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Ebening Meeting.

Monday, April 20th, 1868.

MAJOR-GENERAL J. T. BOILEAU, R.E., F.R.S., in the Chair.

NAMES of MEMBERS who joined the Institution between the 30th March and the 20th April, 1868.

LIFE.

Saunders, A. W. O., Captain, 21st R.N.B. Fusiliers. 9/.
Logan, Alfred, Lieut. Roy. Art. 9/.

ANNUAL.

Weguelin, J. C. R., Capt. 2nd Royal Surrey Mil. 1/.	Varlo, Henry, Capt. h.-p. R.M.L.I.
Conybeare, Frederick, Lt.-Col. R.A. 1/.	Burgess, C. J., Capt. late Adj. 9th Adm. Batt. Lancashire R.V. 1/.
Garforth, E. St. John, Comr. R.N. 1/.	Adams, Thos., Capt. late 39th Regt. 1/.
Stafford, P. P. Leslie, Major M.S. Corps.	White, H. G., Capt. 1st Royals. 1/.
Addington, Hon. C. J., Major 38th Regt. 1/.	

MUZZLE-PIVOTING GUN-CARRIAGE; LEVER, FULCRUM, AND INCLINE-PLANE PRINCIPLE.

By Captain T. B. HEATHORN, h.-p. R.A.

THE subject which I have the honour of again bringing before you, is one that I resume from the discussion, after Colonel Shaw's able and interesting lecture on his muzzle-pivoting gun-carriage, which took place here on the 5th June, 1865.

It may be remembered that I then first introduced to this Institution the lever, fulcrum, and incline-plane principle for muzzle-pivoting gun-carriages, producing drawings, and giving a short statement of my construction, which the Committee were kind enough to publish in No. 37, Vol. IX of the Society's Journal.

Although in those diagrams a counterpoise was shown in order to assist in lifting the weight of the gun, in my later constructions I have dispensed with it; not abandoned it as useless, by any means, for I still consider a counterpoise as a useful and effective adjunct for many circumstances, but I purposely omitted for the following reasons:—

1stly. Because sufficient was accomplished without it.

2ndly. Because, if required, it could always be added.

3rdly. Because it cost more.

4thly. Because the Ordnance Select Committee, who at that time I fancied were favourable to my invention, did not like the counterpoise as increasing the weight of the carriage, without commensurate advantage.

It is pretty generally felt here and abroad, that muzzle-pivoting gun-carriages will be used in the future to work guns through minimum embrasures, the advantages of which I will endeavour to set before you as follows:—

1st. Increased protection to guns and gunners; and as guns are expensive, and men scarce, both may be considered worth protecting. In a direct ratio to the size and power of a gun is the length of time between its discharges. Its powerful blows, though hard, are slow; and to the gunners behind a large embrasure, the annoyance from the enemy's riflemen would be disastrous.

2nd. A gun need not project so far through a small embrasure as through a large one to clear the port of back flash; it is consequently less likely to be struck by an enemy's shot.

3rd. A gun standing clearer back from its shield has room for a higher angle of traverse.

4th. The sill of an embrasure will be about $1\frac{1}{2}$ feet higher than that of an ordinary port on the same "terre-plein," or deck—a great naval consideration.

5th. In every position of elevation, a muzzle-pivoting gun and carriage are considerably protected, being below the sill of the embrasure.

6th. Whatever angle of elevation or depression the gun may be at, the muzzle remaining in the same position in space, greatly facilitates the serving of muzzle-loading ordnance, and consequently simplifies the construction and arrangement of such necessary mechanical contrivances as are used to deliver charge and projectile to the hands of the loader.

7th and lastly. A small embrasure gives a stronger shield.

For ordinary parapet and broadside purposes, a minimum embrasure does not so much interfere with pointing as may be at first supposed, although a small aperture necessarily gives a small field of observation, but the area is not so much lessened when the muzzle-pivoted gun is at either a high angle of elevation or depression, as in an ordinary port with a piece of ordnance mounted upon an ordinary trunnion pivoting gun-carriage. There, in elevation, the bulk of the gun crosses the field of sight in the embrasure, and prevents the captain of the piece from laying it on the desired object.

A series of careful experiments in this matter would bring forth curious and interesting information, and would be as novel as inexpensive.

The only one disadvantage, therefore, of using small embrasures, is the necessary adoption of muzzle-pivoting gun-carriages; inconvenient, I will allow, in having to lift so much more weight to move the gun through its vertical arc, but more than counter-balanced by the solid advantages of the strength and protection afforded by the minimum port.

Muzzle-pivoting gun-carriages, or rather gun-carriages so constructed as to pivot the piece at any required or pre-determined optional point in its lateral axis, may be classed under the three following heads:—

Fig. 1.

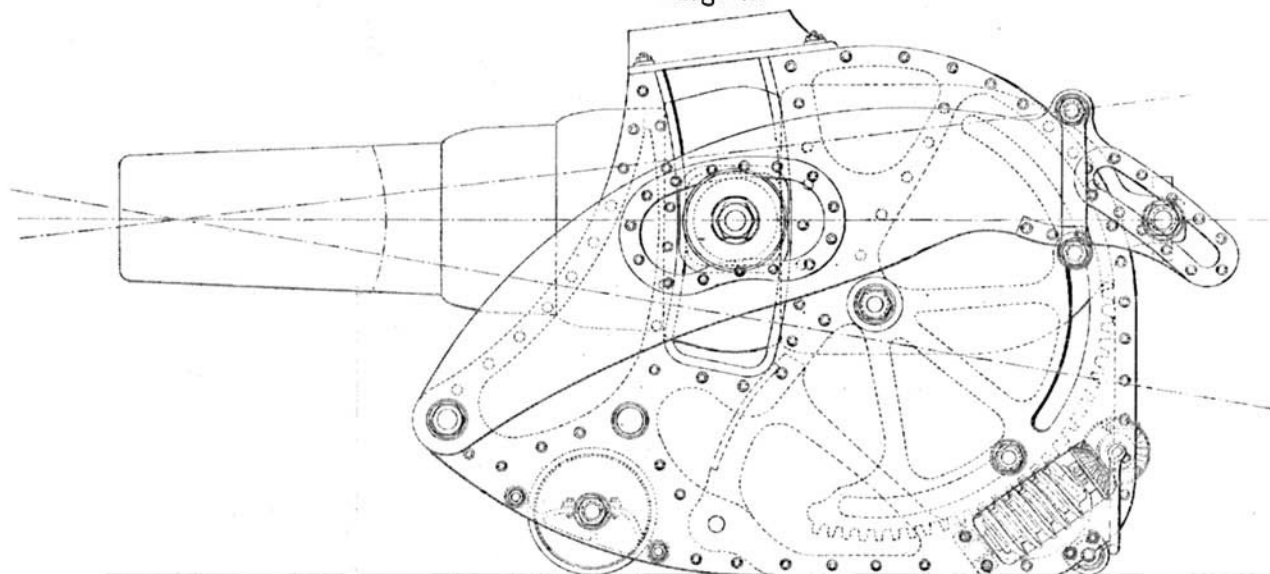


Fig. 3.

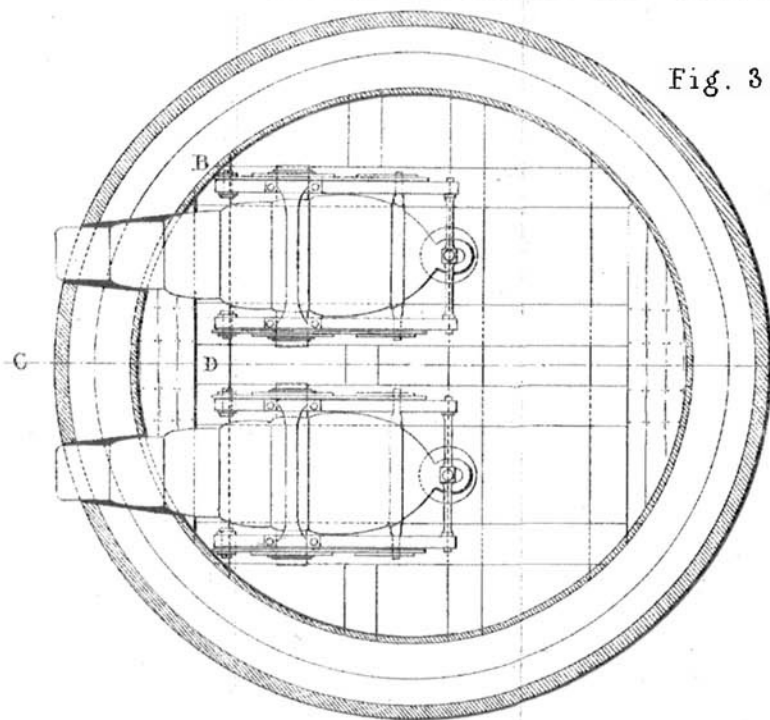
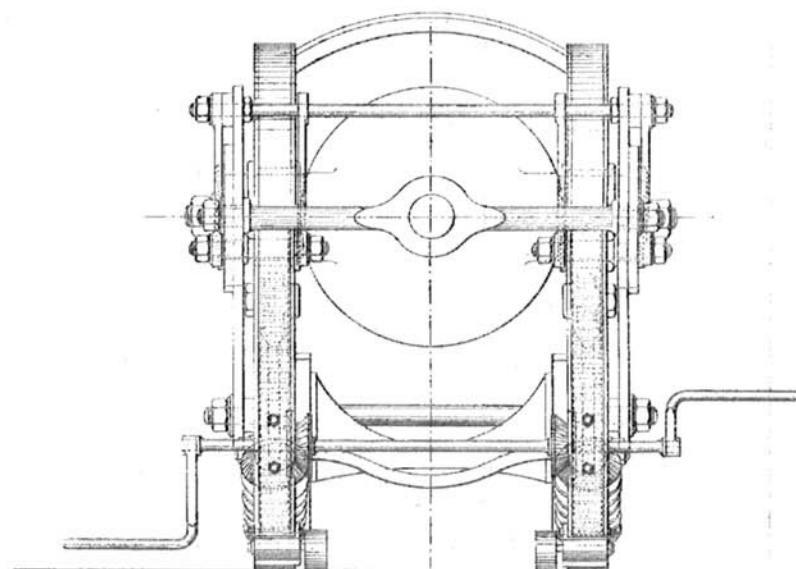


Fig. 2.



Those that use an absolute support with the gun, to cause it to pivot on a point.	Mr. Mallet's first. Captain Blakeley's. Captain Scott's. Colonel Shaw's. Gruson's.
Those whose pivot is imaginary in space.	Lient.-Col. Inglis's. The present Arsenal carriage. The Austrian carriage.
Those that use an imaginary pivot, but whose pivoting gear is wholly free from, and independent of, the power applied for motion.	Mr. Mallet's last. My own.

Upon the last-mentioned construction I will continue.

Early in 1865 I was impressed by the fact that the facilities for working heavy guns did not keep pace either with their size, or with the anticipation of the results to be achieved by them. Proper schemes for working appliances were undetermined, and it appeared to me to be such a new field of professional interest that I resolved to study the subject—with no particular benefit to myself, as it has turned out, but with a good deal of interest at the time, and ambition for results.

Amongst other things, I constructed the carriage before you, on the following resolutions:—

To use a lever, fulcrum, and incline-plane principle, to lift the weight of my gun, and also create a pivoting motion on an optional point.

To take the shock of recoil always at a right angle with the force of the recoil, the strongest part of the gun meeting the strongest part of the carriage.

As much as possible to avoid cog-wheel motion.

To make the muzzle-pivoting gear wholly independent of the application of power, so that derangement of the one might not interfere with the action of the other.

So to construct my carriage that for constant discharges at high angles, it could serve as a good mortar bed. This is done by scotching up the trunnions in the slot of the carriage readily and efficiently with a number of handspikes, balks of timber, or simply adjusted "quoins" made for the purpose, and, if possible, to make my carriage serve both purposes of muzzle- and trunnion-pivoting, the latter in case of derangement to the muzzle-pivoting gearing.

In March, 1866, I forwarded a model illustrating the principle of my invention to the War Office; but I am sorry to say that then, as now, in a general sort of way it was rejected and disapproved of, as inapplicable to the service.

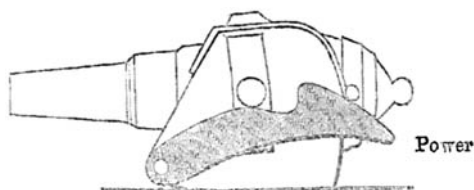
Soon afterwards Mr. Wells, an engineer, joined me in the matter, and together we took out a patent for the principle and construction of what is here before you (see Plate viii, figs. 1 and 2), and may be thus described.

Two ordinary gun-carriage checks sufficiently high to hold the gun-

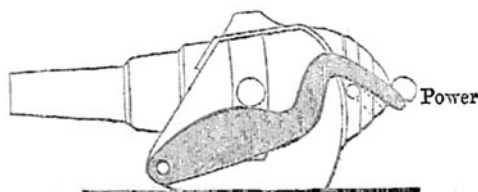
trunnions in every position of elevation and depression, bound strongly above by a massive cap-square, and equally firmly together at the base, embrace between them the gun they support. These cheeks are made of iron frames plated, or of wood covered with steel or iron plates, through bolted.

The gun-trunnions are caused to rise and fall in slots in the gun-carriage by levers fixed on either side, having for their fulcrum a common bolt. These levers may be placed either inside or outside the carriage cheeks; this was specified on my first introduction of this subject. In all these drawings I have placed them outside preferentially, because I consider their extra liability to injury in that position over-balanced by the greater facility of getting to them, in case of accident or other derangement. Moreover, the shoulders of the trunnions coming in closer contact with the slots in the carriage, take the shock of recoil better, do away with leverage, and give greater stability. But beyond this, there is no reason why, still using my system of levers and cams, the whole machine should not be boxed up, giving a perfectly flat side with no projections or working parts exposed in any way. The slots in the gun-carriage are the arcs of circles with the centre of the muzzle of the gun (or the required pivot) as centre; and the distance of same to centre of trunnion as centre radius. In each of these levers are two cams or slots—slots being preferable to cams merely because they strengthen construction, and tend to provide against disturbance by vibration; one pair of these cams or slots, act upon the trunnions causing them on the application of power to rise and fall as required; the other pair acting on a cross bar, adjust the proportional motion of the breech of the gun in excess of the trunnions, and produce muzzle-pivoting.

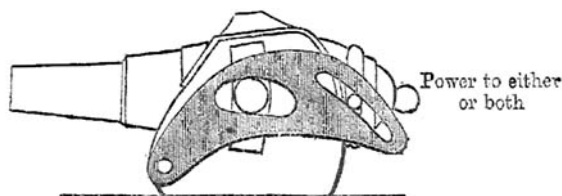
This is the principle of the pivoting gearing, and is always independent of the applied power, which may be from above to lift, from below to raise, by hydraulic ram, screw, pulley, steam power, or any other mechanical motion.



Form of lever necessary, when power is applied to levers.



Form of lever necessary, when power is applied to gun.



Form with slots, adaptable to both cases.

That the round surface of the trunnion, which at the time of the recoil strikes the slot in the gun-carriage at right angles to the force, may not cause a dent, but distribute its blow over a large surface, brass blocks to fit the slots are provided, in which the trunnions ride.

For naval carriages, I also propose to make use of the top of the cap-square, as a place to fix a strong eye or ring, to lash the gun-carriage steady to the upper deck in a sea way.

Further details of construction would here be out of place and uninteresting, I will therefore go no farther into them beyond stating, that the cams or slots in the levers are related to each other in such a way that the curve of the trunnion slot is always as nearly as possible at right angles to the vertical diameter of the trunnion, and the rear slot at as high an angle with the vertical diameter of the cross bar as circumstances will permit.

Although the plans I have here may convince you that this principle of muzzle-pivoting is applicable in many ways, I have still others showing various dispositions, of levers and application of powers.

Early in 1866, I had the good fortune to be introduced to Admiral Halsted; he liked my invention, thought it applicable to the service, and induced me by his energetic example to persevere. Through his kindness and estimation of my system, I was enabled to show it in his "Model Turret Fleet of the Future," exhibited in the "Exposition Universelle," at Paris, last year. This was a great opportunity. International public opinion is a grand and fair criticism. I jumped at the chance of obtaining it.

Numerous artilleryists of various nationalities, naval and military, were good enough to inspect my models, and by their favourable report recompensed me for my trouble. They gave me full credit for the originality of the idea, and the simplicity of construction; this credit I intend to hold on to as long as possible, and to it I think the fact of my introducing my plans to this Institution as early as June, 1865, entitles me.

Admiral Halsted's models will be exhibited at the School of Naval Architecture in the Kensington Museum very shortly,* and I feel quite absolved for the liberty I take in asking you to go and see my system there, by the pleasure I suggest to you, and which you will certainly receive, in inspecting his turret ships. In his broadside armament, all

* These models are now to be seen at South Kensington.—ED.

the guns have a lateral traverse of 90° , $45''$ each way, which is only obtained by muzzle-pivoting.

In the spring of 1867 Mr. Wells and I were ordered by the Admiralty to furnish plans for a carriage for experimental purposes. It, however, was never constructed, and I was not treated well, for later I was informed that a somewhat similar plan was in the course of construction in the Arsenal for experimental purposes, and that no further steps regarding my carriage could be taken till the results of that trial were known.

"The Engineer" of this day, exhibits drawings of, and describes the latest carriage made in the Arsenal on the muzzle-pivoting, or rather approximate, muzzle-pivoting principle. My lever and fulcrum principle is adopted, and also the position of my fulcrum bolt. Muzzle-pivoting, however, is sacrificed for the always desirable object, of using lower power, the framers of the carriage contenting themselves with an approximation to it, and they are content to get a very limited vertical arc by dropping the muzzle, as they lift the body of the gun through space. But this is not a principle capable of extended development, for if any attempt is made to increase the vertical arc to what will be absolutely necessary, and give the gun a few more degrees of elevation and depression, the proportionally increasing passage of the guns "wabbling," muzzle will immediately demand a large embrasure. Both advantages of trunnion and muzzle-pivoting carriages are thus missed without participation in the advantages of either: and preferentially receiving the shock of recoil on the fulcrum-bolt and cogs, instead of allowing the trunnions to communicate it immediately to the body of the carriage, cannot be right. I very much object to, and disapprove of this construction as a very retrograde march, and a bad copy of my own.

I rather think that my carriage suffered from the following circumstances: viz., that I was instructed that all the running in and out gear, compressors, &c., in fact all accessories beyond the muzzle-pivoting motion were to be carried out by Captain Scott, R.N., consequently I furnished no detail for these matters; I was told to arrange for 7° depression and 10° elevation, and did so. Strange to say, on enquiry I ascertained, that the trial of my carriage had been objected to, chiefly on the grounds that it had no compressors, no running in and out gear, no buffers for recoil, and only went through a vertical arc of 17° . This was a very unfortunate circumstance for me, and I mention it because it has materially retarded the development of my plans and thrown me in the background, inasmuch as my statement that the English Admiralty were going to construct and experiment, prevented others from moving further in the matter until results were arrived at, and I have just received, curiously enough, a letter from Paris, wanting to know when the promised experiment was coming off, as much was pending on its success.

As you will not fail to notice, I commit myself to no particular system of running in and out gear, nor of compressor nor any other adjunct, buffers included, but I shall be happy to furnish muzzle-pivoting carriages to all who want them on this system, with simple

and effective gearing for compression, handy running in and out gearing, and buffers *ad libitum*.

This little model, my last construction, made for the French Exhibition, very well illustrates my plans. Since its return from France it has been deposited in this Institution. It has had a very great deal of handling, but has never been hurt by work. Its principle is exactly the same as shown in diagram No. 7.

Description of Diagrams.

No. 1 represents a 12-ton gun, muzzle-pivoted, side and end elevation with a vertical arc of 15° , viz., 10 elevation and 5 depression, forwarded to the Ordnance Select Committee early in 1866, it is worked by two vertical fixed screws assimilated in their action by worm-wheels on a common spindle acting on cog-wheels at the base of each. These screws cause the cross bar through the cascade and the rear slots in the levers to rise and fall as desired.

No. 2 represents the same gun, with the same levers, going through the same passage as No. 1, but with a different application of power; this was forwarded along with No. 1.

A powerful worm-wheel on either side works into a toothed sector, with A as centre; at that end which gives motion to the cross-bar and causes it to rise, an eccentric is provided, to allow for the action of the two constricting radii, C A and A B. Here the cross-bar does not go through the cascade, but underneath it, to leave it free for Mr. Whitworth's rear vent, of which I think a great deal, and which will be adopted, in all probability, some day abroad, if not at home.

No. 3 and No. 3a (see Plate viii, figs. 1 and 2) show side and rear elevations of the carriage, designed for the Admiralty at their request about this time last year, by myself and Mr. Wells, for a 12-ton gun, Government pattern. The cheeks are strong iron frames, iron-plated on either side. It is on the toothed-sector and worm-wheel elevating principle, the same as No. 2, but the eccentric is simplified by parallel motion and the levers connected together by a cross-bar.

Its vertical passage is 7° depression and 10° elevation, and it is also applicable for using Whitworth's rear vent.

It is calculated that four men will elevate it at the rate of 15° a minute.

Although the handles for working it appear low, they are not so in reality, for when we come to consider the thickness of the slide for broadside guns, or corresponding baulks in turret arming, it will be found that there is plenty of room; and the handles are in comfortable working position.

In both cogged-sectors, five teeth bite the worm-wheel at the same time, and thus the evils of cog-wheel motion are modified.

The bolt head near the worm-wheel shows a through fastening, serving both to bind the cheeks of the gun-carriage together, and to guide and keep the toothed-sector to its work.

No. 4 shows a plan and elevation of a carriage giving 10° depression

and 15° elevation, to one of Mr. Whitworth's 70-pounders. This is to be seen in model, in Admiral Halsted's combined Turret and Broad-side System, shortly to be placed in the School of Naval Architecture, South Kensington.

This carriage is constructed of wood, steel-plated, the whole mass bolted together, which for cheapness and strength is considered very good. The power is a fixed vertical screw, worked much as No. 1 is worked.

The levers are shorter than those of the others, and the cross-bar is superseded by a pair of light trunnions on a belt.

No. 5 diagram shows the advantages of muzzle-pivoted guns, in command and protection over the usual trunnion-pivoting system, the amount of freeboard obtained, and the difference in the size of the necessary port.

The section represents Admiral Halsted's combined turret and broad-side system.

No. 6 is a drawing of a gun-carriage, giving to a 600-pounder four degrees of depression and ten of elevation, designed for Captain Cowper Coles, C.B., September, 1866.

Like No. 4, it has short levers and a fixed vertical screw.

The fixed vertical screw is, I find, objected to by many, but this objection I do not participate in; the cascables of all guns mounted with this power, are slotted so that little or no vibration can be communicated to the screw; and as the trunnion-boxes in which the trunnions ride, are in close contact with the carriage, and communicate the shock at once to the carriage, I do not see what the screw has to fear. I tried the experiment of firing a little model I have in Paris, with a considerable charge, in fact, as much as it could hold; and though I bent one of the trunnions (which were rather too slight in consequence of having been turned down to fit friction-wheels upon), and smashed the table, I did not harm the screw. If any one will fire an ordinary musket with about three charges, he will find that the somewhat severe shock of recoil comes directly against his right shoulder, and may knock him down, but his left arm is not interfered with; the lever, in fact, of my carriage.

No. 7 shows almost the same plan as this model, with an ascending and descending screw. The box through which it descends, forms the centre of a large bevelled wheel supported underneath by a cradle working on trunnions, through the centres of which run the spindles bearing the small bevelled wheels communicating power.

I bring to your notice this plan of a pair of guns in an ordinary "Captain Cowper Coles turret" (Plate viii, fig. 3) to show as clearly as possible what the requirements of a muzzle-pivoting gun-carriage really are, for turret purposes. First of all the chase of the gun must be free from and project beyond the carriage at least as much as shown at C D, as the muzzles must clear the port, and the gun-carriage cannot run out further than B.

Approximately-muzzle-pivoting guns cause their muzzles to wobble up and down, in a diminished port truly, but with a very restricted vertical arc; but a very restricted arc is very unsatisfactory and

inefficient—for in the future, turret ships, will not only have to counter-batter their adversaries at low angles of elevation; but with 20° or 25° elevation for their guns, they will have to run in and bombard high surrounding land works, to be silenced and overcome in no other manner.

These elevations will never be got by any other than absolute muzzle-pivoting carriages, at least if a small embrasure is thought necessary; with a large one, as heretofore, the present system is simple and efficient.

I read a paper "on muzzle-pivoting gun-carriages for naval armaments," on the 3rd instant, at the Society of Naval Architects, in corroboration of the advantages of which system, the Assistant Constructor of the Navy, Mr. Barnaby, thought, that "I (Captain Heathorn) would be glad to hear that the Brazilian Government, who had been engaged in war, and who had been very successful, had had ships built of different forms, but that their latest was a casemate vessel of 1,000 tons burden, in all essential particulars like the old 'Research,' except in the particular that the guns fitted to her were muzzle-pivoted. The only serious defect they had observed in the ships, was the largeness of the ports, and, considering that the river was very narrow in the front of the forts with which they had been engaged, it had been a most serious matter to them."

Admiral Halsted also observed, that "immediately before he had left Paris one of the last visits paid to inspect his new system was by Lord Lyons, and on showing him the mode of elevating the guns, he had said that if the Northern American monitors had had such means of elevating their guns, it would have put a stop to the warfare many months before. They could not elevate their guns, and they did not dare to list their ships for fear of exposing their bottoms."

This statement strongly backs up the necessity for having muzzle-pivoting gun-carriages, so constructed as to allow the guns to be laid at high angles of elevation, and be well protected from enemies' bullets pouring in through the ports. At the same time Mr. Mallet said, as a matter of fact, that he could state "that a 12-ton gun, giving 10° of elevation, and 15° of depression, could with muzzle-pivoting, be manoeuvred between the decks with the arc which at present existed, leaving some inches to spare." He endorsed entirely what I had said as regarded the importance of muzzle-pivoting, stating that, "whatever might be the height of the port, if you had a muzzle-pivoting gun, there was no room for water to come in. And that whether on land or at sea, the larger you made the embrasure the more you weakened the structure of a shield."

I now conclude my paper, Mr. President and Gentlemen, by thanking you for your kind attention.

Captain MITCHELL, R.E.: Though not an Artillery Officer, but an Officer of Engineers, I should like to ask Captain Heathorn a question. Captain Heathorn has informed the meeting that the War Office rejected his gun-carriage as inapplicable to the Service. Has he any objection to tell us the reasons the War Office gave for not adopting his gun-carriage? Probably, they gave those objections in detail; and no

doubt it would be very interesting to the meeting to hear the reasons that the War Office assigned.

Admiral Sir HENRY CODRINGTON: There are one or two questions on the subject that I should like to ask. First, as to the stability of the gun at sea when elevated; because, as it is elevated considerably, the movement of the ship would then have much more effect than when it is at its lowest position. Next, whether any of the thrust of the gun, or the recoil of the gun in short, comes upon the bolt that I see at the cascable, or what actually bears it? What takes the thrust of the gun? I should also like to ask him a question as to the case with which the damage that may be made by an enemy's shot, or by accidents and the wear and tear that there is in action, may be repaired?

Lieutenant-Colonel CONYBEARE, R.A.: I think Captain Heathorn stated that one of the advantages of his lever principle was that it afforded the means of elevating the gun on the old method, by moving it on its trunnions in case the lever got out of order. Perhaps he would be kind enough to explain to us what arrangements he would adopt for doing that?

Admiral CODRINGTON: I understand that the whole weight of the 12 tons is to be raised each time on the levers—the whole weight is to be raised on those cogs?

Captain HEATHORN: No, the weight is divided between the fulcrum and the cogs.

Captain MITCHELL: There are a large number of garrison carriages in the service. If Captain Heathorn's carriages are brought into the service to supersede the present carriages, I should like to ask him how far he could adapt the existing garrison carriages so as to meet the requirements of the plan which he proposes to introduce?

Captain HEATHORN: In answer to Captain Mitchell's first question, of the reasons why the Government objected to my carriage, I have never had such a definite explanation that I could give him. "Inapplicable to the service" has been the great reason urged. I never could get very deep into the subject, therefore, I regret to say I can give Captain Mitchell no further information upon that point. As regards the adaptation of the present garrison carriages to muzzle-pivoting, I do not think the present old wooden carriages would be very useful; and perhaps it would scarcely be desirable, because they are for mounting smaller guns than we are constructing. Now I do not think any alteration in that particular way would be an advantage. Muzzle-pivoting gun-carriages will only be used with minimum embrasures. Minimum embrasures with their expensive shields will only be afforded to very prominent positions. Then, again, I very much doubt whether the whole course of fortification at the present time is not undergoing a considerable *l'ouversement*. It is just a question whether shields, except in very particular positions, or rather I may say permanent works, will not have to give way to another system of artillery, of which my friend Captain Moncrieff is the originator, and which I believe in for certain purposes. As regards the stability of these muzzle-pivoting carriages in a sea-way, both in broadside and turret ships, I think you will remember that I propose to place rings or such fastening gear on the top of my carriage, as would in a sea-way fasten broadside carriages in a position of stability to the upper deck. In turrets I propose, as shown in Admiral Halsted's models (to be placed in the South Kensington Museum), so to construct the top of the carriages, that they may run under guiding rails, and prevent that upsetting which would occur by the oscillation of the vessel. As regards the recoil being taken by the bolt, it is a thing which I think is extremely objectionable; but I regret to say it is what the Government have adopted in their last construction, where they have used my levers, and have taken, as will be seen in the number of "The Engineer," of April 20th, 1868, the whole of the recoil on the bolt. I suppose they have a good reason for it, but I am unable to find it out. In the case of repairs to muzzle-pivoting gun-carriages, as in everything else where anything like mechanical attributes are used, duplicate parts must be provided. There are not many required in my construction; there are not many in most constructions; but duplicate parts would be provided. There would be spare levers; there would be a spare screw gearing. If the screw-gearing gave way, the ordinary handspike and quoin arrangement, with a purchase from the top if they can get it, or pressure from below, will be brought in to work the gun through space. The arrangements for converting the gun into a trunnion-pivoting gun would be very simple. It would be merely to

knock off the levers, then it would be a trunnion-pivoting gun. One of the models on the table shows it very well; take off the levers, and it becomes a trunnion-pivoting gun.

Admiral CODRINGTON: It would not then work through the ports.

Captain HEATHORN: A gun on that model would not, but one on the other would; it has, you notice, an oscillation below the screw.*

Mr. ROBERT MALLET, C.E.: I beg to make a few observations, if not too late, on the paper of Captain Heathorn. As I claim to be myself the first and original inventor of muzzle-pivoting ordnance, it could not be supposed that I intend to say anything in dispraise of the general principle of muzzle-pivoting. I must, however, say that Captain Heathorn, in stating that in the event of a muzzle-pivoting gun being disabled, you could revert with it to the ordinary method of trunnion working, is to claim for muzzle-pivoting a power which it does not, and on no possible construction ever can possess. Therefore, I hold that Captain Heathorn is entirely in error in that opinion. You cannot by any mechanical arrangement, re-convert a muzzle-pivoting into a trunnion gun, if you are to derive the advantages which muzzle-pivoting is intended to offer, and without which it is of no value, viz., the reduced aperture. Captain Heathorn will agree with what I say, and I think he must inadvertently have made his statement, that that is one of the advantages of muzzle-pivoting. And it is not unimportant that it should be corrected, because the very essence of muzzle-pivoting is this, to reduce the aperture through which the gun fires, to the size of the muzzle of your gun, so that except at the moment when the gun is withdrawn by the recoil, it is not possible for a shot to enter the hole at all. Therefore it is not likely that the gun will be dismounted in the way that ordinary guns are. It is quite possible it may be dismounted by a shell bursting inside; or it is just possible it may receive a downright "ceer" by a shot coming through the hole and striking the muzzle; or it may be deranged more or less by a shell bursting inside. In all these respects the muzzle-pivoting carriage is on a par with the old constructions, but in its main advantage of the reduced aperture, it is far before them. There are various plans already produced by different persons for practically carrying out this method, or "system," as it was called. That construction will practically be best which is the simplest and cheapest, provided it fulfils the conditions required for perfect muzzle-pivoting. The great point to be attended to in the design of a muzzle-pivoting carriage, is to get a carriage of the simplest possible construction. It should have as few parts as possible beyond the existing carriage. There should be nothing above the level of the gun itself at any time; and it should be such that, if a naval gun, you could pin the whole thing down to the slide, and pin the slide down to the deck; so that no matter what movement the vessel might take, the gun could not by possibility get loose. As an inventor and a patentee of muzzle-pivoting, I do not think it would be graceful were I to criticise that particular construction invented by Captain Heathorn, and referred to in the paper. On the importance of muzzle-pivoting itself, Captain Heathorn and I, and other inventors, are thoroughly agreed. It is the point presented for the improvement, as regards the future, of mounting ordnance. There may be other plans, such as that of Captain Moncrieff, which offer great advantages, perhaps. I myself was one that saw vast difficulties in making that system practically useful, for it is one thing to make an exceedingly ingenious looking machine, but to make one that shall stand the rough usage of actual warfare, is another thing. Muzzle-pivoting is the mode to be adopted with ordnance to fire behind the shields of casemates, for if you want to make a strong shield you

* Captain Heathorn wishes the following memo. to be inserted:—"I thought Admiral Codrington meant, that if the levers were taken off it would not work as a trunnion-pivoting gun-carriage, hence my reference to an oscillation below the screw. I never wished in any way to state that my muzzle-pivoting carriage minus the levers, could produce muzzle-pivoting. What I wished to explain was, that without levers it was a perfect trunnion-pivoting gun-carriage, the same power applicable in both cases. The advantage of a gun-carriage, with both muzzle-pivoting and trunnion-pivoting action, is, that one pattern is better than two."—Ed.

must have a small aperture in it. But a few years ago the authorities flouted the idea of muzzle-pivoting as utterly absurd; they have since altered their views, and a member of the Ordnance Select Committee itself has even become an inventor and a successful one of one form of muzzle-pivoting carriage. I believe that the authorities are now at last quite alive to the importance of the method. They are, however, taking a very questionable mode of getting the problem best solved by getting this or that Officer or person to adopt without acknowledgment, portions of plans devised by others, and precluding inventors from having their methods completed and fairly tried under their own direction. Some of the designs which I have seen, said to be on board the "Minotaur," are certainly only worthy of being called attempts to evade the rights of inventors.

The CHAIRMAN: I wish to ask Captain Heathorn whether the pattern of the carriage he sent for the "Captain" has been adopted or not?

Captain HEATHORN: Here is the drawing that I sent up to the Admiralty, at their request. They were going to adopt it; why they did not I have not yet heard.

The CHAIRMAN: It has not been adopted?

Captain HEATHORN: No, except that this (referring to the drawing in the "Engineer" of the Government carriage) was brought out at the Arsenal afterwards.

The CHAIRMAN: I think I am only expressing the sense of the meeting when I offer to Captain Heathorn our thanks for the paper which he has read to us this evening. The subject is one which is very nearly new, and like many similar subjects which have had, if not their origin, certainly early notice in this theatre, it will produce results which I have no doubt will be considered in a national point of view as of great importance, while it is creditable to those who have brought it forward. There appear to be some differences of opinion in respect to the arrangements of this muzzle-pivoting carriage, which Captain Heathorn has brought before us; but there is no doubt whatever—and I quite agree with what has fallen from the talented inventor, who last addressed the meeting—that for the future muzzle-pivoting will be the system. With regard to guns on shore, fortifications as well as artillery are undergoing a transition; they are now in a state in which nothing can be considered as settled. Much is under experiment; much will probably have to be altered, although we may have the elements of what the future will be, both of guns and of fortifications. But as regards ships, this system appears to me to have pre-eminent excellence, inasmuch as it reduces the ports through which the guns are fired, to their *minimum*—it admits of guns being trained to almost any requisite amount, and elevated or depressed through very many degrees without the aperture into which the muzzle of the gun is forced being enlarged unnecessarily in either direction. There appears to be one point which has not been noticed with regard to the ports for these muzzle-pivoting guns. It is in respect of their training, that a large portion of the iron-plating has to be cut off, to admit of the gun being moved laterally. Now, it is evident that this weakens to a certain extent the armour-plating of vessels. But we must take into account the extreme improbability of a shot hitting one of these ports. If we take the diameter of a port at 14 inches, which will give a surface of one foot, and take the side of a ship as between 3,000 and 4,000 superficial feet, the chances that the shot will hit that hole are as 3,000 or 4,000 to 1; that is almost saying that they would not hit at all. But not to enter into a discussion on a subject of which the discussion is closed, I will merely offer on the part of the meeting our thanks to Captain Heathorn for the valuable paper which he has read, and urge him to persevere in his invention. I trust the same success will follow his endeavours to bring forward this carriage, and other modified carriages on this system, as has happily attended the efforts of others who have favoured this Institution with explanations of their inventions, and which have had for their object, the improvement of our defences. I am sure that we all feel greatly obliged to Captain Heathorn, and to other Officers who come forward with the same good will that he has shown to-night, and demonstrate such beautiful illustrations of their systems as hang upon these walls, and who initiate here inventions of great national importance, and which cannot fail to make their way among continental authorities, as well as with our own Government.