube being interposed to prevent any moisture from the aspirator from penetrating the system of tubes.

It will be evident that this plan renders it possible to compare the relative proportion of the completely burnt products of combustion with those in which combustion has been imperfect. With regard to the proportion of carbon lost as soot, the evidence afforded by the results of the tests made at the Exhibition, although they do not unfortunately render it possible to give a clear and precise answer to the question, are sufficiently definite to show that the amount probably does not exceed 1 per cent. of the total carbon in the fuel, and is in many cases far less.

The coal used in testing the grates and stoves was either 'Wallsend,' which yielded 67·1 per cent. of coke, or Anthracite, giving 94 per cent. on distillation in a closed vessel.

With regard to the completeness of the combustion, the carbon present in the form of carbonic anhydride varied in relation to that present as carbonic oxide and as hydrocarbons, C_xH_y, within the limits of 1,000 to 4 and 1,000 to 375, but of the whole eighty-six tests in only three was the number indicating imperfect combustion below 10, and in only nine cases was it above 200, and six of these nine cases (three grates and three stoves) were worked purposely for "slow combustion."

The total amount of carbon present in the gases ascending the flue (either in the free state or combined with carbon) bore a relation to the hydrogen present which varied between the limits of 1,000 to 8 and 1,000 to 259, the latter probably being due to the fact that the grates and stoves were tested whilst the mortar in which they were set was still wet.

The mean of the results of the tests of the seventeen best grates shows that the loss of carbon in the form of carbonic anhydride and hydrocarbons is about 3·4 per cent. of the carbon in the fuel used (in the case both of Anthracite and Wallsend), the mean for the whole of the grates being about 9 per cent. of the total carbon.

The comparative imperfection of the combustion shown in some of the tests is hardly to be wondered at when it is remembered that the bituminous coal employed yielded on distillation no less than 32 per cent. of volatile matter, and that in the case of many of the appliances the cold fuel was simply charged on to the top of a mass of coal already in the state of incandescence.

Professor Roberts cautiously points out that all that has hitherto been done in this series of tests "merely renders it possible to select certain typical appliances which deserve more detailed examination." He appears, however, to have spared no pains to render this very laborious investigation as complete as the circumstances allowed, and the Chemical section of this Report is certainly one of the most important contributions ever made to our knowledge of the combustion of fuel.

E. FRANKLAND

NORTH AFRICAN ETHNOLOGY

Sahara und Sudan: Ergebnisse Sechsjähriger Reisen in Afrika. Von Dr. Gustav Nachtigal. Part II. (Berlin: 1881.)

NEARLY a decade has elapsed since Dr. Nachtigal's return to Europe after his travels in East Sahara and Central Sudan during the years 1869-74. Most of the geographical and ethnological results of his researches