This article was downloaded by: [University Of Maryland]
On: 14 October 2014, At: 14:16
Publisher: Routledge
Informa Ltd Registered in England and Wales Registered
Number: 1072954 Registered office: Mortimer House, 37-41
Mortimer Street, London W1T 3JH, UK

Royal United Services Institution. Journal

Publication details, including
instructions for authors and
subscription information:
[http://www.tandfonline.com/loi/
rusi19](http://www.tandfonline.com/loi/rusi19)

A System of Air Torpedoes: With Remarks upon the Late Attempts at Air Navigation for War Purposes

Frederic A. Gower Esq.
Published online: 11 Sep 2009.

To cite this article: Frederic A. Gower Esq. (1885) A System of Air
Torpedoes: With Remarks upon the Late Attempts at Air Navigation
for War Purposes, Royal United Services Institution. Journal,
29:131, 857-873, DOI: [10.1080/03071848509427123](https://doi.org/10.1080/03071848509427123)

To link to this article: [http://
dx.doi.org/10.1080/03071848509427123](http://dx.doi.org/10.1080/03071848509427123)

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy
of all the information (the "Content") contained in the

publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

Wednesday, May 20, 1885.

PROFESSOR SIR FREDERICK A. ABEL, C.B., F.R.S., in the Chair.

A SYSTEM OF AIR TORPEDOES: WITH REMARKS UPON THE LATE ATTEMPTS AT AIR NAVIGATION FOR WAR PURPOSES.

By FREDERIC A. GOWER, Esq.¹

The CHAIRMAN: It is scarcely necessary for me to introduce to you formally Mr. Gower, the well-known collaborateur with Professor Graham Bell in the successful development of the telephone—a gentleman who has, by his practical results and scientific attainments, gained for himself a reputation which will lead us not to consider lightly any statements which he will bring before us. The subject which he is to deal with this afternoon is comparatively a novel one, that is novel so far as a discussion of the subject goes; but we have during the last half century been from time to time reminded that it is very short-sighted to deal hastily with any suggestion which at first sight appears purely theoretical, or even purely visionary. We know in the case of the telephone, for example, that even eight or nine years ago it would have been considered almost visionary to believe that friends and business acquaintances would freely converse as they do now from distant parts of this metropolis on all subjects with the greatest ease. And, again, to turn to a matter that is more immediately cognate to the subject of to-day's discussion, fifteen years ago he would have been considered a visionary enthusiast who would have predicted that every Navy of any important Power would consider itself imperfect unless provided with the locomotive torpedo; and so, as we have seen the successful development of locomotive torpedoes under water, we may, it is possible, I might even go so far as to say it is not improbable, expect to see in the future the successful development of a system of aerial torpedoes. However, I will not venture to predict, I will only ask you to receive attentively the information and the views which Mr. Gower is good enough to place before us to-day, and to give them your careful consideration.

THE question to which I ask your attention to-day may be very easily stated. Can a sudden expansion be given to existing methods of attack in war; can armies, forts, and arsenals be seriously assailed from that quarter in which attack is not now expected—the air above them? My belief—from four years of study and observation—is in the affirmative, and as means to this end I propose simply to transfer to the upper levels the general plan of torpedo warfare, upon a larger scale, and with its effective range indefinitely extended.

The term "air torpedoes" naturally suggests itself for such a system, but is not quite descriptive, inasmuch as each supporting aërostat may be made the means of delivering several missiles with any desired interval between them, resembling rather the action of a

¹ Lost his life when crossing the Channel in a balloon from Cherbourg in July.—
ED.

battery, and I have, therefore, generally used the term "aërial batteries," for greater accuracy of definition. Such batteries, like marine torpedoes, fall under two heads: those directed through the air by conscious agents whom they carry, and those sent upon a favouring wind to deliver their fire by automatic means. Study and observation lead me to conclude that the latter class contains all the immediate importance of the scheme, and it is a system upon that general plan which I have to bring before you.

Its leading feature is, and has for some time past been, under due consideration by Her Majesty's military advisers, and I should, therefore, under ordinary circumstances, be precluded from bringing the subject in its present stage to your attention, and this more especially as I believe there is little or no doubt suggested as to the probability of the apparatus which I have devised accomplishing substantially its intended purpose. The point of general interest which does arise (and which chiefly leads me to bring the matter under discussion) is as to the probable effects of this mode of attack in war if carried into practical use. Upon this head there appears to be no information derived from actual experiments, and that for the simple reason that it is difficult to carry out a series of such experiments with due regard to the rights and comfort of the public in time of peace; while an important element in the system—the probable effect upon the *morale* of armies—is obviously one which cannot be settled in time of peace at all. There is, moreover, behind all this, the fact of a still-threatened outbreak of war seeming to make it my right, and perhaps also my duty, to raise the question as to what a resort to armed force by civilized Powers at the close of the nineteenth century may be made to mean.

In attempts at navigable balloons, there is little to add to facts with which you are already familiar, and which were admirably put forward by Lieut. B. Baden-Powell, in a paper read before you on Friday, June 1, 1883, Sir Charles Nugent being in the Chair.¹ Henri Giffard, inventor of the injector for steam-boilers, made an *aërostat* in Paris, in 1852, which carried a steam-engine working a screw at the rear of the car. He attained a slight forward motion in calm air, and could also deviate from the line of the wind in moderate breezes. But in ascending from the Hippodrome with a fresh breeze, he was carried at once to leeward. In 1872 M. Dupuy de Lôme obtained a slightly better result by substituting the muscular force of eight stout labourers for the steam-engine, but still nothing sufficient to encourage perseverance in the trials, as the principle of propulsion—that of the screw—seemed incapable of producing practically-important results unless applied upon the largest possible scale. In 1882–83 I carried on experiments near Paris with a steam balloon having a lifting power of two tons, in which a new and promising principle of motion was involved. The machine is shown in Fig. E now before you. It was, as you see, a cylindrical balloon 100 feet long by $33\frac{1}{2}$ in diameter, and contained not far from 2,500 cubic yards of hydrogen. The steam-boiler was

¹ See *Journal*, vol. xxvii, page 735 *et seq.*

heated by gas made in the car by forcing a current of air through a body of half-refined petroleum. The propelling wheel had flat blades, and was placed at the bow of the machine, where it rarefied the air in turning, and thus drew the *aërostat* after it by suction. This beautiful scientific idea was suggested by Auguste Debayeux, mechanician, of Paris, and I believe that it contains a possible germ of the future navigation of the air. It produced at the first trial a speed of 6 miles to the hour, as I noted it, in driving the steamer for distances of 100 yards, near the ground, against a breeze of about $2\frac{1}{2}$ miles to the hour. I was struck by the fact that in driving against this light breeze there was no sense of wind upon the face, as in steaming with a head wind at sea. The movement of air seemed still from the stern to the bow, as if the machine created its own fair wind as it went along, and I accounted for this upon the theory that the revolving wheel, having a speed of 400 turns to the minute, produced a rarefaction higher than that distant one which was then attracting the air from our vicinity and so causing the wind. It seemed, then, probable that perfecting the mechanical details might give a rate of 10 miles to the hour in calm air, but it was clear, as it had been with the earlier experiments, that a very large and very costly machine would be needed to obtain results of practical value. The trials were, therefore, discontinued in June, 1883, their chief result having been to establish the *possibility* of driving a large balloon fairly against the wind by steam-power, even at a low rate of speed. In October, 1883, the MM. Gaston and Albert Tissandier applied an electric battery to driving a large *aërostat*, forming a most beautiful combination of scientific research with practical knowledge. They retained, however, what seemed to me the error of placing the screw upon the car under the centre of the *aërostat*, and their experiments did not result in any notable increase of speed. Upon the 9th August, 1884, MM. Renard and Krebs, of the French Army, ascended from the Military Balloon School at Meudon, near Paris, with a machine (sketched in Fig. F before you) embodying all that was valuable in the previous essays. The *aërostat* had pointed ends like Giffard's and Dupuy de Lôme's, it was driven by an electric engine, and had a screw-wheel with blades almost flat placed at the bow of the machine, where it seemed to act by rarefaction as well as in some degree by direct propulsion, like a screw at the bow of a steam-ship. There was not—so far as I have been able to learn—any novel principle in this instance, but simply a utilization of known principles to the highest degree, with the possible exception that the projectors still held in great part to the idea that their machine must force its way against the resistance of the air, and would thus, as I think, quickly reach the limit in resisting strength of the necessarily-fragile material composing the *aërostat*. Whereas, upon the principle suggested by M. Debayeux, the pressure of the air being made the means of progress, I see no apparent reason why the speed attained should not reach a considerable rate by the use of a very large *aërostat* and consequent increase in power available. With the perfected and costly apparatus of MM. Renard and Krebs a speed of about

13 miles to the hour was attained in calm air, upon the third trial the machine obeying its helm and returning to its point of departure. But the weakness of the system appeared in the second experiment when the rising of what seemed only a moderate breeze carried the machine 2 miles to leeward, whence it had to be towed back across the country by a squad of infantry.

With full credit given to the skill and patience which have produced these latest results, I cannot yet see any probability of their practical use for attack in war. The degree of success thus far attained has been possible at all only by keeping the *aërostat* inflated in a specially constructed building, and seizing the occurrence of a nearly perfect calm. Wind must not arise during the trial, nor the machine touch ground except by aid of careful hands. Its endurance is at most but for an hour or two, and the least derangement of its delicate machinery would be likely to deliver it to the enemy. Its bulk is of necessity great (thus far a mean capacity of about 2,000 cubic yards), and the difficulty of inflating it in the field, alone, makes its use almost out of the question. The result to be gained from the advent of a new motive force at a weight of, say, not above 20 lbs. to the horse-power would be of the greatest interest, but pending such a discovery I venture the prediction that we shall see little success with any "directed" balloon in actual war. Sir Frederick Bramwell, F.R.S., in his President's address to the Institution of Civil Engineers, 13th January, 1885, has inclined to a more hopeful view; but I yet venture to believe that his impression of present achievement, if not his hopes, would be modified by practical acquaintance with any "directed" *aërostat* thus far devised. And even if control of the movement of these machines be attained, their great size will make them an easy mark for each other's riflemen, and their fate would be almost certain. When A can manœuvre with his *aërostat*, B can do the same. Inventive talent would soon provide a rifle-ball capable of exploding or igniting the gas in a balloon, and the two machines, upon coming within range, would simply destroy each other like soap-bubbles colliding.

But at the present time every practical advantage seems to lie in using the wind rather than seeking to oppose it—in working with a favouring breeze at long range rather than in waiting for a calm at close quarters. The Austrians attempted this in 1849, and the idea has since entered into various schemes for *aërial* torpedoes. All of these seem to have failed through want of some means of keeping themselves aloft for the required time, without rising to an excessive height when first set free, and thus encountering an upper cross-current or a calm, either being fatal to their advance (see Fig. A) and the former involving a chance of their return upon their senders (see Fig. B). A balloon, as is well known, upon leaving the earth rises at once to its point of equilibrium, and then almost instantly tends to fall. Its normal course is a sharp ascent to its limit of buoyancy, followed by a steady decline upon a path of greater or lesser angle to the earth, according to the velocity of the wind. The *aëronaut* corrects this latter tendency by a gradual discharge of ballast to com-

pensate for the gradual loss of ascending power from the escape or condensation of the gas. But the presence of an *aéronaut* in an *aërial-battery* system would mean quadrupling the size of each machine, with even more than a proportional increase in difficulty of use in the field, great enlarging of the mark offered to the enemy, and the probable sacrifice of a life for each *aërostat* employed, conditions which have easily sufficed, hitherto, to prevent the use of the ordinary large balloon for offensive purposes, while for small ones there has hitherto been the radical difficulty of their rising to an excessive height at starting, as already pointed out. Now, I have observed that an *aërostat* can neither rise nor fall without perceptible change in its volume. Gas must expand before the balloon can rise; gas must contract before the balloon can fall. When the gas expands, the *aërostat* changes its form along the line of least resistance, and I find this to mean an increase of its horizontal diameter. When the horizontal diameter increases, the vertical must, if the *aërostat* be spherical, diminish to the same degree, less the elasticity of the material of the envelope. When gas contracts, the contrary effect arises. In other words, the balloon shortens from top to bottom as it goes up, lengthens from top to bottom as it comes down. The extent to which the effect of this principle is measurable was first shown in an experimental voyage which I undertook, by the aid of M. Albert Tissandier, from Auteuil, in Paris, 27th August, 1884. We then found that in rising a distance of 1,800 metres the vertical diameter of the *aërostat* (which was of 600 metres capacity) decreased by no less than 33 centimetres; that is to say, roughly speaking, at a height of 1 mile the balloon was 1 foot shorter than when it left the earth, and in coming down the reverse took place, until, at the earth's surface, the balloon had regained the vertical diameter with which it started. This shortening of the *aërostat* took place notwithstanding a weight of ballast, car, and passengers exceeding 900 lbs., the constant tendency of which would seem to be towards elongating the balloon. Subsequent experiments seemed to show that the same law governs smaller *aërostats* in proportion to their size, and its effect is generally so immediate as to indicate any change of level a trifle sooner by the apparent lengthening or shortening of a suspended cord from the crown of the *aërostat* than from the motion of the needle of the barometer (Fig. D).

This principle once known, its employment is almost self-apparent. Substitute liquid for solid ballast, place this liquid in a tank having a valve at the bottom, inside, to which is attached the cord coming down from the crown of the *aërostat*; adjust the tension of this cord until it barely fails to open the valve against the weight of the liquid which normally keeps it closed, provide for taking up the slack of the cord so long as the *aërostat* is rising, and then weight the machine to rise to the height at which it is to travel, that is to say, to the level of the favouring wind. Upon reaching its equilibrium at that height it will tend to fall. This tendency, as we have said, involves the lengthening of the *aërostat*, this lengthening puts strain upon the cord, the cord opens the valve, ballast escapes, and the tendency to

E.

F.

VIM
27

fall is arrested almost as soon as it is begun. A rising tendency instantly follows, the aërostat shortens, the cord is relaxed, the valve closes, and at cost of a few ounces of water, position is maintained. The best illustration of this simple device in actual working is shown by the performance of machine No. 112A (the numbers indicate approximate capacity in cubic metres), from Auteuil, 17th October 1884. It was set free with 60 lbs. of water-ballast, when the air at the surface of the earth was nearly calm, but with a north current at a height of about 300 yards, shown by a pilot balloon. Only $6\frac{1}{2}$ lbs. of ascending power were allowed, but this sufficed to raise the machine to the level of the north current as intended. It then fell a few yards, righted itself by a visible discharge of water-ballast, set off southward with the wind at a high speed. Before leaving the view it traversed a light mist without any fall which powerful glasses could detect, and it ultimately fell at 63 miles from its point of departure, in precisely the direction which it took at starting, $2\frac{1}{2}$ hours from the time when it was set free. Only $\frac{1}{2}$ lb. of water remained in the tank, as noted by the finder, in accordance with the request attached to the machine.

To have kept this aërostat aloft for an equal time without automatic discharge of ballast would have involved giving it the whole, or nearly the whole, of the 60 lbs. in the form of excessive buoyancy at starting. It would then have shot up to a height of 2 miles or more, where a different wind or a calm would have led to nearly certain, making its subsequent direction a matter of conjecture.

This I believe to have been the invariable fate of all attempts at aerial torpedoes up to the present time, and it is this radical difficulty which we seem now to have overcome (see Fig. C). Nothing is new at its birth, and it would be folly to pretend that we have here an exception. But there is here a *principle* which seems novel in its discovery and application, and I cannot but believe that its careful study will finally enable us to send these terrible missiles with frequent success, since we are enabled to choose for them any level which the wind may serve. A similar mechanism may be applied to the discharge of gas if we desire; but I have not found especially of this. To keep up, rather than down, is the chief consideration.

The question now arises, how is such a system to be practically applied? I foresee a column composed of squadrons generally similar to light artillery, perhaps better horsed and escorted, and with only one gun. The caissons contain strong reservoirs, into which hydrogen has been compressed to the greatest degree practicable in the field apparatus, or the supply may be derived from larger sources up at headquarters, and sending forward portable reservoirs which can be thrown aside when emptied. Gas-making systems, already in use by several nations for military ballooning, show what is possible in this direction. It was brought out by a Paper read before you, 30th January of the present year, by Major G. Mackinlay, F

¹ See Journal, vol. xxix, page 93 *et seq.*

(General Sir Henry Lefroy being in the Chair), that 8-foot steel tubes charged with hydrogen for balloon service, at a pressure of 150 atmospheres, had held their contents without loss for months, and were so light as to float in water. At this rate eight of these 8-foot tubes would supply the hydrogen required for the inflation of a torpedo-balloon of the size to be usually employed. And I should say that the capacity of 25 to 30 such tubes could usefully be given to one such reservoir-caisson as I have mentioned. Other caissons or supply-wagons contain aërostats of varying size, closely packed, and of material strong enough to sustain their weights without netting, which I find quite practicable. A quantity of small pilot balloons is provided, bearing marks to assist the trained eye in judging the speed and depth of wind currents from them. And there is provision, of course, of the "regulating apparatus" of which I have spoken. With the minor details duly prepared, the aërial-battery service is then ready to take the field, in close connection with the established systems of military ballooning.

The enemy is advancing in force, and his main body is telephoned from the observers aloft to bear north-east, at a distance of 25 miles, and to cover about 3 square miles of ground. His formation may be compact or much extended. It will matter little, as the nature of the attack now in question does not require nice accuracy of aim. The wind may be toward the enemy, with a depth of half-a-mile in which our missiles can travel, and a counter-current above which will bring to us his reply (see Fig. B). Or there may be a calm at the surface, and a wind to favour our attack a half or quarter-mile above (see Fig. C). The variations are many, as my own experience has shown, but it may, I think, be laid down as a general law that there is very rarely a day when a wind-current to favour one army or the other for an hour or two cannot be found at some given level within practical use by such a system as we are now considering (see map of six voyages, Fig. G). Quick manœuvring for the weather-gage will often come into play, and the service will be planned with a view to that end. And it is obvious that our line may be of great length, with its firing-stations so disposed as to include the largest practicable arc with reference to the enemy, and then the trained eyes in the car aloft at headquarters may order the fire from whatever station they see to be in best position, noting, in the daytime, the effect of the missiles, and changing the range at their discretion. Supposing ourselves to be at station D, 5 miles east of headquarters, the field-telegraph clicks off the message "Prepare;" inflating-tubes are got ready, ballast-tanks filled, and a dozen or more of aërostats brought forward. They will be from 10 to 20 feet in diameter, and quite manageable upon the ground in ordinary weather. The hydrogen will be delivered from under pressure with great rapidity, and the last moment may be awaited for filling them. Around the neck of each is a collar, so fixed as to obtain the whole strength of the envelope at that point, and to this is suspended the ballast-tank, arranged as I have described, and the explosive charge.

As to this last I am hardly entitled to speak, and I venture to do so at all, only in the hope of eliciting important facts from the great authority whom I see before me. It is obvious that the system we are discussing will admit the use of the highest class of explosives, and very possibly of some which have not yet found employment in the field from the want of practicable means of discharging, without exploding them. Sir Frederick Abel will, perhaps, supply these wants of a short future with something even more destructive than gun-cotton, but for the present purpose the lightness and convenience of handling of this latter make it specially adapted. And for practical effect, both moral and physical, upon the enemy's forces, it would seem that we might well trust to a series of explosions of hundred-pound shells of gun-cotton, distributed over his position—though this is the question now before you.

Next comes the firing order, "Twelve, five hundred, forty-eight fours," that is to say, "Send twelve batteries, at a height of 500 yards, to deliver their fire at one-minute intervals from forty-eight upward, with four charges to each battery." Inflation completed, the parts of the battery are quickly put together, the whole twelve, in case of a well-drilled squad, being let go nearly at one time. The charges have no firing mechanism, but are to be exploded by the shock of their fall. Each is held in place by a timed fuse cut to burn forty-eight minutes and upwards, as ordered from the calculations of the observers at headquarters, the four charges upon each battery dividing the minute interval between them. Ballast enough will have been allowed to keep each *aërostat* up to its level until its charge has fallen, and its loss then is of no importance. The cost of each, with its four charges, will have been rather less than that of one shot from an 80-ton gun, and there is a fair chance that the machine itself may return into our hands upon the upper current to which it will rise when its weights have fallen. These are points of little value. The question is as to the effect which these forty-eight charges, or double or treble that number if we choose, may be expected to produce in falling. It is, I believe, an abandoned notion that the higher, and quickly-burning, explosives, such as gun-cotton and the various compounds based upon nitric acid, require close confinement for the development of their power. But that the condition as to confinement may affect the *direction* in which that power exerted seems to me to be beyond question. Now it has appeared from such very imperfect experiments as have come under my observation that the momentum of a falling charge acts as a confining power against the upward effect of the explosion produced by concussion, and thus tends to heighten its effect along the line of least resistance, the horizontal. I have by no means such data as would warrant my stating this as a fact, but I confess that I am unable upon any other theory to account for the effects of a series of experiments with nitroglycerine shells, carried out upon the Potomac River, near Washington, in March of this year. I have not the exact official report at hand, but I have seen several informal reports upon the matter, and have been favoured with a confirmatory statement by an eye-witness.

which seem altogether to leave little doubt upon the points with which we are now chiefly concerned. It appears that charges of gelatine, of from 9 to $11\frac{1}{2}$ lbs. each, were thrown from a mortar, at a range of about 1,000 yards, and alighted upon the flat face of an extensive ledge of rather friable rock, where they exploded by concussion. And the result of each shot is stated to have been an excavation of the rock to a central depth of 6 feet and a diameter of about 25, with great flight of splinters in every direction.

Subject to all due correction, I cannot avoid the impression that if such, or nearly such, results were produced by explosions of 9-lb. charges of a form of nitro-glycerine, the effect of gun-cotton charges of six to ten times this weight, and delivered at a quite equal, or greater, velocity, must be greater in proportion. If we make a large allowance for errors of direction, and consider that one-third of the missiles we have just seen prepared will take effect upon the enemy, we shall have a total of sixteen heavy explosions, in rapid succession, within his lines, and possibly without warning. He may, if the attack be made by day, foresee the missiles, and lessen the material effect by rapidly extending his formation. But the attack may almost equally well be made by night, and it would not infrequently happen that varying currents at different levels would give us means of concentrating the fire of several of our stations upon the enemy's position.

In considering the physical effect of such attack, I assume that when you have gained a position enabling you to shell the camp of the enemy's main body, you have beaten that enemy for the time being. And I cannot better express the aim of the aerial-torpedo system, as applied against armies, than in saying that it seeks to enable you to do in this way at 30 or 40 miles distance, that which you now effect at 3 or 4. It is upon this point, first of all, that your judgment is invited. Would an attack so delivered be likely to add very greatly to the destructive effects of war? Here arises, of course, a vital objection. Would the army attacked be as defenceless as what I have been saying seems to imply? Would not rifles, machine-guns, or light artillery bring down these missiles as soon as they arrived within range, and before they came above the enemy's position? The chances against this defence are almost hopeless. Experiments carried out in France have shown that an ordinary balloon is safe from riflemen at a height of 600 yards, and for these miniature aërostats which we are discussing, half that height would commonly be sufficient, even if, for using a specially favourable current, we wished to send them so low. The difficulty would lie in their unknown size, distance, and rate of speed, making it impossible for any range to be found for them. A weapon like the Hotchkiss revolving cannon, delivering, as I have seen it do, 6-lb. shells at the rate of sixty to the minute, with a range of 4 miles upon the earth, might, now and then, bring down one of the advancing torpedoes from a relatively low level, but it must not here be forgotten that the smoke from any of these quick-firing arms makes accuracy of aim almost impossible after the first two or three discharges. The vertical height of the

aërostats from the earth would, however, very rarely be less than 1,000 yards, and I venture to say, with the hope of challenging correction, that the advance of a small balloon at such a height is most unlikely to be stopped from the earth's surface by any weapon now employed.

Picket-balloons stationed in front of the enemy's lines, and containing riflemen, might in some degree protect him in the daytime, but a wind of moderate strength would keep them near the ground if they were captive, and carry them to the rear when it favoured the advance of the enemy, if they were free. A calm belt above the current in use by the enemy would offer a chance of picking off his missiles as they advanced, from a free balloon hovering in the calm region, a condition which I noted above Versailles, in October, 1884, and which formed the basis of Fig. A, before you. But the chance occurrence of such a state of things would obviously be a slender reliance for the safety of an army.

With this assumption in mind, we now come to what seems to be an all-important consideration—what effect upon the *morale* of an army may be expected? I shall, in this room, be quickly corrected if I am wrong in saying that nothing so tries the courage of the bravest soldier as a suspicion of the presence of mines. What, then, will be the effect, even upon well-seasoned troops, of a feeling that any chance shift of wind—taking place, it may be, upon an upper level without their knowledge—is likely to bring down upon them an avalanche of mines of this terrific kind? What will be the effect upon the formation of an army when a series of such explosions—often from invisible sources—has begun? Is it in the nature of man to stand against an attack which he has no *hope* of resisting? Men will face death—rush upon it—for duty or glory, but how will it be when there is nothing to rush upon, and glory has disappeared—when it comes to an end of personal achievement, almost an end of military distinction; merely a few groups of engineers, applying to war the methods they have learned to use against other barriers which they find in the path of civilization?

I have dwelt upon the case of opposing armies as being the primary feature of war now existing. You will note, in passing, that I do not claim your assent to the working of the mechanical details which I have shown. The question is simply that of the *effect* to be produced, granting that these devices do their work as intended. Let us look at one or two conditions of warfare which might be created by the advent of a system of air-torpedoes. We have assumed that its effective range may sometimes exceed 100 miles for a few hours at a time. Let us suppose the inevitable war to be rekindled for the possession of the Franco-German provinces; or that Prince Bismarck has disagreed with the French authorities in some distant Colony, and put in execution his threat to "open the gates of Metz and march forward." Will then a French commander, from along the summits of the Vosges, be able to enforce the evacuation of every German town for a distance of 50 or 60 miles from the frontier, explaining that such a course is forced upon him in the interests of humanity, as

it is not certain which particular town he will first be able to destroy? And if we go farther afield, may the establishment of certain known quantities of hydrogen and gun-cotton along the north-western frontier of India sensibly aid the efforts of diplomacy to restrain migratory tendencies in that direction? And it is worth remarking that a chain of fortified posts—small and inexpensive though they might be—equipped for warfare upon such a plan, would exercise a singular—and by a judicious management a permanent—influence upon the superstitious minds of tribes around them, whose aid would have to be sought by any intending invader.

Again, right to destroy an enemy's naval stations would hardly be denied to be among the usages of war, provided that non-combatants have notice to withdraw. What answer should be made, then, to a French or even a Belgian commander, who should announce his intention of attacking Sheerness and Chatham upon the first easterly wind, and warn all non-combatants to withdraw to at least 10 miles inland? He would obviously have planted his own firing-stations far enough inland to be out of reach of bombardment from the sea, and very large armies would be beside him. If under these circumstances it were thought best to remonstrate with him, he would hardly fail to point out that, while he regretted the necessity of his intended action, he saw ships being built or sheltered at these stations which menaced the safety of his own fleets at Flushing or Boulogne. He might, of course, with a northerly wind, be paid in his own coin; but when we consider the chances of the south wind arising first, and the comparative magnitude of the interests threatened in the two cases, does it appear that the merely forbidding a tunnel under the Channel has fully dealt with the possible situation? I need not dwell upon the reluctance with which I allude to a possibility so appalling, but we are dealing, gentlemen, with the methods of the sternest game ever invented, or practised among men, and it is not to an audience of soldiers that I look for any shrinking from whatever consequence the admitted laws of that game may now be found to imply!

Time and your patience would fail me in attempting to follow the possible use of these weapons into nearly every branch of military and naval operations. But there is one possibility which comes to my mind so vividly that it will not be denied. The most obvious defect in the whole system appears to be the difficulty of transportation, either of quantities of stored hydrogen, or the means for producing it; and there is one feature of the scheme from which this element of difficulty disappears. The surprising growth of the torpedo system in recent years directly suggests the air-torpedo cruiser, a steamer, let us say, of 1,000 tons, without great guns or armour, attaining a speed of 20 knots, and carrying great tanks of hydrogen under pressure, filled before leaving port, and fed, if need be, by auxiliary apparatus on board. In her lockers are a hundred aërostats of varying size, and her magazine is filled with the parcels of highly-compressed explosive of which we have spoken. Her especial mission is against the enemy's naval stations, coaling ports, and any other element of his naval power which she can reach, and her

method simply to place herself in a windward position and launch at the point of attack, a score or more of her batteries. She will, of course, have nothing to fear from "14-knot leviathans," and though lightly-armed cruisers may have speed equal to her own, she will sooner or later, elude them long enough to deliver one attack which will amply compensate for her own subsequent destruction, after the manner of torpedo-boats in general. Her cost will be much less than that of any ironclad, and there is no apparent reason against her being built, or bought, in scores by Powers having no naval importance at the present time.

In brief, I propose to you a warfare by gun-cotton and hydrogene to make the loss of an army a result of its meeting an opposing wing to destroy the security of fortified positions; and finally to show, upon the simplest principles of self-preservation, that nations *must* keep peace and great armies be disbanded! If it be urged that the plan is horrible, I admit that it is precisely as horrible as the existence of war between civilized Powers; that it takes unfair advantage, I repeat that it works in the open sky, while, if to hold the weather-gage of an enemy be an unfair advantage, how many naval statues must come down!

I have been asked by a very high authority, whether the use of a torpedoed may not—like that of explosive bullets—be forbidden by a league of the principal nations. And I answer, precisely as the use of gunpowder might have been forbidden by a league of the men-of-arms. There is no analogy, here, with the explosive bullet, a wanton and useless addition to the horrors of war. The aim in this case is to shorten, and thus alleviate, war, and a league against this plan for doing this will last no longer than the first sight of a victorious army marching upon a capital. I do not believe that London, Paris, Berlin, or Vienna will submit to preventible invasion because of a protocol signed by the previous Government, nor for any ethical objection to destroying the advancing enemy by whatever means science and the forces of nature may have combined to supply.

No, gentlemen! In asking your judgment upon the probable importance of the effects which I have indicated, I assume that this is the art of inflicting the greatest loss upon the enemy, within the shortest time. And if we can suddenly expand that loss to the verge of annihilation, we shall, I think, be in a fair way to *improve* it from off the face of the earth, when every other means to make an end of it has failed!

THE CHAIRMAN: It is now my pleasure to invite observations, and, in doing so, I would remind gentlemen that although Mr. Gower has put before us some interesting information with regard to balloon navigation, still that is not the prominent subject of the paper. What we wish to discuss is the question whether supposing Mr. Gower's plan for regulating the height of a balloon, so that it proceed in the direction in which it is originally launched, to succeed—what will be the value, from a military point of view, of the system of aerial torpedoes which he proposes?

SIR E. J. REED, M.P.: You have, Sir, rather discouraged the only remark intended to offer, viz., those upon the first part of the paper, because I radically differ from Mr. Gower as to the propositions he has laid down with regard to

propulsion of balloons. I think there were some very serious oversights in the exposition which he gave of the two modes of propulsion which he referred to, but you have ruled, Sir, that we cannot enter into that part of the subject. With regard to the main question, I can only say it seems to me, from my experience in connection with naval warfare, that there is a very immense amount of experimental ground to be traversed before the question, which alone you allow us to discuss, becomes an urgent one.

Dr. POLE: I have had no experience in regard to the principal subject of the paper, and although I have directed attention to the propulsion of balloons, as Sir Edward Reed has said, that is clearly excluded. I will, therefore, confine myself to one point. Mr. Gower mentioned a comparison made by Sir Frederick Bramwell, as President of the Institution of Civil Engineers (an Institute of which I have the honour of being honorary secretary), between the activity of the French and ourselves with regard to the propulsion of balloons. I think Mr. Gower has rather misunderstood Sir Frederick Bramwell in supposing that when he said the French would have had a balloon looking down into Khartoum, he had any idea of any warlike operation from the balloon. All he meant was that they would have had such a balloon as a means of observation; it certainly would have been a great improvement upon any kind of captive balloon. There is no doubt the French have already arrived at such a degree of practical skill in the propulsion of balloons as to make a guided balloon a really practicable thing. However much reluctance there may be in this country to believe it (and it is astonishing how obstinately the English disbelieve in the possibility of propelling balloons), it has been proved beyond all doubt that balloons can be propelled with considerable speed, and as means of observation these must certainly have an advantage over the old form.

Mr. BREARY: Will you allow me to put one question? All I wish to know is how these balloons are kept in shape? We see them in very ship-shape form now, but they must be kept out of shape if any degree of propulsion is obtained.

Major-General Sir ANDREW CLARKE, K.C.M.G.: I did not intend to take any part in this discussion. It is a question which I think we are hardly prepared to consider, and it has come upon us in its present form in this country rather as a surprise. It is entirely a new application of the subject, and we English people are always, as a rule, very careful in committing ourselves to a matter of this kind, which takes us into an unknown and uncertain field. I trust, therefore, that the lecturer, who has been good enough to bring this before the British public, will not think, because we are comparatively silent upon this question, that it is not a matter which has interested us, and I may give him the hope that although at this present moment there does not seem to me to be any immediate prospect of our having controllable balloons established, still in the year 1882 I was most anxious that our army going to operate in Egypt should be accompanied by captive balloons for the purposes of observation. My proposal—I had the balloon ready—was not accepted, though it had the support of His Royal Highness the Commander-in-Chief and the Secretary of State, so the balloons were not sent. I believe myself—I am now quite convinced from the experience we have had—that had these captive balloons been sent then over to Egypt we should have had a very considerably less loss of life than we unfortunately had, and in all probability should have done the work more thoroughly than it was done. I hold in my hand a letter that I received yesterday from Major Templar, who is now at Tambouk along the line from Suakim to Berber, in which he gives me some interesting facts with regard to the observation and the reconnaissance that he has been able to do along that line. He speaks of the assistance that it has been to the Army, and of the moral effect produced upon the Arabs—who believed it to be Mahomet's coffin suspended mid earth and heaven—by the appearance of the balloon, and who in truth, to this superstition it is pretty well attributed, have not again waited in force on subsequent advances. I have a still more interesting letter from Sir Charles Warren, who is at the other extreme point in South Africa, where he has been practising with his balloon, and we find, for the first time in the history of warfare, the General Officer commanding an expedition in the field himself reconnoitring from a balloon, because Sir Charles Warren has made several ascents. Indeed, considering that during the short space of two years captive balloons have been found of con-

siderable value to our armies operating in the field, I do not at all despair of being able to learn how to control a balloon for the purposes of observation. I not desire to commit myself in any shape to advocating that these controllable balloons should be used for the purpose of aggressive warfare; I shall be content we can get a balloon or an ærostat which, to a certain extent, will give us the means of observation in the field. With that I shall be perfectly satisfied, and at present moment my efforts in our School at Chatham are in that direction. I hope to be able to get within certain limits a balloon which will resist certain climatic influences and conditions, and which will, with comparative certainty, enable the General Officer to take observations, and with that, as far as I am concerned, I think we ought to be satisfied. As to the question of explosives, I am quite prepared to have certain experiments made in that direction, which I am arranging with Mr. Gower, but I myself am not very sanguine or, indeed, desirous of their success.

Sir E. J. REED: I am afraid I spoke rather too briefly about the balloon. What I wished to point out was this. Mr. Gower seems to treat the whole question of balloon propulsion as if balloons of a ship-like shape were not benefited by following current, whereas, he thinks, a blunt balloon would be so benefited. I think that is not at all the case. Any body moving in a perfect fluid would actually move ahead without resistance, because the work done upon the after part of the balloon by the following current is equal to that done by the fore part. The ship-shaped balloon profits by the following current just as much as the blunt balloon does. At any rate, I should like to make it quite clear, as far as my humble knowledge goes, that the theory which Mr. Gower supposes of getting a balloon to advance in the best manner by making a sort of proximate vacuum in front of it is quite in contravention of anything that I have ever seen, and certainly is in contravention of the now accepted doctrine of the motions of bodies in fluids, which recognizes in the fullest manner the propulsive forward effect of the closing in the following current on the after part of the balloon.

The CHAIRMAN: Before calling upon Mr. Gower to reply to the few observations which have been made with regard to the subject matter of his paper, I should like to be allowed to say, although it is hardly within the province of the paper, that I am glad I am to hear from the Inspector-General of Fortifications that our captive balloons appear so far to have been attended with a considerable measure of success. Personally I have been very much interested in their development. In the thirty years I have been engaged from time to time in connection with the development of balloons for military purposes, the elaboration of methods for the generation of gas in the field, and the construction and management of captive balloons, and it has been particularly pleasing to me, intimately connected as I have been with the Royal Engineer Establishment at Chatham, to observe how rapid has been the progress towards comparative perfection in this direction during the few years, thanks to the energy and talent of a few young Officers who have devoted their time to this subject, my friend Major Templar being among the most. The method now used for transporting the requisite hydrogen gas in the field really leaves little to be desired. No doubt we shall succeed in making lighter vessels, and no doubt the material of the balloon itself, greatly improved as it has been already, will be still further improved. We have still to learn how our balloon material is as permanent in different climates as it should be, but the exception of these few points I think we may congratulate ourselves on having already established, although on a small scale, a really efficient balloon equipment for purposes of observation. With regard to the immediate topic of Mr. Gower's paper, I need hardly say that it has interested me greatly. His method of trollying and maintaining the height of his balloon appears to me certainly ingenious and to present at any rate some germ of promise. How it is likely to work successfully, so far as to overcome the practical difficulties which I can foresee, which I would hardly venture to discuss now, remains to be seen. No doubt Mr. Gower will continue to devote his talents and his great perseverance to the completion of the mechanical arrangements by which he has so far succeeded in demonstrating the theoretical soundness of his views. As regards the effect of explosives thrown from or dropped from balloons, I would venture to express

opinion that unless balloon warfare could be carried out upon a very extensive scale it would be of comparatively little value. I can conceive it possible that a series of balloons may convey explosive charges under favourable conditions towards dock-yards, or towns, or military works, and that charges, allowed to fall from such balloons from a somewhat considerable height, may, if used in very large numbers, produce an amount of havoc which may perhaps exceed that attainable by bombardment, from a limited number of ships, or by a limited number of guns. But I confess I think the idea of the use of explosives in the manner proposed against an army in the field is not one which I should look upon as affording great promise of important results. I have had much personal experience with regard to the area of destructive effect of the modern explosives which are used in land or submarine mines, and can vouch for its being much more limited than many are inclined to believe. The recent experience of those heroes, Police-sergeants Cole and Cox, showed that comparatively large charges exploding within a very few feet of human beings certainly did not destroy them, and did not even permanently affect their health; and I myself may go so far as to say, from personal experience, that a man may be within 30 yards of the explosion of a ton of gun-cotton and not be very much the worse for it after a few weeks. Under those circumstances I venture to think unless charges carried by balloons can be used upon a very extensive scale, indeed a scale even much more extensive than Mr. Gower contemplates, they are not likely to have that effect of annihilation, as regards warfare, which our friend has emphatically predicted. With these few observations I will call upon Mr. Gower to favour us with any reply he has to make.

MR. GOWER: Mr. Chairman and gentlemen, I have been exceedingly interested in the valid and serious objections, as I recognize them to be, which have been offered, but which still, to my mind, seem to admit of the possibility of explanation. Sir Edward Reed believes that I have overlooked the difference in the modes of propulsion. I have not overlooked that difference, but in connection with my study of the work of Messieurs Renard and Krebs, who have gone very deeply into the question, and with various other observations as to what has been done in Germany and in Russia, and is just now being organized on an unprecedented scale by the Government in America, it has seemed to me that there was so vast a disproportion between the results obtained by any method of pushing a balloon through the air, and the force actually expended, that there must be something radically wrong in the idea. As to the difference in form between a lean balloon and a thick one, the analogy in my mind was that of the cartridge which you employed to transmit a message through a pneumatic tube, which you not only make as thick as convenient, but also furnish with a rim round the rear end, so that the air will act as much as possible over all its perpendicular surface. We thought, as a matter of fact, that it might not be a bad idea to surround this balloon with a rim at the back in order that the air coming from behind might have as much hold on the perpendicular part of the balloon as possible. If the air coming along the surface of a balloon exerts as much force upon a long, fine line as it does upon a perpendicular flat surface, then I should, if I were a designer of yachts, be inclined to commit suicide without further delay. Dr. Pole gives us indication of great hope, which I am much pleased to see, in the future of directed balloons, and I may perhaps confess to having usefully spent as much money and time in that direction as anyone I know of since Mr. Giffard's time. I cordially hope that they will be successful, but I believe that they are and always will be so absolutely defenceless against each other, so vulnerable at the extremest rifle range, or even to a revolver or anything that can fire a small explosive bullet, that I cannot see how two such balloons could possibly live within a mile of each other. That is really my greatest objection to the directed balloon in war. I shall only be too happy to join as I can in aiding propulsion through the air consistently with my own experiments. Mr. Breary has asked how these directed balloons are kept in shape. Balloons propelled by a screw, like that of Renard and Krebs, are not kept in shape as far as I know, but show a remarkable deflection when pushed against the wind, while the *aérostat* used by M. Debayeux and myself in the previous year (1883) forms a hollow in its front just behind the revolving wheel when under way. But other than that there is no deflection in the shape of that *aérostat* whatever; it does not change its

form for this reason, that it does not force itself against the wind; the fan-wh simply tends to clear away the air from its front; the air rushing after it brings balloon along, and there is no cause for the balloon to deflect or change its fo Theoretically it is true that you have driven away the air from your line of progr in all directions, and therefore caused its return from all directions as well; whereas the air coming from in front encounters the revolving wheel and is ag thrown off, the air coming from the rear impinges along the length of the aëros and pushes it ahead, creating in some degree the effect of going with the wi The idea is to create an artificial fair wind. I have driven this steamer at speed of $8\frac{1}{2}$ miles to the hour, and have found that there were no signs of wind the face, and you could fancy that you were in an almost perfect calm. Th certainly was no effect of facing the wind. Sir Andrew Clarke has given us rem that I approach with the greatest diffidence, because I cannot but feel that ther no one so peculiarly qualified (unless it may be some one in the French service know what has been done and what is likely to be done in certain lines of balloor as he is. His remarks have reminded me that we had the honour of a in 1882 at the establishment at Ville-Neuve-St. Georges from Major (who then Captain) Lee, and had the great pleasure of hearing his observations the prediction he was kind enough to make, and he then told us, as nearly remember, substantially what we have heard in more extended form from Andrew Clarke to-day, that it was hoped that a directed balloon would be of v for observation, but that it was not felt on this side the Channel that it had great immediate value for offensive operations. That agrees, I must say, with own view at the present time, provided, of course, that each party to a war posse them. If one side alone be allowed to use them, the results are too obvious to description. The other party would be simply annihilated, or put to flight, r the first calm day. I believe that there is interest, as Sir Andrew Clarke has ki told us, in this country in the manufacture of directed balloons, but as comp with the interest being felt and the money expended in other countries, I fe simply my duty to inform you that that interest is invisible. So far as I can le there is no war balloon now being prepared in this country which might meet French one in the event of an outbreak of war. The German Government making a series of experiments of very great importance, and they have re results practically equal to those of Renard and Krebs. There is one enthusia France who seeks to drive a balloon by successive explosions—by successive re from the discharge of a cannon, and by that curious means he has succeeded getting (at infinite danger) a certain amount of propulsion—two or three mile hour in speed through calm air. It seems to me, as an investigator in these mat that a directed balloon would have been of the very greatest value in the Sou and when Sir Frederick Bramwell (speaking from his almost unequalled positio a scientific observer) said, "I strongly suspect that if our lively neighbours ins of ourselves had been invading the Soudan, they would long before this have h 'dirigible' balloon looking down into Khartoum," I made the obvious inference they would have provided that aërostat with one of the admirable weapons sup by Mr. Gardner or Mr. Nordenfelt (even if they could not reach the weight of used by Hotchkiss); for I should not have supposed it possible to avoid opportunity of throwing over ballast to such tremendous advantage. That however, I ought to state, in passing, in a balloon carrying passengers, is open t serious difficulty that on throwing over a weight of 100 lbs. your balloon rises such startling rapidity that you are almost sure to be asphyxiated, unless you your valves well in hand. I am specially pleased to hear from Sir Andrew Cla and I know the whole fraternity of investigators in aërostation will rejoice wit—that a General Officer has braved those awful terrors which I assure you ar much more than a voyage in an average tramcar if the service be properly orga and that he has made a practical ascent for practical purposes. Sir Andrew C does not despair of having a controllable balloon, and in that I agree with him fully. When you have attained a speed of 13 miles an hour, of course you already a controllable balloon. Still, it must be a very gentle breeze which do exceed that speed, in fact you would scarcely at that rate say the wind blew a and naturally, if one is exposed to be driven over to the enemy by the first

breze which arises, the danger of the system is almost prohibitive. I ought, perhaps, to say that the particulars of the experiment being undertaken by the American Government which I referred to have only reached us this morning. The balloon is to have a lifting power of 7 tons, and it is undertaken by the Ordnance Department that all questions connected with controlling the movements of a balloon shall be thoroughly thrashed out. I will only add this, that the larger you make the balloon the more mark you will offer to attack by some system, or in the case of an army, by such system as I have ventured to point out. I am also very glad to hear that the effects to be produced by dropping a charge as distinguished from detonating a charge on the surface of the earth, are going to be thrashed out as well; but I am struck by the fact that there seems to be no convenient place in or near existing stations in which one such experiment can be tried. If the effect is to be local, I really do not see what interferes with our carrying out such an experiment at or near Chatham, Aldershot, or some other place. If the effect is to be only local, I suppose a piece of ground 100 yards square would be considerable for such a purpose, but for the moment the difficulty appears to be that you cannot find any place wild enough and remote enough to be sure of escaping a coroner's jury and a charge of manslaughter in producing such explosions. I will scarcely venture to reply to what has been said about the effect of explosions by so great an authority as Sir Frederick Abel, but I may perhaps point out that the scale of operation which I propose has evidently not been grasped in your minds. The expense of these aërostats would in almost every case be less than that of one shot from an 80-ton gun. I should never think of employing so few as 100 for an ordinary attack, and for such an attack as I have ventured to indicate, made from a distance of 100 miles or less, upon a fixed point like a large naval station, I should say the enemy would be wanting in judgment if he started with less than 1,000 aërostats. If he launched these on a steady easterly wind, with their detaching charges cut to different lengths, I think it is in accordance with the most obvious doctrine of chances that he will destroy that naval station, while if he does not do it the first week, he will do it the second. Then, in making such an attack as that, I should by no means suppose that he would commit the error of confining himself to mere explosives. It is not his object to make a noise; it is his object to start a series of practically inextinguishable conflagrations, and I think science in our days is fully equal to providing the mechanism, provided the means thus prepared can be dropped in anything like the positions expected. I am greatly obliged to Sir Frederick Abel for the encouragement he has given, and I can assure him that I shall continue to work out the system, as he has so kindly suggested. One great object which I had to-day was to let it be known to the highest authorities (in the way of military judgment) that such a system exists, and we shall certainly hope to hear in some way of the matured judgment which may be passed by gentlemen who have, as Sir Frederick Abel has indicated, not felt able to go into the details of the matter to-day. I am greatly obliged to you, gentlemen, for the patience with which you have listened to me.

The CHAIRMAN: I am sure I shall do what you desire if I express your hearty thanks to Mr. Gower. He has given us a vast amount of very interesting information, and has set us thinking on a variety of subjects. We thank him very much for his lecture.