The nitro-glycerine high explosives used in mining are unsuitable for shell filling, owing to the sensitiveness of nitro-glycerine to shock, which would cause premature detonation in the bore of the gun. The ammonium nitrate group of high explosives, also used in mining, which contain nitro-hydrocarbons, and in some instances aluminium, have been advantageously adapted for shells. Although the hygroscopic nature of ammonium nitrate is detrimental, this may be successfully overcome.

Abel, in 1865, first proposed the use in mines of compressed wet gun-cotton fired by means of a dry gun-cotton primer; this was later used for filling torpedoes, but it has the disadvantage of low charge density. Gun-cotton cannot be compressed to a greater density than 1.25. In other words, a torpedo head which would hold 125 lb. of compressed gun-cotton could hold from 160 to 180 lb. of the denser trinitrotoluene or picric acid, with a corresponding increase of destructive power.

Sprengel, in 1875, first showed that picric acid could be detonated, and in 1881, Turpin, in France, demonstrated the practical possibility of using it for filling shells. The idea was rapidly taken up by other countries.

The methods of manufacturing nitro-hydrocarbons suitable for shell filling are very similar to those in use for producing nitro-glycerine. A mixture of sulphuric acid and nitric acid is used, and large quantities, very frequently as much as a ton or even more, are made in one operation. To obtain the highest yields of pure products very great attention must be paid to the composition of the acids, to the efficiency of agitation, and to the temperature, which is regulated by internal heating or cooling coils.

Picric acid, discovered in 1771 by Woulfe, of London, when used for filling shells has a different name in each country. It is called *Mélinite* in France, *Lyddite* in England, *Pertite* in Italy, *Shimose powder* in Japan, *Granatfüllung 88* in Germany, and *Ecrasite* in Austria. It is not always employed in the pure state, there being occasional addition of *crésylite* (trinitroresol) or a salt of that substance, the object of which is to reduce the temperature of fusion. It is manufactured from phenol (carbolic acid, obtained from the distillation of coal-tar) by first dissolving in sulphuric acid and then treating the resulting phenol-sulphonic acid with nitric acid in excess. It forms yellow crystals with an intensely bitter taste. It has a specific gravity of 1.777 and melts at 122.5°C. Picric acid, if heated gradually, takes fire without explosion, giving rise to dense black smoke, but the application of a red-hot rod will cause it to detonate, as will also the explosion of a capsule of fulminate of mercury. Owing to the readiness with which it forms certain unstable metallic salts, the use of picric acid is not free from danger, and it is largely on this account that it is being rapidly replaced by the somewhat less energetic but much safer trinitrotoluene.

Trinol, trotyl, trilitite, tritolo, or T.N.T., as trinitrotoluene is variously called, is made from

toluene (obtained from coal-tar naphtha), and was first proposed for use in shells by Häussermann, in 1891. The result of the first nitration of toluene is a mixture of mono-nitro-toluenes, which are then treated with a mixture of strong nitric acid and sulphuric acid, and raised to the third or trinitro degree of nitration in one stage. Trinitrotoluene, when pure, forms brownish-yellow crystals with a melting point of 81°C. It is very stable, not igniting below 300°, but when it explodes it does so with great violence. Its density when melted varies between 1.57 and 1.60. Neither picric acid nor trinitrotoluene can be detonated with certainty by fulminate of mercury, and a small quantity of an intermediate priming charge is employed. In the case of trinitrotoluene, the use of tetranitromethylaniline has been found suitable.

Tetranitraniline is a very powerful explosive, and has a higher density than either trinitrotoluene or picric acid.

The nitro-hydrocarbon high explosives used for the shell bursting are, in the molten state, poured into the cavity of the shell, in which they solidify, sufficient room being left for the priming charge and the detonating fuse. All the above nitro-compounds can only be obtained in a state of purity by re-crystallisation from various solvents.

Fulminate of mercury has been mentioned several times as a detonator, or initiator of explosion. Lead azide has been used, in conjunction with fulminate of mercury and tetranitromethylaniline, as a detonator for high explosives.

It will be noticed that the majority of the high explosives referred to are derived from coal-tar products, and it is therefore evident that Mr. Lloyd George's statement, "If there were a shortage in the coal supply for any reason, the consequences would be very calamitous," is one which must be taken very seriously.

GEORGE W. MACDONALD.

SCIENCE IN THE SERVICE OF THE STATE.

MODERN war is an affair of applied science—military, engineering, chemical, medical, and economic. Its successful prosecution requires more than an extremely high efficiency on the part of the officers in their professional work. Everything that chemical, physical, and engineering science can suggest must be pressed into service. The scientific men of the country have been keenly aware of this necessity from the beginning of the war, and many of them have individually done a great deal of important work for the Government and the various Services. The Royal Society has formed a War Committee, to which the Government has confided the solution of many pressing scientific problems arising out of the war. The public thanks of the country have been given to the Royal Society by Mr. Asquith. We note also with pleasure the issue, by the Council of the Chemical Society, of the letter (see p. 523) announcing that the Council has constituted itself a consultative body to consider, organise, and utilise all suggestions and inventions which may be communicated to it.

British chemists have now a clearing house for their ideas and discoveries, whilst the Government knows that it has the expert chemical advice of the country at its immediate disposal.

It is not going too far to say that practically without exception the services of the scientific laboratories of the universities, university colleges, and technical colleges have been offered to the Government. Very many—perhaps all—of these laboratories have done, and are doing, important public work relating to the war and the industries of the country. In this connection the Royal Society War Committee has done good work in organising special chemical work of an urgent character in the above-mentioned laboratories, and in obtaining from them competent young men to assist in the carrying on of the special chemical manufactures required at the present time.

The Institute of Chemistry has done excellent work in various directions. Particularly deserving of mention is the splendid public work done by the Glass Research Committee. The important scientific results obtained by this Committee have been made public (see *NATURE*, April 15, p. 192) and are therefore at the disposal of every manufacturer.

There is not a scientific society, scientific laboratory, or scientific man in the country that is not anxious and willing to help. Much good work has been already done. But there is undoubtedly a feeling that with better organisation and knowledge a vastly greater amount could be done. Speaking in the House of Lords on Friday last, Viscount Bryce urged that—

Every possible effort should be made to utilise the services of scientific men. They all knew to how great an extent the German Government had turned the services of scientific men and establishments for investigation and research to account for military purposes. We possessed in this country a body of scientific men not, indeed, so numerous, but fully equal in competence and fully equal, he need hardly say, in earnestness and zeal to serve their country. He understood that there had been during the past months a certain amount of regret among scientific men that they had not heard from the Government how they could help. Any efforts which the Government made to give them a chance of coming in, and enabling them to turn their scientific knowledge, whether in chemistry or engineering, to the common purpose we all had at heart would, he was certain, be welcomed by them. The universities, in which there were so many scientific men, would gladly drop all their work in order to assist.

It is to be hoped that these wise words will be taken well to heart.

Science is standing Germany in good stead at present. It is known that the Badische Works, employing the process initiated by the scientific researches of Prof. Haber, had arranged for an enormous output of synthetic ammonia during the present year. About twelve years ago Prof. Ostwald, foreseeing (as he has himself publicly stated) a nitric acid famine in Germany during a period of war, investigated the conditions for the economical oxidation of ammonia to nitric acid. This process has been worked for several years at

a factory near Vilvorde in Belgium. It is rumoured that Prof. Haber and the Badische Works have greatly improved the process, and that in conjunction with the synthetic ammonia process it now provides a large part of the nitric acid required by Germany for the manufacture of her explosives. *Ohne Phosphor kein Gedanke* said the materialist once upon a time. So might he now say, "No nitric acid, no war." Interesting notices have appeared from time to time in the *Chemiker Zeitung* relating to the activity of organised German science during the past twelve months. A new industry of zinc extraction has been developed, and it is reported that means have been found to replace the French bauxite required for the production of aluminium.

The shortage of copper has been discounted by the use of special alloys. It is also stated that processes have been developed for the manufacture of gasoline and lamp oil. Alcohol is being largely used in internal combustion engines.

We may feel sure that not only the universities and technical high schools, but also the splendid special laboratories of the *Kaiser Wilhelm Forschungsgesellschaft* are working at high pressure in the service of their State.

It is necessary—urgently necessary—that we should do as much, if not more. Let Britain call, British science is ready. It is straining at the leash. All that is wanted on the part of our leaders are imagination and sympathy. A little more of these, and the good that has been done can be magnified a thousandfold.

F. G. DONNAN.

MAMMALS OF EASTERN EQUATORIAL AFRICA.¹

MR. ROOSEVELT'S second book dealing with his East African experiences will probably be more valued by naturalists than his first, though some portions of it may leave the naturalist cold where they excite to frenzy the man of primitive instincts, who still thinks

Cet animal est très méchant,
Quand on l'attaque il se défend.

To the mammalogist *Homo sapiens*, even in his Caucasian variety and English or Anglo-American race, is not more interesting than *Felis leo* or *Loxodon africanus*; and he is just as shocked and pained at the death agonies of the latter as of the sportsman who fails to kill dead at the first shot and is afterwards eaten up or trampled under foot. In fact, I for one, when I read in a newspaper some ten years ago that a German hunter who had frequently evaded my inquiries in East Africa as to big-game regulations and had at last—thank goodness!—been killed by a rhinoceros after having needlessly slain about seventy-three rhinoceroses for no purpose whatever but sheer love of killing, could not resist an expression of delight.

¹ "Life-Histories of African Game Animals." By Theodore Roosevelt and E. Heller. Vol. i., pp. xxviii+420. Vol. ii., pp. x+421-798. (London: John Murray, 1915.) Price 42s. net. Two vols.