provements, for here large savings might be possible, because at present about eight units are thrown away for every one doing useful work.

The steam turbine is regarded as combining the greatest number of advantages among the prime movers of to-day, and as an interesting novelty the Lundholm turbine is mentioned, consisting of two discs and blades revolving in opposite directions.

As there is no difference of expansion of the two discs there is every prospect that the clearances of the blades can now be reduced to a minimum, and that this very serious source of loss will be materially reduced.

The possibilities of the gas-engine, and particularly of the internal-combustion turbine, perhaps in the near future, appeal to Mr. Stromeyer and lead to the following :—

From a national economic point of view the combination of the internal-combustion engine with electric distribution of power would seem an ideal one. Our collieries would then be encouraged to mine even our dirtiest coal. This coal would produce by-products for farmers and for the coal-tar industries and supply the engines with suitable gas, and our factories would receive their power at a lower cost than they could produce it.

The general attitude of the author seems to be that of an experienced engineer, convinced that economy in power production is going to be so vital to us after the war that strenuous effort and a bold and encouraging policy as regards both invention and research are primary conditions of our continued commercial progress.

Although in all probability no such effective blight could be laid upon the work of scientific investigation in any field as that of undue centralisation and impossible regimenting, enough has perhaps been said to indicate that the scale of research necessary for adequacy in the domain of fuel necessitates, among other things, liberal financial support, and if the Government is going to provide that support it will naturally seek for guidance. Presumably the new Board of Fuel Research is to guide. Its director is Sir George Beilby, whose varied industrial and scientific experience should prove of the greatest value. Sir Charles Parsons, Mr. Richard Threlfall, and Sir Richard Redmayne will assist him as members of the board, and Prof. W. A. Bone will act as consultant. This form of organisation for research is new to the country and its working will be watched with great interest. There are pitfalls in the way, which it may be difficult to avoid, and would certainly be folly to ignore, but an administration directed with liberality of spirit to really national ends will go a long way to command success. JOHN W. COBB.

THE SEPTIC PROBLEM IN WAR.

OF all the many varieties of wounds with which surgery has to deal, incised, contused, lacerated, etc., the most dreaded one is the punctured variety. This is because the inflicting weapon is almost necessarily infected with pathogenic organisms, and because these organisms are therefore implanted in the depths of a long and narrow track, into which antiseptics can be made to penetrate only with considerable difficulty.

Of all punctured wounds those produced by gunshots are the most difficult to deal with. The reasons for this become obvious upon consideration. The mere force of impact, in the first place, is an unusual and important feature. The energy in foot-tons of a projectile of known weight and velocity can easily be calculated, and it is to be remembered that this energy is concentrated upon a small area, with the result that the actual track of such a missile in human tissues is a tunnel the walls of which are *dead tissues*.

The importance of this fact in favouring bacterial growth is immense. Moreover, the tunnel is surrounded by a cylinder of tissue of which the constituent elements are bruised and under the influence of local shock, so that their vitality and resisting power to bacterial invasion are reduced. If such a missile strikes hard bone, a high degree of shattering and splintering takes place, while portions of broken bone are driven into the surrounding muscles, sometimes lacerating important vessels and nerves, and even bursting through the skin, and forming a large opening known as an "explosive exit." Owing to the ballistic properties of the pointed bullet, which is now used by all countries, and which tends to turn over on its short axis on impact, the proportion of these severe wounds is somewhat greater than in previous campaigns.

Another difficulty in the case of gunshot injuries is their special liability to severe forms of septic infection in the circumstances of the present campaign. In South Africa military surgeons found that a large number of wounds, even when bone was involved, showed small wounds of entrance and exit, and, so far as infection was concerned, merely required cleaning and sealing to heal without trouble. This was in part due to the shape of the bullet and its tendency to traverse the tissues by a straight course without turning on its short axis. This meant small external openings, and therefore less liability to infection from them. But the chief cause of the immunity from infection was the comparative dryness of the country, and a soil for the most part uncontaminated by human occupation or cultivation.

The conditions in the European area of the present conflict are very different. The humidity of the climate is greatly in excess of that of South Africa, and intensive cultivation means copious manuring of the soil, so that most of the ground occupied by our troops is thoroughly sown with bacteria of fæcal origin, which include, besides those ordinarily called pyogenic or pus-producing, the special germs of tetanus, malignant œdema, and gas gangrene. It is in ground thus infected that our soldiers sleep, take their food, and are occasionally buried alive. Their skin and clothes are plentifully smeared with bacterial mud, and it is no matter for surprise that when a bullet passes into their bodies

it carries with it, and implants in all the interstices of a deep and complicated wound, the potentialities of a surgical catastrophe.

That the bullet is infected by passing through muddy skin or clothing, often carrying with it portions of the latter, seems fairly certain. Some wounds in South Africa became infected when the bullet passed through the mouth or any part of the alimentary tract, both highly infective regions of the body. The bullet itself, when fired, is probably a fairly clean body from a surgical point of view. The sides are cleaned by the friction of the rifle barrel, and the base is seared by the flame of the explosion. Nevertheless Col. La Garde's experiments have shown that if deliberately infected before firing, it can be shown to be still carrying infection after firing.

The problem, then, which was presented by gunshot injuries was how best to combat sepsis in punctured wounds of all varieties, complicated often by bone injury and severe lacerations of soft parts, the bacterial infection coming usually not from the wound openings, but being deeply implanted by the actual stroke of the bullet as it passed through the tissues. Obviously, the mere application of even the most efficient antiseptics to the parts about the external wounds will not meet such a case. The infection must be attacked in the depths of the tissues, preferably at a very early date after the receipt of the wound, before the bacteria have time to multiply in the tissues. Moreover, practically all wounds of any depth must be dealt with thus. It would be bad surgery to wait until the infection was established, even though few signs of mischief appear at first. Accordingly it was soon recognised that the wound must be opened up, cleaned as far as possible, foreign bodies removed, and free exit provided for discharges by means of drainage tubes.

Some surgeons hoped that in a wound thus opened up, and thereby converted from a punctured to an incised type, it might be possible to remove the infection altogether, and here the advocates of the application of strong antiseptic solutions had their view. A mass infection can be completely destroyed by the application of, say, pure carbolic acid. At a very early stage of infection this may perhaps be possible, but not when the bacteria are in the depths of the tissues. Moreover, it is difficult to reach all the recesses of a large wound, and if one pocket is left unattacked, the surgeon's pains are thrown away. Strong antiseptic solutions, too, are very damaging to the tissues, which, it must be remembered, are in a condition of impaired vitality already. Another drawback to the use of antiseptic solutions, whether weak or strong, is the fact that many of them tend to become inoperative when in contact with the albuminous solutions like blood or pus. They form inert compounds with albumin, and will no longer destroy bacteria. It is claimed for an entirely new antiseptic, called from its colour flavine, that it actually proves more formidable to germs when in solution in blood-serum than in aqueous solution. But further trial is required before its value can be exactly classified.

Another device for the early removal of septic matter is to cut away the infected tissues bodily. The extremely localised nature of gunshot injury is a help in this case. It is possible to excise the entire internal surface of the wound *en masse*, with all its sinuosities and pockets, and to sew up the clean cavity remaining. This method enjoys the advocacy of Col. H. M. W. Gray, who has had success with it, but to be satisfactory it obviously must be done early, and requires in many cases considerable surgical skill. Cranial injuries and wounds of joints have been treated by this method with an encouraging measure of success.

But both the above methods can be effectively applied only when the wound is seen early, and in warfare this is not always possible. Many hours or even days may elapse before wounded men can be collected and carried to the casualty clearing stations. What, then, can be done when bacteria, deeply implanted in the tissues, are multiplying freely and in circumstances very favourable to their growth? Here the physiologist steps in and reminds the surgeon that the living body has its own guards against bacterial invasion; that healthy blood fluids are inimical to the growth of many, though not of all, bacteria; that the white corpuscles, the so-called phagocytes or germ-eaters, form an immense army for home defence; and that the effect upon the body of the absorption of the special toxins produced by bacterial action is to cause it to elaborate a neutralising substance or antitoxin. Here, then, is the physiological basis both of the salt method and of the vaccine method of treatment. It is found that if a strong or saturated solution of common salt be applied to an infected wound, the salt by its osmotic action sets up a greatly increased flow of lymph from the tissues into the wound, thus relieving the inflamed tissues of congestion, and setting up a flow of fluid from within outwards which tends to wash away bacteria. Both the lymph and the strong salt solution are unfavourable to the growth of bacteria. So far as the white corpuscles are concerned, strong saline solutions are unfavourable to their vitality; but when the wound has become healthier it is usual to decrease the strength of the salt solution until its saturation has reached that of a fluid of the same specific gravity as the blood. In a fluid of this degree of concentration the phagocytes can live and act freely.

The practical application of these principles consists either in packing the wound with gauze, between the folds of which tablets of salt are placed, or arranging for the continuous irrigation of the wound with a solution of salt of a known concentration. The latter method is suitable in a fixed hospital. And it is one of the great advantages of the former method that a case so dressed often requires no redressing for a few

days, so that the anxieties connected with the provision of fresh dressings during transport from the casualty clearing station to the base hospital are set aside. The question of treatment by vaccines can scarcely be efficiently dealt with within the limits of a short article. In any case the *rôle* of vaccines is to neutralise tissue poisons elaborated by bacteria, rather than to contribute directly to the closing and healing of the wound itself. The ideal vaccine would naturally be one which, injected into the body immediately after the wound is inflicted, has the power of getting in ahead of the toxins and neutralising them. This prophylactic action is possessed by one of the serums used, and fortunately in the case of one of the deadliest of the bacteria, the tetanus germ. It has been found that the use of this serum in a moderate dose immediately after the infliction of the wound protects the wounded man from tetanus, and consequently an important part of the treatment at the casualty clearing stations is the administration of this preventive dose. As regards the other bacteria, serums and vaccines are used, but their value is not so well established as in the case of tetanus, though important results have been obtained and valuable lessons learnt from their trial.

It will be seen from the above remarks that surgeons had not only to appreciate and elucidate a problem which at first presented many new and puzzling features, but also to devise means for its solution. How far they have been successful cannot be quite known until after the war. But enough experience has been gained to justify the hope that we are on the right track, and that the treatment our brave soldiers have a right to expect can now be given to them.

NOTES.

AN article of immediate interest and importance appeared in our contemporary *La Nature* (February 17, p. 100) on the utility of supplying soldiers with body armour—a proposal which has been already urged in this country. The writer, "A. G.," states: (1) That in trench warfare nearly 75 per cent. of wounds seen in hospitals are caused by missiles of low velocity—such as could have been warded off by a comparatively thin armour-plate. (2) That missiles of low velocity which lodge in the body are more dangerous to life than missiles of high velocity which penetrate and leave the body, because every missile which lodges is presumably an infected body. (3) That the total mortality from head wounds has been enormously decreased since the introduction of protective helmets. The form of body armour proposed by the writer in *La Nature* is fully illustrated and compared with suits worn by soldiers in the Middle Ages. A cuirass of armour-plating is proposed for the protection of the thorax and upper abdomen, covering the most vital organs; a gorget of chain mail protects the neck, and a girdle or short "kilt" of the same material the loins and groins; there are a mask for the face, and sheaths for the shoulders, elbows, and knees. How far such an armour would interfere with mobility is a matter on which only military men can decide, but from a surgical point of view such a protection has every recommendation. We may here point out that a soldier of average stature presents, as he faces the enemy in open field, a target with an area of 2740 square cm. Of that target the head and neck make up 9 per cent.; the thorax and abdomen 28 per cent.; while the less vital parts—the limbs—make up the largest part, viz. 63 per cent. Even if only the more vital parts could be protected, there would be a great saving of life.

THE Committee on Commercial and Industrial Policy, of which Lord Balfour of Burleigh is chairman, has recently forwarded to the Prime Minister a copy of resolutions passed on the subject of Imperial preference, and its report (Cd. 8482, price 1*d.* net), which includes a copy of the covering letter addressed to the Prime Minister, has been presented to Parliament. In the light of experience gained during the war, the committee contends that special steps should be taken to stimulate the production of foodstuffs, raw materials, and manufactured articles within the Empire, wherever this is possible, and it therefore recommends that preferential treatment should be accorded to the products and manufactures of the Colonies, either by exemption from, or reduction of, duties. Such recommendations from the committee, composed as it is of well-known representatives of politics, economics, engineering, metallurgy, trade, and industry, will no doubt carry considerable weight. There is, however, one direction in which this committee ought to be strengthened. Since the beginning of the war the importance of applied chemistry has become obvious to everyone, but it is not yet sufficiently realised by Government Departments and public officials that there are many industrial and economic questions in the consideration of which some knowledge of the science of chemistry and its applications, actual or potential, is indispensable. These questions cannot be handled with success by ordinary men of business, however able, without such knowledge, and it appears therefore eminently desirable that a duly qualified representative of chemical industry should be added to the committee.

COUNT ZEPPELIN is dead, and has left a name that brings to our minds the murder of innocent women and children in air-raids over open towns. Yet it must be admitted that his work in developing the rigid airship, in spite of many failures, is worthy of all praise. Count Zeppelin showed us how far the rigid airship can be developed, and the war has shown us the use and abuse of such aircraft. As scouts for the navy they are invaluable, being able to hover over one spot for lengthy periods without wasting their fuel reserves, a manœuvre impossible to an aeroplane. It is, however, clearly recognised that the use of airships for raiding open towns is quite indefensible, and that as a means of invasion they are very unlikely to prove a serious menace. In peace time they might be used to convey mails and passengers, but their speed is not higher than that of an express train, and their liability to destruction in bad weather is a serious objection to these uses. In spite of Count Zeppelin's painstaking labours, in face of great difficulties, it does not seem that his rigid airships are ever likely to be serious rivals of the aeroplane, either for military or commercial purposes.

IT is interesting to learn that the Imperial Institute proposes to constitute a comprehensive bureau of mineral intelligence, with the object of supplying information as to all mineral deposits within the British Empire. For some years past the Imperial Institute has been doing a certain amount of such work, and it will be a decided advantage to have a mineral intelligence bureau available to the public. This subject