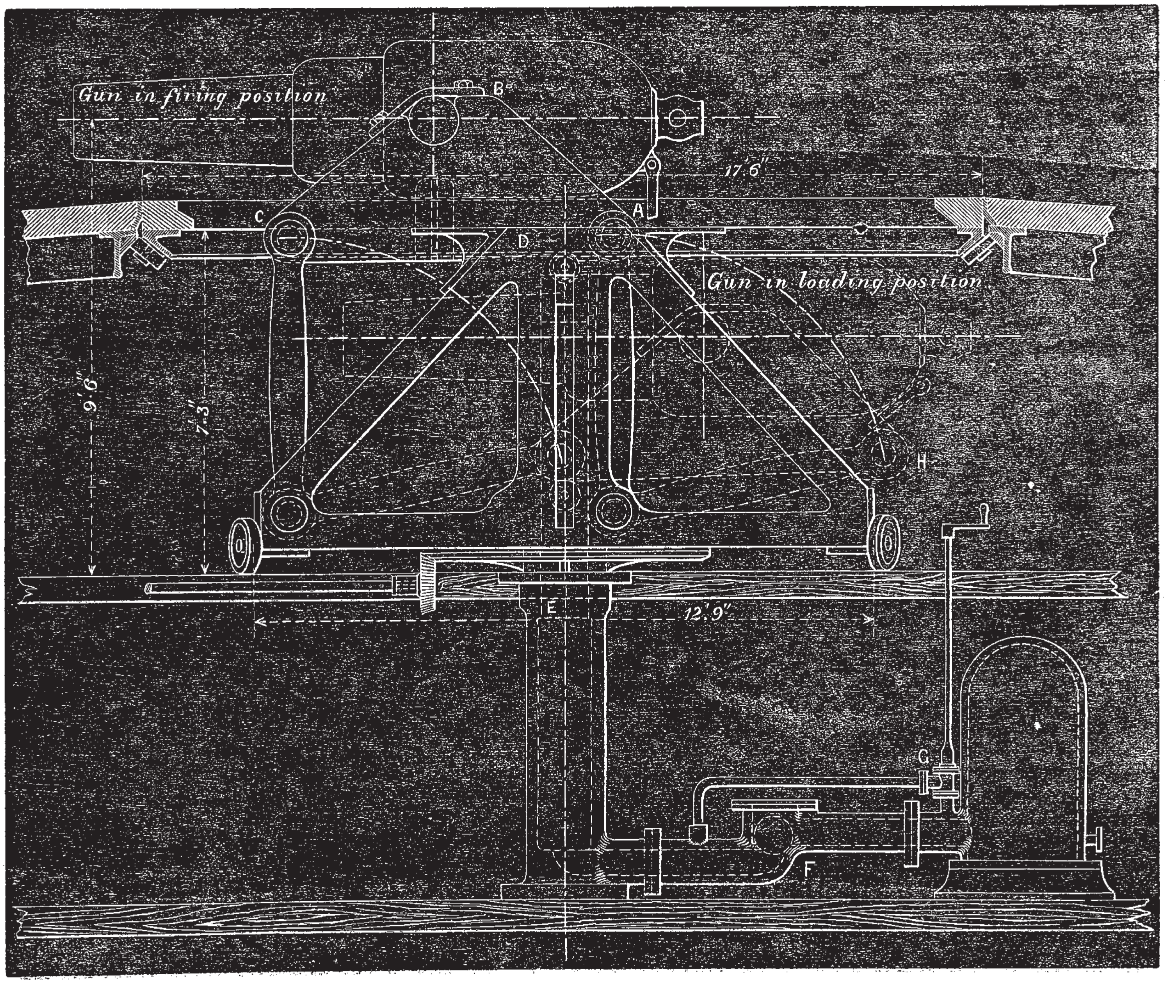
THE SCIENCE OF WAR

I.

CAPTAIN MONCRIEFF'S HYDRO-PNEUMATIC GUN-CARRIAGE FOR SEA SERVICE

SOME apology is needed for venturing to trouble the quiet of NATURE with an account of military engines. The desolation that war is now spreading over some of Nature's fairest scenes, and the waste caused thereby of her bounteous annual gifts, may account for these jottings, which have, perhaps, strangely found their way into her note-book; such topics have been suddenly and violently forced of late upon her attention.

But a further and more substantial reason for finding a place for a subject of this kind within NATURE'S domain is that the action of Nature's forces is in some ways best displayed in warlike engines. In them we use, examine, and experiment with force in sudden and violent action. To produce and also to control and direct the instantaneously created power of explosives has taxed the ingenuity, and also enlarged the knowledge of both the chemist and the mechanician. But for the necessities of war we should know little of Nature's forces in this aspect. The arts of peace only in a very limited form make use of explosive agents. The wonderful progress made of late years in military engines—a progress whose rapidity surpasses the advances of any mechanical inventions for other purposes—has called an amount of attention to those forces and agents which the modern artillerist employs, that has not failed to bring out many special facts in relation to them. Nature's territories are everywhere so rich that he who diligently ploughs any corner, however remote, seldom fails to be rewarded, not only by the crop which he seeks to cultivate, but also by some unsuspected fragments of truth which his plough-share has, as it were, accidentally turned up. For instance, some of the most remarkable examples of conservation of energy are to be found in the action and effects of the mighty projectiles of modern times.



The inventions of the gentleman whose name stands at the head of this paper, afford several important illustrations of the foregoing remarks. It is not more than two years since his Protected Barbette Gun-Carriage for land defence was tried with an instantaneous success that filled the public with astonishment—an exceedingly rare occurrence in inventions so entirely novel in their principles. Having previously existed only in the inventor's mind and in small models, when applied to a 7-ton gun (a monster unknown so recently as the Crimean war), it was found to work with perfect exactness and to realise all that had been promised for it. It may be well to recall briefly to the reader's mind what this carriage effected, and the means by which it acted, as the new carriage is designed to effect a somewhat similar object, though by a wholly different agency.

The purpose which the Protected Barbette Carriage accomplishes is the utilisation of the recoil. This force, which in modern heavy ordnance is a very considerable one, was previously known only as a destructive force. It strained racers and pivots almost beyond the endurance of iron, and shook the granite foundations on which they rested; and artillerists sought to coax it to waste itself as harmlessly as they could in friction. The Protected Barbette Gun-Carriage utilised this force by causing it to raise a counter-weight, while the gun descended below the parapet into safety and concealment from the enemy. This was effected by interposing between the gun and counter-weight a *moving* fulcrum. Any fixed fulcrum, such as a pivot, was found, no matter how strong, incapable of resisting the almost inconceivably rapid action of exploding gunpowder; it was torn from its position before it had time to move. But in the moving fulcrum there is nothing to be broken. The recoil of the gun rolls back the elevators, which raise the counter-weight, and this is retained in its position when the recoil is exhausted, and when released and allowed to fall restores the gun to the firing position again. It should be further observed that the gun commences to move in the direction of the recoil, gradually descending on a cycloidal curve, and thus the force of the recoil is not suddenly checked, but guided. This is one of the conditions essential to its success.*

The invention, which it is the design of this paper to discuss, effects a similar object for naval gun-carriages to that accomplished on land by the Protected Barbette Gun-Carriage. By it the gun is gradually lowered in its recoil below the surface of the deck of the vessel, and the force of the recoil is stored up to raise the gun at pleasure to its firing position above the deck. But the means by which it is accomplished are wholly different. There is no counter-weight and there is no moving fulcrum. It is manifest that at sea the fall and rise of a counter-weight could not be used. The direction of the force of gravitation is fixed and invariable, but the platform of a ship's deck is not always horizontal, and is often rapidly changing its inclination. In the Hydro-pneumatic Carriage, advantage is taken of the elasticity of air to store up and utilise the force of the recoil. A volume of air is compressed by the recoil of the gun, and being retained at pleasure in its compressed state, it is able to lift the gun to the position it occupied before the discharge; and as the moving fulcrum transferred the force of the recoil to the counter-weight without any check or jar, so in this naval carriage a like office is performed by water, which smoothly and effectually conveys the force of the recoil to compress the air in its reservoir. This is accomplished in a very simple manner, which can be easily understood by the accompanying diagram. The lines represent the gun and carriage in the firing position, the dotted lines in the loading position, showing the effect of the recoil. The gun is carried in a small triangular carriage (A, B, C), and this moves down through a quarter circle by the parallel motion of four strong bars, jointed on the carriage and on a platform on the lower deck of the vessel. In the firing position this part of the apparatus is supported by a plunger (D, E) or piston, and by the descent of the carriage this plunger is forced into a cylinder filled with water. This cylinder communicates with an air vessel or reservoir; consequently by the recoil a volume of water equal in bulk to the cubic content of the plunger is forced into the air reservoir; the volume of air is diminished by that amount and the pressure increased. The valve at F is self-acting in one direction only; it allows the water to flow into the air reservoir, but not to return. Consequently, when the recoil has exhausted its force in compressing the air, the gun remains in the loading position. When the valve G is turned, the water is driven from the reservoir by the compressed air, rushes into the cylinder, raises the plunger, and with it the gun and its carriage into the firing position. It should be observed that there is a circular portion of the upper deck, which, with the platform on the lower deck, to which the parallel bars are attached, traverses round on the plunger as a pivot, and so enables the gun to be pointed in any direction. In this rotating circular portion of the upper deck there is a rectangular opening which opens and closes by a pair of self-acting shutters with the rise and fall of the gun. A minute description of these minor arrangements is not here necessary.

One of the most remarkable features of this invention is the extraordinary power of adjusting the force employed to meet the recoil of the gun. By the descent of the plunger the air space is reduced by the cubic content of the plunger; and as the air space can be varied by admitting more or less water into the reservoir, so can the elastic force be varied to meet the recoil. For instance, did the air space in the reservoir equal the volume of the plunger, then the plunger could not possibly descend entirely into the cylinder, as that would compress the air to nothing. On the other hand, were the air space three or four times the volume of the plunger, then a small force of recoil would be sufficient to bring it completely down. The resisting force may thus be adjusted within almost any limits to meet the force of the recoil. It will be further observed that as in the Protected Barbette Carriage with counterweight, the recoil is met by a very slight resistance at the commencement, and is allowed to start in motion in its own direction. The first backward motion of the gun depresses the plunger very slightly, but as the recoil goes on it causes an increasingly rapid descent. For instance, the rollers must travel over two-thirds of the quadrant A H, to send the plunger half way down into the cylinder; the remaining one-third would send it down to the bottom. Thus the resistance to the recoil goes on increasing in a double progression, both from the increased pressure of the air as its volume is diminished, and also from the fact that the motion of the gun produces an increasing diminution of that volume.

Let us go through the process of adjusting the machine into working order. The reservoir and cylinder are both empty, the plunger is at its lowest descent, the gun lies down in the loading position. By a pump communicating with the reservoir, water is driven into the reservoir until the air space is reduced to one-half or one-third, as the case may be, of the volume of the plunger. This will raise but very slightly the plunger and its load. Now air must be pumped in till its pressure in the air space is sufficient to raise the plunger with the gun and its carriage into the firing position. The gun may then be brought down to the loading position.

This entire process need not be literally gone through in every case to adjust the machine. When once (if the expression may be borrowed) the "constants" of the carriage have been determined, *i.e.*, the amounts of air and water required in the reservoir, those quantities can be pumped in, keeping the valve G closed, and the gun remaining quiescent in the loading position. Water should be pumped in so as to leave a fixed air space, and then an amount of air, such that, with the added volume of the plunger, the pressure would still be sufficient to sustain the gun in the firing position. For a twenty-five ton gun the weight to be raised, including that of the plunger and the moveable part of the carriage, would be about thirty tons. Supposing the sectional area of the plunger to be two square feet, this would require a pressure of air of a little over 230lbs. on the square inch, or a little under sixteen atmospheres. When once adjusted, the carriage would remain in complete working order for days or weeks, in fact, until the water was allowed to run off.

While the main object and purpose to be accomplished

* While this article was going through the press, an attempt to make a gun descend an inclined plane by recoil and raise a weight, and so to form a protected Barbette carriage, was tried in the Royal Arsenal, and failed for this reason: The horizontal force of the recoil was not met in its own direction, but at an angle. The gun would not descend the inclined plane beyond a foot or two, and the violent concussion destroyed the elevating gear at the second shot.

by the hydro-pneumatic gun-carriage has been sketched, it is evident that all the applications of the principle of utilising the recoil as embodied in this engine have not been exhausted. The force of the recoil which must be exhausted in bringing the gun down to the loading position is very much greater than the force that would be required simply to raise the gun again to the firing position. The recoil takes place very rapidly, much more rapidly than it is desirable that the gun should rise again. If in the Protected Barbette Carriage it was allowed to return freely to its firing position, it would come up with an inconvenient or even a dangerous violence. The superfluous energy of the recoil stored up in the counter-weight must, therefore, be controlled and exhausted by friction bands. In the hydro-pneumatic carriage the return of the gun can be completely controlled by the valve or stopcock G, so as to bring it to the loading position as gently as desired, and the superfluous energy of the recoil will take the form of heat developed in the compressed air of the reservoir. But this superfluous energy may be seized and utilised. If a second and smaller plunger is attached to the cross head of the main plunger, which supports the gun and its carriage, with a cylinder and reservoir of its own, the power there accumulated may be used for any other purpose, as training the gun and carriage. In this case also, though the pressure produced and the heat generated in the main reservoir will not be so great as if there was no second plunger, still it alone will contain an ample store of force to bring the gun again into its firing position.

To discuss the military advantage of this invention, as a substitute on board ships of war for a turret weighing 300 tons of wrought iron, affording more complete protection to gun and gunners, and not weighing for a twenty-five ton gun more than sixteen tons altogether, would be travelling out of the realm of NATURE.

We have only endeavoured to show in this example with how great efficiency and docility Nature obeys those who understand how to direct her forces, and that all her work is not only efficient but instructive. If we can persuade her to undertake a new task she will teach us a new lesson. In the hydro-pneumatic gun-carriage a means supplies itself for measuring the exact amount of work done by the recoil. The compression of the air in the reservoir, and the heat generated in the process, will give accurate data for measuring the force exerted, and by this a step will be made towards measurements of the power of explosives with a precision hitherto unattainable.

Nature, like the great ancient fabulist, if she is compelled to be our slave, is resolved also to be our teacher.

NOTES

THERE is one part which neutrals may take in the Continental war. With no sympathy for those who have caused the war on either side, our sympathy is all the more due to those who innocently suffer from it on both sides. The following appeal, posted on the walls of every *mairie* in France, will touch other hearts than those of Frenchmen :—"*Appel à la France.*—Au nom de Dieu, au nom de la patrie, au nom de nos fils, de nos frères, de nos braves soldats tombés avec honneur sur le champ de bataille, et toujours héroïques quoique vaincus aujourd'hui, nous faisons un appel à tous les cœurs français. De grâce, donnez-nous de l'argent, du linge, des chemises, des couvertures, des vêtements, de flanelle, etc. Là-bas, sur nos frontières, l'élan des villes, les offrandes touchantes des villages ne suffisent déjà plus à nos chers blessés.—Les besoins sont immenses.—Le temps presse.—Donnez, oh! donnez vite! Envoyez les dons en nature et en argent au siége de la société à Paris, Palais de l'Industrie, porte No. IV." Here is a work in which all may unite—French, Germans, and neutrals, men of science, men of literature, men of business; and above all, our women. Nobly already have English, Irish, and Americans, surgeons, nurses, sisters of charity, come forward in the good work, but still it can only be as a drop in the ocean. To offer succour to the wounded and sufferers on both sides, to assuage as far as we can, the horrors of war, never exhibited on a more fearful scale than within the last few weeks, is now the duty of our more fortunate countrymen and countrywomen.

ANOTHER sacrifice of science to the war! The Congress of Alpine Geologists, the meeting of which we announced to take place on the 31st of this month, is adjourned to a more favourable time. It is probable also that the Congress of Anthropology and Pre-historic Archæology which it was proposed to hold at Bologna, and that of German naturalists to take place at Rostock, will not be held.

THE following sectional arrangements of the British Association are now announced :—A—MATHEMATICAL AND PHYSICAL SCIENCE (in the Crown Court, St. George's Hall) : President—J. Clerk Maxwell, F.R.S. L. and E. ; Secretaries—Prof. W. G. Adams ; W. K. Clifford ; Prof. G. C. Foster, F.R.S. ; Rev. W. Allen Whitworth. B—CHEMICAL SCIENCE (in the Royal Institution, Moore Street) : President—Prof. Henry E. Roscoe, PhD., F.R.S., F.C.S. ; Secretaries—Prof. A. Crum Brown, F.R.S.E., F.C.S. ; A. E. Fletcher, F.C.S. ; Dr. W. J. Russell, F.C.S. C—GEOLOGY (in the Concert Hall, Lord Nelson Street) : President—Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. ; Secretaries—W. Pengelly, F.R.S., F.G.S. ; Rev. H. H. Winwood, F.G.S. ; W. Boyd Dawkins, F.R.S., F.G.S. ; G. H. Morton, F.G.S. D—BIOLOGY (in the Reading Room and Lecture Room of the Free Public Library) : President—Prof. G. Rolleston, M.D., F.R.S., F.L.S. ; Vice-Presidents—John Evans, F.R.S., F.G.S., F.S.A. ; Prof. Michael Foster, M.D., F.L.S. ; Secretaries—Dr. T. S. Cobbold, F.R.S., F.L.S. ; Thos. J. Moore ; H.T. Stainton, F.R.S., F.L.S., F.G.S. ; Rev. H. B. Tristram, LL.D., F.R.S. E—GEOGRAPHY (in the Small Concert Room, St. George's Hall) : President—Sir Roderick I. Murchison, Bart., K.C.B., D.C.L., LL.D., F.R.S., F.G.S. ; Secretaries—H. W. Bates, Assist. Sec. R.G.S. ; Clements R. Markham, F.R.G.S. ; Albert J. Mott ; J. H. Thomas, F.R.G.S. F—ECONOMIC SCIENCE AND STATISTICS (in the Council Chamber, Town Hall) : President—Prof. Jevons ; Secretaries—E. Macrory ; J. Miles Moss. G—MECHANICAL SCIENCE (in the Civil Court, St. George's Hall) : President—Charles Vignoles, C.E., F.R.S., M.R.I.A., F.R.A.S. ; Secretaries—P. Le Neve Foster ; J. T. King.

THE Dutch Society of Sciences, of Haarlem, instituted last year, in addition to its ordinary prizes, two large gold medals, each of the value of 500 florins, one of which bears the name and effigy of Huyghens, the other of Boerhaave. These medals are to be awarded alternately, once in two years, to the *savant*, Dutch or foreigner, who shall have contributed the most, during the previous twenty years, to the progress of one particular branch of mathematical physics or of natural science. The Huyghens medal is to be devoted in 1874 to chemistry, in 1878 to astronomy, in 1882 to meteorology, in 1886 to mathematics, pure and applied. The Boerhaave medal is to be granted in 1872 to mineralogy and geology, in 1876 to botany, in 1882 to zoology, in 1884 to physiology, in 1888 to anthropology. The series will then recur. At their recent annual meeting the society made the first award of the Huyghens medal to M. Clausius for his discoveries in thermo-dynamics.

SIR FREDERICK POLLOCK, late Chief Baron, whose death is announced as having taken place on Tuesday last, in the 87th year of his age, was an amateur photographer of no mean ability, and had been President of the London Photographic Society ; he was an occasional contributor of articles on photography to the Philosophical Proceedings of the Royal Society.